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Capacity Development in Renewable Energy Policy and Mapping in Belize

Task 5 Final Report:
Belize 2030 Sustainable Energy Roadmap

July 2016

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Acronyms and Abbreviations

AOSIS	Alliance of Small Island States
AST	Active solar thermal
ATM	Active traffic management
BAU	Business as Usual
BEL	Belize Electricity Limited
BEV	Battery electric vehicle
BNE	Belize Natural Energy
BZD	Belize dollar
CARICOM	Caribbean Community Secretariat
CEIS	Caribbean Energy Information System
CFE	Federal Energy Commission of Mexico
CHP	Combined heat and power
CNG	Clean natural gas
CO_2	Carbon dioxide
CRDEP	Caribbean Renewable Energy Development Project
CSP	Concentrated solar power
CSR	Corporate social responsibility
DOE	U.S. Department of Energy
ECM	Energy conservation measure
ECPA	Energy and Climate Partnership of the Americas
EE	Energy efficiency
EEZ	Exclusive Economic Zone
EUEI PDF	EU Energy Initiative – Partnership Dialogue Facility
GDP	Gross domestic product
GJ	Gigajoule
GoB	Government of Belize
GWh	Gigawatt-hour
HEV	Hybrid electric vehicle
HFO	Heavy fuel oil
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
ITS	Intelligent transportation system
kW	Kilowatt
LCOE	Levelized cost of energy
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
MCG	Meister Consulting Group
MDG	Millennium Development Goal
MEPS	Minimum energy performance standard
MPG	Miles per gallon
MPSEPU	Ministry of Public Services, Energy, and Public Utilities (former MESTPU)
MSW	Municipal solid waste
MW	Megawatt
MWh	Megawatt-hour
NEC	National Energy Council
NEP	National Energy Policy
NSES	National Sustainable Energy Strategy
NSTMP	National Sustainable Tourism Master Plan
O&M	Operation and maintenance
OAS	Organization of American States
OLADE	Latin American Energy Organization
OTEC	Ocean Thermal Energy Conversion
PHEV	Plug-in hybrid electric vehicle
PUC	Public Utilities Commission
PV	Photovoltaic
RE	Renewable energy
R&D	Research and development
RD&D	Research, development, and deployment
SDG	Sustainable Development Goal
SE4All	Sustainable Energy for All initiative
SIDS	Small-island developing state
SIEPAC	Central American Electricity Interconnection System
SME	Small and medium-sized enterprise
SWMA	Belize Solid Waste Management Authority
TJ	Terajoule
TTA	Trama TecnoAmbiental
UN	United Nations
UN-ECLAC	United Nations Economic Commission for Latin America and the Caribbean
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States dollar
WWI	Worldwatch Institute

Foreword

The Government of Belize (GoB), the private sector, and civil society are increasingly acknowledging the crucial role of energy for sustainable development. The country has arrived at a critical point in time where a long-term vision, strategy, and plan for sustainable energy policy and development is warranted. The establishment of measurable objectives and the execution of targeted measures and reforms based on sound technical assessments of technologies and solutions are fundamental to the success of the *Belize 2030 Sustainable Energy Roadmap*. The Roadmap also has to be cognizant of the socioeconomic and environmental challenges and needs in Belize.

This report includes data and information necessary to facilitate multi-stakeholder discussions and to create a national consensus on the forthcoming 2030 strategic vision, roadmap, and related action plan. From September 2015 to May 2016, under the auspices of the Ministry of Public Service, Energy and Public Utilities (MPSEPU) of Belize, information was gathered from interviews with stakeholders in the country during on-site visits and from data sourced from publicly available studies, reports, and publications.

The preparation of this so-called *First Draft 2030 Sustainable Energy Roadmap* was led by the Worldwatch Institute in collaboration with Meister Consulting Group (MCG) and Trama TecnoAmbiental (TTA) under an EU Energy Initiative Partnership Dialogue Facility (EUEI PDF)-financed project entitled "Capacity Development in Renewable Energy Policy and Mapping in Belize."

The goals, targets, and action plan presented in this *Draft 2030 Sustainable Energy Roadmap* are subject to review and refinement, and need to be confirmed by Belize's National Energy Council (Energy Council) and stakeholders prior to its official launch. Part of the outstanding work is the need to establish a strategic vision statement, set clear goals and objectives, confirm measurable targets, develop a monitoring and evaluation system, and establish a periodic update and reporting process to measure progress during the implementation of Belize's *2030 Sustainable Energy Roadmap*.

Executive Summary

In recent years, Belize has been confronted with extended periods of drought, crop disease, reduced exploitation and export of crude oil, and the potential fallout of the PetroCaribe deal.[1] Although Belize exploits its crude oil resource, almost all of this is exported for refining, and crude oil export values have declined sharply in the recent past. The Ministry of Public Service, Energy and Public Utilities (MPSEPU) indicates that Belizean crude oil output peaked in 2010, with current production at around 5,000 barrels per day. Recent exploration efforts have not yielded the expected results, resulting in a need for greater attention to diversification and greening of the nation's energy sector.

A critical area that demands attention is the transport sector, which in 2014 consumed about 50% of Belize's total primary energy supply.[2] The main fuels consumed in the sector are kerosene, diesel, and gasoline. No recent quantitative analysis has been performed to understand fuel supply and consumption patterns in Belize's transport sector in order to identify areas for intervention.

The power sector has shown more positive signs, as more than 50% of the electricity consumed in Belize originates from domestic renewable energy sources. However, key challenges remain to increasing the country's renewable generation capacity. These include: a lack of in-depth research and resource assessment of biomass, hydropower, and waste-to-energy potentials, among others; a lack of energy data and statistics on energy production and consumption patterns to perform energy analyses and to set priorities for action; and challenges related to land ownership and land-use competition. Outside of utility-scale, grid-connected power systems, there is very limited distributed generation in Belize, and there is a need for clear and effective grid interconnection protocols, among other incentives, to make renewable energy technologies both accessible and affordable.[3]

With regard to energy efficiency, there appears to be great potential for improvement in the public sector, particularly through retrofits and procurement processes. There also is a critical need for institutional capacity building in the energy sector, where basic processes such as tendering, project evaluation and selection, and follow-up activities for measuring results are not considered standard procedures. All of these issues represent challenges in the transition to a sustainable energy future in Belize and require a comprehensive, all-inclusive strategy and action plan.

The Government of Belize, through this report, is launching the process of defining and confirming the scope of its *Belize 2030 Sustainable Energy Roadmap*. This strategic Roadmap needs to be coherent, to support national energy policy, and to set out clear priorities and measurable objectives for the short, medium, and long terms. In this context, established priorities and targets will address—in addition to energy goals—cross-cutting issues as climate change, poverty eradication, inclusive and equitative development, gender equality, and other key issues to achieve sustainable development. A transparent and participatory process in collaboration with stakeholders from different parts of society is critical to ensure successful implementation of the Roadmap. This report serves as a draft for further elaboration into a formal first edition of Belize's *2030 Sustainable Energy Roadmap* that will replace the current *Sustainable Energy Programme – Strategy and Work Plan 2015–2020*.

This report forms part of wider technical assistance project financed by the EU Energy Initiative Partnership Dialogue Facility (EUEI PDF) entitled "Capacity Development in Renewable Energy Policy and Mapping in Belize." The project is implemented by the EUEI PDF for Belize's MPSEPU. The overall objective of the technical assistance is to enhance the capacity of MPSEPU to develop an effective energy policy and strategy framework and to ensure effective implementation of the 11th European Development Fund (EDF) of EUR 13.5 million (approximately BZD 30 million) to the energy sector in Belize, which will be disbursed in 2017.

The EUEI PDF project on “Capacity Development in Renewable Energy Policy and Mapping in Belize” comprises five activities:

- Energy Council – Project Steering and Governance Structure (Task 1)
- Capacity Building – Assessment of Renewable Energy Workforce Training Needs in Belize (Task 2)
- Energy Mapping Review and Future Mapping Strategy (Task 3)
- Off-grid Rural Electrification – Assessment and Strategy (Task 4)
- Belize 2030 Sustainable Energy Roadmap (Task 5)

This report provides guidance on the final activity (Task 5), developing a comprehensive *2030 Sustainable Energy Roadmap*. It provides the first key elements of the roadmapping process, in particular by: providing sound national baseline data on energy supply, distribution, and use patterns in Belize; proposing energy targets to measure progress and success of implementation of the finalized Roadmap; recommending sustainable technology screening criteria to help identify, evaluate, and select key energy technologies and solutions to consider; providing future energy demand projections; suggesting technology development pathways; and presenting a draft action plan. Thereby, the report lays the groundwork and serves as key input for planned GoB interventions, including the upcoming EU-funded 11th EDF program.

1 Introduction

1.1 Purpose of This Report

The recommendations included in this report are derived from, among others, the National Energy Policy (2012), the MESTPU's Strategic Plan 2012–2017 (2012), the Sustainable Energy Programme – Strategy and Work Plan 2015–2020 (2015), and the Belize Sustainable Energy Strategy (2015).

This report is submitted to the members of Belize's National Energy Council (supported under Task 1 of this EUEI PDF funded project), where it is highly recommended that, in collaboration with other key stakeholders, they carry forward and finalize the work on the first official edition of Belize's *2030 Sustainable Energy Roadmap*. The government's ownership of the Roadmap will lead to a commitment that is essential to other stakeholders that will be looking for long-term policy support and appropriate levels of funding. It is recommended that the Energy Council identify a pertinent entity for the continued systematic implementation, monitoring, and periodic update of the Belize *2030 Sustainable Energy Roadmap* as progress is made, as external factors change, and as more information becomes available.

The process of updating and publishing consecutive editions of this Roadmap enables stakeholders to monitor, update, and further facilitate multi-stakeholder discussions and enable informed decision making regarding planning and development of energy supply, production, and use in Belize to achieve the set targets for 2030. This report can be linked to OLADE's implementation of the *Energy Planning Manual*, the main objective of which is to enhance capabilities and to develop new skills in energy planning within the Latin America and Caribbean region. The project's final aim is to develop guidelines that later will be considered for Belize's national energy plan.

The aim of Task 5 is to assist the Government of Belize in planning actions for a *2030 Sustainable Energy Roadmap*, preparing the knowledge base and information to feed into the EDF-11 program.

1.2 Scope of This Report

At the outset of this drafting process, significant gaps and a lack of coherency existed between several earlier energy policy documents related to Belize, including international commitments, plans, studies, measurement metrics, and project reports. This in itself reflects a need to streamline and coordinate efforts to promote sustainable energy development in the country.

Figure 1 illustrates the structure of a roadmap development process.[4] The process of roadmapping can take between 6 and 18 months to finalize, assuming adequate levels of resource allocation. As indicated via the red circle in the figure, the present report should be considered as a sub-component of the larger roadmapping process required to finalize the 2030 vision and strategic roadmap for Belize.

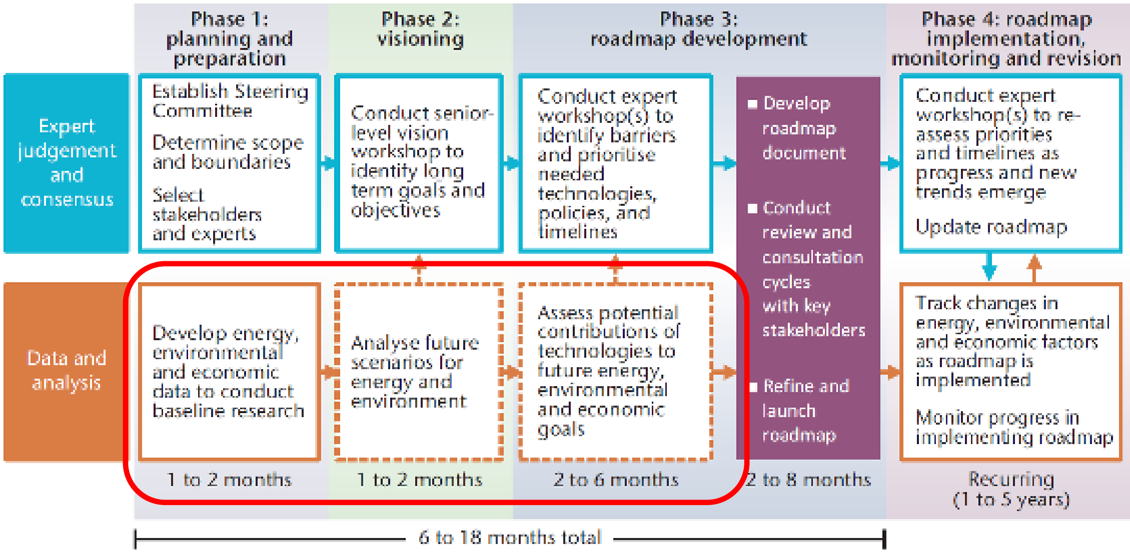

Figure 1. Outline of the Sustainable Energy Roadmap Process

1.3 Methodology

Fundamental issues to address prior to launching the Belize roadmapping process

This report discusses several fundamental issues for the preparation of the roadmap strategy for Belize, including the need for a vision statement, the need to clearly define the role and responsibilities of the government and stakeholders in drafting and implementing a roadmap strategy, the need for guiding principles, and the need to set boundaries of the scope of the roadmap. The report proposes a roadmap template using a combination of templates and approaches. In the case of Belize, several modifications and additional features are included in order to address the multiple challenges at play.

Energy policy framework analysis

This report devotes specific attention to the compilation, review, and analysis of all existing international agreements and energy policy documents relevant to Belize. This was deemed necessary because, at the outset of the study, there was confusion regarding the policy goals, objectives, and targets to take into consideration for the preparation of this DRAFT *2030 Sustainable Energy Roadmap*.

In recent years, Belize has signed on to numerous international agreements and has established targets and made commitments to regional multilateral bodies, as part of the country's contribution to achieving regional and international goals and targets for renewable energy and climate change mitigation. Simultaneously, within the national energy policy framework, multiple studies and reports have been prepared that reflect different sets of targets and objectives. A lack of clarity exists with regard to the set objectives, timelines, and indicators to track progress.

The energy policy framework analysis of this report reviews the policy objectives and verifies how these are linked to the general body of energy policy documents. Where targets are presented, an attempt is made to offer a more in-depth look into how these are established and for what purpose. Finally, the report provides an overview of the relevant policy objectives and targets, and makes recommendations regarding the most relevant policy objectives to guide the establishment of energy savings, energy efficiency, renewable energy supply, and clean production targets in the *2030 Sustainable Energy Roadmap*.

Energy sector diagnostic

As a next step, the analysis explores current energy supply and consumption patterns in Belize. The extent of information provided is subject to the availability of publicly available data and sources. The report provides a specific assessment of the production and consumption of key energy carriers, such as electricity, fuels, and heat. This diagnostic helps to explain the current gaps in data in order to present a more-complete picture of energy sector dynamics and performance, and to identify the gap between the current reality and the presently used targets for the *2030 Sustainable Energy Roadmap*.

Technologies and solutions to consider

After examining current energy sector conditions, the analysis reviews the available technologies and solutions that could be considered for application in Belize. These are organized based on the Trias Energetica hierarchy, which outlines a hierarchical order of interventions to improve energy sector performance. The structure reflects three levels of interventions: 1) avoidance of need for energy, 2) using sustainable energy sources instead of fossil fuel-based sources to address demand, and 3) finally, using any produced energy as rationally and efficiently as possible.

Figure 2. Trias Energetica Concept

In this report, commercially available and demonstrated technologies are prioritized for short- and medium-term consideration over emerging technologies, where further investigation and assessments are needed. The report also describes and recommends sustainable technology screening criteria to use as a guiding framework to evaluate and select technologies and solutions in compliance with sustainable development principles. The combination of the Trias Energetica concept and the sustainable technology screening criteria will serve as recommended tools for capturing commercially available as well as emerging technologies for future incorporation as alternatives for expanding the portfolio of solutions to facilitate Belize's further transition toward energy sustainability to 2030 and beyond.

Technology pathways

Based on the assessments of the energy savings, renewable energy supply, and energy efficiency technologies and solutions, the analysis creates and uses several plausible scenarios to forecast potential technology development pathways. These scenarios are compared to a business-as-usual scenario for the time frame up to the year 2030. Despite the lack of energy statistics, an attempt is made to prepare scenarios for specific energy carriers, including electricity, fuels, and heat.

Programs, activities, and measures needed

Following the forecasts of technology pathways, the report outlines the overall recommended strategy for further developing the *2030 Sustainable Energy Roadmap*. The strategy's draft work plan also presents the initial set of specific measures and activities recommended for the effective transition toward achieving the goals of the *2030 Sustainable Energy Roadmap*.

Next steps

The report ends by providing conclusions and recommendations regarding the existing gaps in data and information for the preparation of the *2030 Sustainable Energy Roadmap*. It also outlines a draft work plan that includes a high-level summary of recommendations and actions specific to Tasks 2, 3 and 4 of this EUEI PDF project that address human capacity development needs, energy data collection and management needs, and rural electrification recommendations to achieve universal access in Belize by 2030. In addition, the report recommends an initial set of activities related to the currently obtained and discussed content of this DRAFT *2030 Sustainable Energy Roadmap* (including the specific issues discussed in Chapters 2–5). The report concludes with a to-do-list of the required next steps in the roadmapping process to help guide the Energy Council in preparing, updating, and finalizing the *2030 Belize Sustainable Energy Roadmap* Strategy and related Action Plan.

1.4 Structure of the Report

This report is divided into eight chapters. **Chapter 1** describes the purpose, scope, methodology, and structure of this report. **Chapter 2** outlines fundamental issues that need to be addressed for the further roadmapping process to prepare Belize's *2030 Sustainable Energy Roadmap*. **Chapter 3** provides the energy sector diagnostic and describes current energy supply and consumption patterns and conditions in Belize. **Chapter 4** includes a review and discussion of priorities for intervention using the Trias Energetica hierarchy and proposed sustainable technology screening criteria for selecting technologies and establishing the order of interventions. **Chapter 5** presents several plausible scenarios and technology pathways modeled based on the data available from the International Renewable Energy Agency (IRENA) and possible scenarios. **Chapter 6** covers the initial scope of action points and activities that are recommended to facilitate the transition toward achieving the *2030 Sustainable Energy Roadmap* goals. **Chapter 7** provides a summary of targets required to address high-level priority issues as building human capacity, addressing data collection needs, and launching rural electrification activities, as well as to engage in the roadmapping process to prepare and finalize the first official edition of the Belize *2030 Sustainable Energy Roadmap* Strategy. **Chapter 8** synthesizes the recommended interventions into one coherent Action Plan, while **Chapter 9** provides high-level conclusions.

2 Designing and Operationalizing Belize's 2030 Sustainable Energy Roadmap Strategy

The Belizean government is cognizant of the need to prepare an all-encompassing *Sustainable Energy Roadmap* Strategy and Action Plan to explore appropriate technologies and solutions to implement and address the existing market, financial, technical, institutional, and human capacity barriers to sustainable energy development within the country's economy and government. Important features of the roadmap strategy preparation process (roadmapping process) include defining the vision for 2030, laying out a template for the Roadmap, preparing an inventory of available data and information, and addressing key aspects necessary for a successful roadmapping process. A properly designed and executed roadmapping process will send the right signals to the wider public and create opportunities for establishing fruitful and long-term public and private partnerships to secure future investment and financing needed for realizing sustainable energy development in Belize. This report discusses these and other essential components of a forthcoming Roadmap and provides recommendations for moving forward.

2.1 The Need for a 2030 Roadmap Strategy

A first key question to answer is: "Why is there a need for a Sustainable Energy Roadmap Strategy?" The following provides a general explanation of key fundamental elements contained in successful roadmap strategies, and a summary and scope of current challenges in Belize, based on observations made during country visits and interviews held with multiple stakeholders.

Despite the strong potential for energy efficiency and renewable energy observed in Belize, the development of sustainable energy systems will not occur organically, at least not to the extent or at the pace needed to rapidly harness the full socioeconomic and environmental benefits of these systems. National governing bodies must be proactive in implementing policy frameworks that promote the investments needed to encourage energy efficiency improvements and to allow renewable energy projects to take hold. No single policy mechanism can successfully transform a nation's entire energy sector. Instead, policymakers must design and implement an appropriate policy mix that matches unique domestic conditions.

International experience shows that countries that have successfully promoted renewable energy and energy efficiency score high on three essential building blocks: 1) a **long-term vision** that includes goals and targets; 2) **concrete policies and measures** to achieve these goals and targets; and 3) **effective administrative processes and governance structures** for implementing and revising these mechanisms.

First of all, establishing an official long-term vision for sustainable energy development that lays out **clear goals and priorities** and that commits all government stakeholders to a **common and cohesive strategic agenda** represents a crucial component of effective sustainable energy planning. In recent decades, Belize has faced challenges that have affected its ability to advance sustainable development. Ongoing financial, energy, and food crises worldwide have weakened Belize's economic competitiveness and resilience, making it difficult for the country's productive sectors to remain relevant in the globalized economy. Recognizing this reality, Belize's leaders are aiming to become less reliant on a single or limited economic sector by diversifying and assessing innovative and efficient practices. To become more resilient to external shocks, they are seeking ways to reduce Belize's high dependence on foreign exchange expenditures, such as imported energy.

As a small, low-lying nation, Belize faces challenges to its sustainable development over the long term. The country's small size represents an absolute limit in available space to maintain or achieve a proper balance between space for human development vis-à-vis nature. This limit determines the country's maximum carrying capacity to develop, prosper, and sustain a good quality of life. Continuous population growth increases the pressure on local ecosystems to supply the Belizean population with the resources and services—such as fresh water, healthy food, and sufficient usable land—necessary to satisfy present and future needs.

In addition to these finite resources, a variety of other general characteristics distinguish Belize from larger developed, industrialized nations.[5] (See Table 1.) These charcteristics accentuate the unique challenges facing Belize in general and highlight the need to have a clear picture of the country's circumstances and needs in order to address its development requirements in a non-conventional manner.[6]

Table 1. General Characteristics of Belize

Category	Description
Small size	Disadvantages deriving from Belize's small size include a narrow range of resources, which forces undue specialization; excessive dependence on international trade and hence vulnerability to global developments; high population density along coastal zones and river systems, which increases the pressure on already limited resources as high competition between land uses and intensity of land uses; high degree of interdependence between human and environmental systems, overuse of resources and premature depletion; relatively small watersheds and threatened supplies of fresh water; costly public administration and infrastructure, including transportation and communication; limited institutional capacities and domestic markets and limited export volumes; and spatial concentration of productive assets which are too small or challenging to achieve economies of scale.
Insularity and remoteness	Belize as a nation is considered remote, but in particular the rural and isolated communities in the hinterlands or on the atolls suffer from high external transport costs, time delays and high costs in accessing external goods, delays and reduced quality in information flows, geopolitical weakness, economic disadvantage, and reduced competitiveness.
Vulnerability to natural disasters	Belize is located in the hurricane belt, which is one of the most vulnerable regions in the world in the intensity and frequency of natural and environmental disasters and their increasing impact, and faces disproportionately high economic, social, and environmental risks and consequences.
Fragile ecosystems	With its large stretches of low-lying coastal zones, and as a maritime territory hosting the second largest barrier reef in the world (which serves as a major source of income through tourism), Belize is very vulnerable to adverse effects triggered by climate change and sea-level rise. These, and long periods of drought affecting the agricultural sector, present significant risks to its sustainable development, and the long-term effects of climate change may threaten the country's very economic viability.
Demographic factors	Belize has a limited human resource base, small population, rapid population changes and increases in population density, distributed urban centers, population concentrated on coastal zone, dis-economies of scale leading to high per capita costs for infrastructure and services.
Economic factors	Belize has a small economy, with high dependence on external finance, a small internal market, high dependence on natural resources, high specialization in a few major economic sectors (tourism, agriculture, and extractive sector), and limited production or manufacturing capacity.

Source: See Endnote 5.

In addition, climate change is considered one of the most critical impediments to long-term well-being, as it increasingly is affecting the environment and carrying capacity of Belize. Because Belize's population, agricultural land, and infrastructure tend to be concentrated in the coastal zone, any rise in sea level will have significant and profound effects on local economies and living conditions. The inundation of major urban centers, such as Belize City and outlying cays, and the loss of land above the high-tide mark may result in loss of exclusive economic rights over extensive areas (e.g., for access to fishing areas and use of natural resources), as well as in the destruction of existing economic infrastructure and human settlements due to hurricanes. Sea-level rise also may affect vegetation and contribute to saline intrusion that may adversely affect freshwater resources.

Certain physical and socioeconomic characteristics tend to intensify Belize's vulnerability to climate change. The country's high ratio of coastline to land area, high population density, and minimal elevation puts large parts of the population at risk from hurricanes, flooding, and erosion. Within the power sector, extended droughts have contributed to below-average electricity production from hydropower dams. In addition, Belize is host to the world's second largest barrier reef system and depends heavily on its coastal ecosystems, including mangroves and coral reefs, for household income, tourism revenue, and food. These ecosystems are threatened by rising sea-surface temperatures, ocean acidification, and increased storm intensity as a result of climate change.

The challenge posed by climate change on development is well documented.[7] The impact on Belize, one of the countries that has contributed least to the problem from a global perspective, is disproportionate. As a small, low-lying coastal state, Belize emits very low quantities of greenhouse gases, estimated at less than 0.05% of global emissions—a reality that often is contrasted with the country's comparatively limited capacity to respond to the climatic changes.[8]

Evidence from the Intergovernmental Panel on Climate Change (IPCC) points to higher average estimates of sea-level rise than reported previously.[9] Other threats identified include changes in precipitation and sea-surface temperatures, which, coupled with the climatic characteristics of Belize (e.g., El Niño, drought, hurricanes), expose the population to livelihood-threatening circumstances.

Finally, droughts and saline intrusion into coastal aquifers are expected to have adverse impacts on both drinking water and water for agricultural production in Belize. Rising temperatures and increased ocean acidification are contributing to the destruction of coral reefs of high biodiversity value and are affecting fishery habitats. When developing Belize's *2030 Sustainable Energy Roadmap*, it will be important to consider at all times the diverse socioeconomic and environmental impacts of choices made to develop the energy sector on the general well-being of the population.

2.2 A Vision for Belize's 2030 Energy Development

A fundamental issue to address prior to formally launching Belize's roadmapping process is the need to define Belize's "Vision for 2030." It is recommended that the recently established National Energy Council initiate a dialogue process to define and present a first draft of a Vision Statement. This should be accompanied by guiding principles, the Roadmap's goals and objectives, a description of the role of the Government and other stakeholders, and the scope of the boundaries of the Roadmap Strategy to facilitate implementation of the roadmapping process. Finally all of this needs to be presented in an agreed-upon Roadmap layout that will be subject to periodic updates (see Annex 1).

The current Strategic Vision of MPSEPU (former MESTPU), as the Ministry in charge of guiding energy development in Belize, is:

- *"To strategically integrate energy, science and technology into national development planning and decision making and improve policy and regulatory framework for public utilities to improve service delivery."*[10]

The Mission Statement of the Ministry is:

- *"To plan, promote and effectively manage the production, delivery and use of energy through Energy Efficiency, Renewable Energy, and Cleaner Production interventions for the sustainable development of Belize."*[11]

The strategic vision statements presented above can be adopted "as is," or could be adjusted by the Energy Council in an effort to draft a new nationwide strategic vision for 2030 that is based on a combination of objectives derived from the existing body of energy policy documents and the GoB's current strategic development vision that may help frame and operationalize the forthcoming Roadmap.

<u>Recommended Vision Statement:</u>

Based on the review of the body of energy policy documentation pertaining to Belize (see Section 2.3), a potential Vision Statement for consideration by the Energy Council is:

- *"By 2030, Belize will be a net energy-exporting nation with a thriving clean and productive energy sector that helps create opportunities for improving Belizean's lives in an inclusive and equitable manner and where all its people will have access to modern, affordable, and sustainable energy services to achieve sustainable development."*

The above statement captures the four key driving forces derived from the energy policy framework of Belize: 1) reducing poverty and generating employment, 2) expanding electricity access, 3) lowering electricity costs and ensuring energy security, and 4) combating and adapting to climate change.

2.3 Need for Policy Harmonization to Establish 2030 Objectives

Numerous international and national treaties, policy documents, laws, programs, action plans, and project documents relate to and influence the development and governance of the energy sector in Belize. The goals, objectives, targets, and time frames described in the existing strategic plans or policies are not completely aligned, since they were completed at different periods in time, by different authors, and under varying conditions and due to other unknown reasons. An attempt is made here to harmonize the goals contained in the policy documents described below to support the establishment of the 2030 Roadmap objectives.

In an effort to understand and describe this challenge, the present analysis reviews and maps the documents that form part of the energy policy framework of Belize to sort out the goals and objectives described in each respective policy document. The results are then compared to determine where there are common objectives and gaps. The objective is to attempt to harmonize the objectives to be included in the *2030 Sustainable Energy Roadmap* and to determine the suitability and compatibility with the currently proposed Strategic Focus Areas (discussed in Section 2.3.4).

2.3.1 International Commitments and Regional Commitments

Regionally, Belize is part of a series of agreements and organizations that address energy issues, such as the Caribbean Energy Information System (CEIS), the Latin American Energy Organization (OLADE), and the Energy and Climate Partnership of the Americas (ECPA) under the U.S. Department of Energy.[12] Belize also is covered by the CARICOM Energy Policy 2013, which targets a renewable energy supply of 47% by 2027 compared to the baseline year of 2012.[13] To meet the regional target, it is estimated that Belize will have to increase its national renewable energy production from 82.5 megawatts (MW) to 229.3 MW. This would result in a 62% reduction in carbon dioxide (CO_2) emissions compared to business as usual (BAU).[14]

Since 2011, Belize also has been part of the SIDS DOCK Initiative, which gathers small island developing states (SIDS) under the Alliance of Small Island States (AOSIS) framework to provide a collective mechanism that integrates and assists national governments in implementing their sustainable development and renewable energy strategies. The main implementation channel is through institutional cooperation and the generation of financial resources that come from climate change mitigation and adaptation funds.

In May 2012, Belize signed the Sustainable Energy for All (SEforAll) initiative promoted by the United Nations Secretary-General. The initiative was signed at the AOSIS Ministerial Conference on "Achieving Sustainable Energy for All in SIDS – Challenges, Opportunities, and Commitments." According to the Declaration, achieving sustainable energy for all in SIDS requires: 1) ensuring universal access to modern energy services, 2) doubling the global rate of improvement in energy efficiency, and 3) doubling the share of renewable energy in the global energy mix.

The UN's Millennium Development Goals (MDGs), which expired at the end of 2015, were replaced in September 2015 by a new set of Sustainable Development Goals (SDGs). Belize is signatory to the UN's 2030 Agenda for Sustainable Development, which goes much further than the MDGs and includes 17 goals that are tailored to addressing the root causes of poverty and the universal need for development that works for all people.[15]

2.3.2 National Energy Policy Framework

The country's national development plan, Horizon 2030, embodies the vision for Belize in the year 2030, the principles of sustainable development, and the core values that are to guide citizen behavior and inform the strategies to achieve a common vision for the future. One of the strategic priorities of Horizon 2030 is "*the promotion of green energy and energy efficiency and conservation, including the creation of an institutional framework for producing a viable national energy policy*."[16]

Figure 3 provides a chronological overview of events and documentation relevant to the energy sector in Belize, which form the body of policies, acts, and strategy documents to take into account.[17] This is not a complete overview of relevant documents, as additional documents exist that are not depicted in the figure.

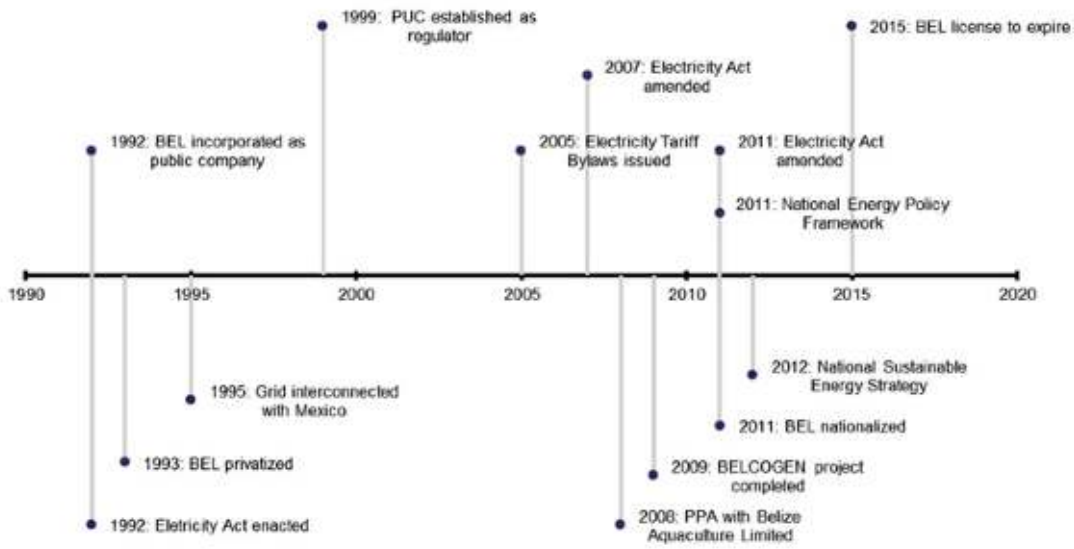

Figure 3. Chronology of Energy Sector Relevant Events and Documentation (IDB, 2014)

The *2030 Sustainable Energy Roadmap* will need to build on the recommendations already provided by these documents. The following sections provide a detailed analysis of Belize's energy policy framework, including descriptions of the documents shown in Figure 3 that highlight the objectives, targets, and recommendations provided. The objective of the analysis is to sort out whether the established goals, objectives, and targets synchronize or not.

The policy framework for sustainable energy in Belize presently comprises six main policy documents (beyond what is shown in Figure 3): Horizon 2010–2030, the National Energy Policy Framework 2012–2017, the Sustainable Energy Action Plan 2012–2033, the National Climate Resilience Investment Plan, the Growth and Sustainable Development Strategy 2014–2017, and the National Climate Change Policy, Strategy and Action Plan 2015–2020.[18]

Horizon 2010–2030 sets forth the national development strategy, based on four main pillars: 1) democratic governance for effective public administration and sustainable development, 2) education for development and for life, 3) economic resilience to generate resources for long-term development, and 4) healthy citizens and a healthy environment.[19] Within the energy section, the government commits to creating an institutional and regulatory framework to promote a viable energy policy.

The document states the intention to build international standards for services and waste, to provide incentives for energy savings and investments in renewable energy, to create government procurement policies for those who have excess to sell to the main grid, to adopt a national transport policy with low environmental impacts, and to provide tax and other incentives for households to more easily adopt "green" technologies.[20]

The **National Energy Policy Framework 2012–2017** focuses on transitioning to efficient and sustainable energy provision in order to: 1) increase energy resilience, 2) meet social and economic needs, and 3) adapt to climate change. The main goals are to foster the sustainable production, distribution, and use of energy as a critical resource; to minimize the cost of energy in the local economy; to mitigate the impacts of uncontrollable events such as external market price and supply shocks and natural disasters on the cost of energy and on the reliability of energy supply; and to create a national culture with appreciation for energy efficiency measures.[21]

The quantitative objectives are to have 80% of the energy supply originating from renewable sources by 2020 and 95% by 2030.[22] The strategies to pursue these objectives include strengthening the institutional framework as well as promoting a diversified, dispersed, and mixed micro-generation network based on local participation and use of indigenous renewable resources.

The **Sustainable Energy Action Plan 2012–2033**, approved under the MESTPU Strategic Plan (2012–2017), focuses on overcoming the barriers to renewable energy production through public programs in order to secure energy supply and improve efficiency. The goals set by the government are to reduce energy intensity per capita at least 30% by 2033 (using 2011 energy use and GDP as the baseline); to reduce the country's dependence on imported fuels 50% by 2020; to at least triple the amount of modern energy carriers derived from waste material; to become a net electricity exporter by 2020; and to strengthen MESTPU's institutional capacity to accomplish its mandate by strengthening the Energy Portfolio through increases in professional staff, training, and human resource development; acquisition of office supplies, materials, and equipment; and funding to undertake institutional studies and audits, public awareness and education, and travel budgets.[23]

The **National Climate Resilience Investment Plan** builds on climate vulnerability and disaster risk reduction throughout economic sectors and social groups of stakeholders. Belize ranks 119th out of 192 countries in GDP-weighted vulnerability to climate change, given the country's substantial low-lying coastline, 1,000-plus small islands, largest vulnerable reef barrier in the continent, and high frequency of floods and hurricanes.[24] Even though the plan is not focused directly on renewable energy strategies, it indirectly influences the sector due to the high importance of renewable energy supply in national adaptation policies. This plan is supported by the World Bank to achieve a more resilient and sustained economy, better access to markets and services, better employment and poverty reduction, and resilient and healthy communities.

The **Growth and Sustainable Development Strategy 2014–2017** highlights the entire state bureaucracy in achieving economic development, poverty reduction, and sustainable development. The objective is to create an appropriate and well-prioritized mix of strategies that will be reflected in the work of ministries and other public agencies. The document underpins the expansion in ongoing activities, the development of proactive approaches and new actions, the conduct of new studies, and the focus on strategies that improve results in the context of limited resources.[25]

The **National Climate Change Policy, Strategy and Action Plan 2015–2020** provides a way to harmonize legislative and administrative measures to address climate change. The main goal is to promote encompassing policy guidance throughout different sectors and government levels in order to achieve national strategies and international commitments.[26] This action plan also is the major source of implementation for Belize's Intended Nationally Determined Contribution (INDC) document, submitted to the UN Framework Convention on Climate Change in October 2015, which states the policies in place for climate change mitigation and adaptation as well as the short- and long-term goals to transition Belize to a low-carbon resilient economy.[27]

(See Annex 3 for a more detailed overview of the specific goals and objectives included in each of the above policy documents that form part of the body of policies, strategies, and plans to improve energy development in Belize.)

2.3.3 Driving Forces to Determine 2030 Roadmap Vision and Objectives

The following driving forces for Belize's commitment to sustainable energy development are derived from the body of existing policy goals and objectives described in Sections 2.3.1 and 2.3.2 above.

2.3.3.1 Poverty Reduction and Job Creation

The GoB's decision to embark on renewable energy and energy efficiency targets for 2030 is based on the desire to create a better future for Belize—a future characterized by wealth creation. Renewable energy, in particular, has the potential to contribute to Belize's sustainable development, poverty alleviation, and job creation aspirations. According to the International Renewable Energy Agency (IRENA), renewable energy jobs worldwide reached an estimated 7.7 million in 2014, excluding large hydropower.[28] Larger-scale deployment of renewable energy will result in a net increase of jobs in the energy sector and in indirect job creation in many other sectors in the future.

Based on the strategies included in the NEP, efforts should focus in the following areas:

- Target poor, isolated communities to improve access to electricity through the use of renewable energy technologies.
- Improve access to reliable sources of energy in rural communities and under-resourced urban pockets through the use of renewable energy technologies—helping these communities gain access to potable water and adequate sanitation facilities.
- Improve education and health facilities through expanded and upgraded infrastructure energized by renewable energy technologies.
- Continue expansion of energy access programs.

2.3.3.2 Universal Access to Electricity

Belize's National Energy Policy framework highlights the importance of access to modern forms of energy; however, it provides no clear guidelines regarding "universal energy access." Belize's INDC, in contrast, includes some actions aimed at tackling that challenge.[29] Noting that expanding the national grid is not the only option, the INDC describes how deploying off-grid renewable energy technologies can help to satisfy most of the energy needs in isolated regions in the country. The main actions included in the INDC are:

- Promoting and supporting universal access to affordable modern energy services, including energy infrastructure.
- Expanding access to electricity, clean fuels, water, and sanitation for under-served communities and households.
- Upgrading the electric grid and supply infrastructure to make it a smarter, more unified, and integrated energy system for all.

2.3.3.3 Reducing Electricity Costs and Ensuring Energy Security

Energy security is a principle issue highlighted in Belize's National Energy Policy and is considered a priority for the country's overall development. Reduced dependence on imported fossil fuels and electricity signifies a reduction in national spending on energy needs for society at large, including for productive economic activities to improve the country's competitiveness in the global market.

Improved conditions in energy supply, management, and use would enable Belize to respond to unpredictable shocks and hazardous events during the transition to a solid renewable energy system.[30] For electricity needs, a policy priority therefore is to increase the country's autonomy in electricity production, given that nearly half of Belize's electricity is presently imported from Mexico.[31]

Worldwide, renewable energy and energy efficiency technologies are improving constantly, providing higher performance and efficiencies. When talking about a 2030 target, it is important to acknowledge that although some technologies might not be viable now, they may be feasible in 10 years due to technological breakthroughs.

Some technologies, such as solar PV, biomass, small-scale hydropower, and wind, are advanced from a technological standpoint and are competitive from a cost perspective. Other technologies, such as concentrated solar power (CSP) and wave and tidal power systems, are not yet technologically mature enough to be cost-competitive. Further investigation and investments in advancing these technologies should be made to facilitate their deployment in the medium to long term.

The most basic indicator of power technology competitiveness is the levelized cost of energy (LCOE), which measures the average cost of electricity over the life of the asset, including the initial capital cost, operation and maintenance costs, fuel cost, and financing. In the past five years, the LCOEs for utility-scale solar and wind power have declined by 78% and 58%, respectively; for CSP by 59%; for geothermal power by 11%; and for biomass by 5%.[32]

Long-term renewable energy contracts in Belize can provide a barrier against fuel price volatility, which is essential for utilities and private investors. Grid-connected renewable energy also can provide system-wide benefits in the form of wholesale price suppression. Since most renewable energy technologies have no fuel requirements, the marginal cost is zero, lowering the wholesale market clearing prices and benefiting all consumers.[33]

Although newer technologies, such as CSP and wave energy, are still at early phases of cost discovery, they warrant systematic attention and consideration, as the pathway to a sustainable energy reality in Belize will be long and needs to remain flexible for the incorporation of new technologies and ideas.[34]

2.3.3.4 Climate Change

In recent years, there has been increased awareness of the interdependence of energy and climate change in Belize. Hydropower dams are underperforming due to extended periods of drought; in the agricultural sector, reduced crop yields are leading to less bagasse for power production; and with hotter days on average, more cooling is demanded in buildings across the country. The variability in weather patterns is affecting patterns of energy supply and use in Belize.

It is recommended to include climate change as an additional pillar of Belize's *2030 Sustainable Energy Roadmap* Strategy. This includes placing attention on both climate change mitigation and adaption.

Within the context of promoting sustainable energy development, low-carbon technologies and solutions are categorized as climate change mitigation efforts. The focus in the *2030 Sustainable Energy Roadmap* may be on promoting and deploying such technologies and solutions to help reduce greenhouse gas emissions and mitigate climate change impacts.

Belize's CO_2 emissions from energy consumption totaled 675,200 metric tons in 2012.[35] Rising demand for electricity, alongside continued dependence on conventional power sources, will lead to a significant increase in the country's greenhouse gas emissions. The impacts of these emissions and associated environmental changes on resource competition and in other areas will affect the citizens of Belize. These impacts include, among others:

- Climate change,
- Eutrophication of water bodies (over-fertilization caused by phosphorus and nitrogen excess), and
- Urban and regional air pollution.

If coherent measures are implemented in a timely manner, renewable energy could potentially provide 89% of the electricity supply, electricity consumption could decrease by 24%, and stationary fuel consumption could decrease by 19%, lowering greenhouse gas emissions by approximately 2.4 million tons by 2033.[36] This estimate compares the net cost of electricity and stationary fuels in a BAU scenario with the net cost of electricity and stationary fuels in a national sustainable energy strategy (NSES), resulting in cumulative emissions for 2014–2033 of 6.9 $MtCO_2e$ for NCES and 9.3 $MtCO_2e$ for BAU. The NSES scenario indicates that Belize can reduce its expenses on energy while at the same time decreasing its emissions, using commercially available technologies.

Sustainable energy can benefit Belize by reducing greenhouse gas emissions by approximately 2.4 $MtCO_2e$ during 2016–2033.[37] The country's emissions can be reduced through:

- Energy efficiency measures to reduce demand in electricity and stationary fuel end-uses, and
- Switching from fossil fuel-based energy to renewable energy sources.

These objectives go hand in hand with the objective of increasing energy security by using domestic renewable energy resources.

Environmental health risk factors should be considered as a significant contribution to disease. Indoor use of solid fuels such as wood and coal in open fires or inadequately designed cook stoves lead to air pollution in households and cause respiratory infections. Other environmental impacts that cause pressure on the environment in Belize as well as worldwide are:

- Overexploitation and depletion of forests

- Pollution with nitrogen and phosphorus
- Habitat, land-use change, and natural resource impacts (competition for water, ecosystem services, minerals).

2.3.4 Strategic Focus Areas

The Strategic Focus Areas presented in this section are extracted from the *Sustainable Energy Programme – Strategy and Work Plan 2015–2020*. Based on interactions with MPSEPU, it is understood that this is how the Ministry has decided to organize the current and future set of programs and the project portfolio and related activities and measures, including those recommended in the draft work plan contained in this report (Chapter 8).

Belize's sustainable energy strategy has the following five Strategic Focus Areas:

1. *Energy Efficiency* to dramatically lower energy intensities across the key economic sectors of Transport, Agriculture & Industry, Buildings (Commercial & Residential), and Public Lighting.

2. *Renewable Energy* to shift the energy matrix away from fossil fuels (especially oil) and toward alternative renewable energy technologies.

3. *Clean Production* to upgrade production systems in the processing of agriculture and forestry outputs to co-produce biofuels and/or electricity.

4. *Enhancing National Capacity* in clean energy and clean production by developing human, technological, and institutional and governance resources.

5. *Striving to Achieve Universal Access* to affordable, modern energy services, including resilient energy infrastructure.

The presently used rationale is that Belize's focus is set on investing in the development of indigenous capacity to utilize domestic energy resources and to convert these into modern, world-class energy services that are reliable, affordable, and sustainable for all.

The order of priority set forth by MPSEPU is, first, to establish the proper energy sector governance framework and structure (Strategic Focus Area 4; see also the Task 1 report of this EUEI PDF project), of which the present report focusing on the establishment of a *2030 Sustainable Energy Roadmap* is a part. The focus then is placed on lowering energy intensity across sectors, particularly in the power sector (Strategic Focus Area 1), while shifting the energy supply from fossil fuel-based sources to renewable energy sources (Strategic Focus Area 2).

Since the largest growth in energy demand is expected in the power sector, there is a considerable need to invest in upgrading the power grid and related infrastructure (Strategic Focus Area 5; see also the Task 4 report of this EUEI PDF project) and to implement low-hanging fruit energy efficiency opportunities (Strategic Focus Area 2) to facilitate the integration of renewable energy supply technologies and to increase renewables installed capacity in Belize. This approach will enable the country to increase its economic and energy security while gradually transitioning from being a net energy importer to being a net energy exporter.

The clean production goal (Strategic Focus Area 3) relates mainly to the need to transition away from using fossil fuels for heat generation to process agricultural and forestry products. This includes shifting to alternative fuels sourced from renewable energy sources for heat purposes and exploring mutually beneficial solutions to optimize energy use in production processes and create value-added byproducts. Table 2 summarizes the strategic focus areas that MPSEPU presently uses to guide its efforts to make the Belizean energy sector more sustainable by 2030.

Table 2. Five Strategic Focus Areas, as Presented in the Sustainable Energy Programme – Strategy and Work Plan 2015–2020

1. Energy Efficiency	2. Renewable Energy	3. Clean Production	4. Governance	5. Infrastructure
Dramatically lower energy intensities compared to business-as-usual (BAU) in Transport, Industry, Residential & Commercial Buildings, and Public Buildings & Lighting	Shift the energy matrix for Electricity, Heat, and Mechanical power away from fossil fuels	Upgrade production systems using the output from Agriculture and Forestry for the co-production of Food, Feed, Fiber, Chemicals and Fuel (including electricity & heat)	Enhance national capacity in Clean Energy and Clean Production	Provide universal access to affordable, modern energy services, including having a resilient power grid

From a technical perspective, Belize's current strategic focus is essentially set on end-use efficiency improvements in select sectors, and on ensuring increased renewable energy supply to address projected energy demand and beyond by 2030.

The Five Strategic Focus Areas will help implement Belize's Renewable Energy Strategy, with its focus on clean production, energy-efficient homes and buildings, sustainable transport, renewable energy, and building capacity in the country to achieve sustainable development.

2.4 Recommended Targets for Inclusion in the 2030 Sustainable Energy Roadmap

2.4.1 Targets Currently Used by MPSEPU

Table 3 through Table 5 include a set of targets that were assessed by different authors at a different moment in time compared to the Strategic Focus Areas presented above. The targets currently used by MPSEPU seem to have some minor discrepancies with the Strategic Focus Areas. For this reason, this report examines the gaps or compatibilities between the presently used targets and the Strategic Focus Areas. Moving forward, it recommends new or adapted targets from a scenario based on the published pre-selected and recommended energy projects to be developed in the time frame of 2016–2019 (March 2015) resulting from Belize's Request for Proposals for Energy Generation launched in 2013, and values covered and explained further in this chapter.

Table 3 provides a summary of key renewable energy and clean production targets, indicators, and timelines established by MPSEPU and presented in the *Sustainable Energy Programme – Strategy and Work Plan 2015–2020.*

Table 3. Belize Renewable Energy and Clean Production Targets for 2020 and 2030 (to be included in the Draft 2030 Sustainable Energy Roadmap)

Energy Carrier	Baseline Year	Unit	Target Year	Targets	Target Year	Targets
Electricity	**2010**	Domestic production from renewables = 77.54%	**2020**	Domestic production: > 80% RE	**2030**	Domestic production: > 97% RE
		Domestic production from renewables = 2,403 TJ		Domestic production from renewables: >2,470 TJ		Domestic production from renewables: > 2,540 TJ

		Net importer of electricity		Electricity trade in balance		Net exporter of electricity
				Electrification: > 95% of households		Electrification: > 98% of housholds
Fuels	**2010**	Domestic production of bioethanol = **0 gals**	**2020**	Domestic production of bioethanol: **> 15 million gals**	**2030**	Domestic production of bioethanol: **> 30 million gals**
		Domestic production of biofuels = **0 gals**		Domestic production of liquid biofuels (other than ethanol): **> 150,000 barrels**		Domestic production of liquid biofuels (other than ethanol): **> 750,000 barrels**
		Domestic production of gaseous bio fuels = **0 m^3**		Domestic production of gaseous biofuels: **> 50 million m^3**		Domestic production of gaseous biofuels: **> 150 million m^3**
		Domestic production of commercially tradable solid biofuels = **No baseline available**		Domestic production of commercially tradable solid biofuels: **> 15,000 tons**		Domestic production of solid biofuels: **> 50,000 tons**
Heat	**2014**	No baseline available	**2016**	Establish industry reporting mechanism to collect baseline data	**2018**	Set targets for the remaining time frame till 2030

Based on Table 3, the information for the 2030 targets to consider for the *2030 Sustainable Energy Roadmap* can be translated as follows:

When specifically looking into the set Electricity Targets, domestic generation of electricity from renewables in Belize in **2010 was 2,403 terajoules (TJ)**, representing **77.54%** of the domestically generated power. By **2030**, the target is to generate at least **2,540 TJ** from renewables domestically and to achieve a renewable penetration level of **97%** of domestic electricity generation. This would require generating **12,513 TJ** with renewable sources to satisfy **97%** of domestically generated electricity.[38] Next, Fuel Supply Targets are expressed in quantitative values expressed in standard volume metrics to be achieved by set years.

A challenge in assessing and verifying these set targets is that, during the drafting of this report, it was not deemed possible to verify how these targets were determined or what method was used to put forward the quantitative values as presented in Table 3.

Table 4 summarizes the key Energy Efficiency Targets, indicators, and timelines established by MPSEPU in the *Sustainable Energy Programme – Strategy and Work Plan 2015–2020* to guide Belize's transition toward sustainable energy development over the next 15 years. (Note that this information is gathered from an unofficial draft document prepared as an internal operational guide for the Ministry, which is used as the starting point for the further elaboration and preparation of the first formal edition of the *2030 Sustainable Energy Roadmap* for Belize.)

Table 4. Belize Energy Efficiency Targets for 2020 and 2030 (to be included in the Draft 2030 Sustainable Energy Roadmap)*

Sector	Baseline Year	Baseline (GJ/capita/yr.)	Target Year	Targets	Target Year	Targets
Transport	**2014**	16.42		-5.0%		-15.0%
Industry	**2011**	6.77	**2020**	-10.0%	**2030**	-30.0%
Residential & Commercial	**2011**	2.27		-10.0%		-30.0%

* During the drafting of this report it was not possible to verify the applied method to quantify the presented targets

Buildings						
Public Buildings & Lighting	**2011**	9.62		-20.0%		-50.0%

Table 5 provides a complete summary of presently used targets in order to structure and facilitate the process of proposing modifications or completely new set of targets. The table also clearly groups the targets in three main energy carrier categories, namely electricity, fuels, and heat, and proposes targets for the rational and efficient use or consumption of these same energy carriers.

Table 5. Summary of 2030 Targets to Consider for Inclusion in the 2030 Sustainable Energy Roadmap

Category	Target	Description
Energy Efficiency	1	Increase energy efficiency by 15% in the transport sector (compared to 2014 baseline) by 2030
	2	Increase energy efficiency by 30% in the industrial sector (compared to 2011 baseline) by 2030
	3	Increase energy efficiency by 30% in residential and commercial buildings (compared to 2011 baseline) by 2030
	4	Increase energy efficiency by 50% in public buildings and lighting (compared to 2011 baseline) by 2030
Electricity	5	Generate a minimum of 97% of domestically generated electricity from renewable sources in 2030
	6	Generate a minimum of 2,540 TJ of domestically generated electricity from renewable sources in 2030
	7	Become a net exporter of electricity by 2030
	8	Electrify at least 98% of households by 2030
Fuels	9	Produce a minimum of 30 million gallons of bioethanol from domestic renewable energy sources by 2030
	10	Produce a minimum of 750,000 barrels of biofuels (other than ethanol) from domestic renewable energy sources by 2030
	11	Produce a minimum of 150 million m^3 of gaseous biofuels from domestic renewable energy sources by 2030
	12	Produce a minimum of 50,000 tons of solid biofuels from domestic renewable energy sources by 2030
Heat	13	Set targets for the remaining time frame till 2030 by 2018

2.4.1.1 Energy Efficiency Targets (1–4)

To be able to measure the increase in energy efficiency compared to the energy use and consumption conditions in the baseline year, it must be recognized that energy efficiency covers all types of energy carriers used or consumed in all sectors of the economy. This requires sub-dividing the energy efficiency targets by energy carrier and sector to enable the practical collection and organization of data necessary to measure performance over time.

As an example, for setting energy efficiency targets related to power, the following types of efficiency sampling or assessment areas need to be taken into account:

1) Energy conversion efficiency of the electricity generating system;
2) Efficiency in the transmission, distribution, and final delivery of electricity to users; and
3) End-use electricity efficiency based on the portfolio of end-use technologies in Belize.

Addressing energy efficiency relevant to electricity requires a holistic approach, starting from the macro-level and narrowing down to identify and target more-specific issues. In other words, the increase in renewable electricity generation must occur in parallel with the increased rational and efficient use of that same electricity.

During the pathway from efficient power generation to efficient transmission, distribution, or delivery of the electricity to the final user, limiting losses is critical to guaranteeing cost-effectiveness and sustainability of these systems. Furthermore, the portfolio of energy end-use appliances used in respective sectors in society (e.g., commercial, industrial, residential), up to the national level, must increasingly comprise more highly energy-efficient appliances, machinery, and technologies. Beyond energy efficiency, behavioral changes are additional strategies that contribute to energy conservation and that can contribute greatly to achieving the set energy efficiency targets relevant to electricity. This same approach needs to be applied when setting energy efficiency targets for the increased rational use of generated fuel and heat in Belize.

2.4.1.2 Electricity Targets (5–8)

To be able to measure the increased contribution of renewable energy to overall electricity generation in Belize, the following factors need to be taken into account:

1) The installed capacity of each power generating system in MW; and
2) The energy conversion efficiency and load factor of the electricity generating systems.

2.4.1.3 Fuel Supply Targets (9–12)

To be able to measure the supply of fuels derived from domestic renewable energy sources and thereby also the decrease in the use of fossil fuels for transportation in Belize, the following factors need to be taken into account:

Land-based:
1) The number of registered vehicles in Belize (vehicle fleet, including private, commercial, and public);
2) The fuel efficiency (miles per gallon) of vehicles as part or fraction of the vehicle fleet in Belize;
3) The frequency of use or average distance achieved annually by vehicles in the transport sector.

Maritime:
1) The number of registered maritime vehicles (boats, ferries, etc.) in Belize;
2) The fuel efficiency (miles per gallon) of vehicles as part or fraction of the vehicle fleet in Belize;
3) The frequency of use or average distance achieved annually by vehicles in the transport sector.

Sustainable transportation is a broad term for the use of multiple types of technologies, products, or services and includes also behavioral changes that contribute to reducing the consumption of conventional fuel for transportation.

2.4.2 Need for Modification or Optimization of Targets

Although the presently used targets for 2030 are useful, several gaps and discrepancies exist between the presently set targets and the five Strategic Focus Areas. The following sections provide recommendations on how to match the currently used targets with the Strategic Focus Areas; how to perform monitoring and evaluation of these different Strategic Focus Areas; and how to improve the metrics to measure energy performance and overall progress to achieve the set targets.

2.4.2.1 Strategic Focus Area 1: Energy Efficiency

The main objective of Strategic Focus Area 1 (Energy Efficiency) is to dramatically lower energy intensities compared to BAU in transport, industry, residential and commercial buildings, and public buildings and lighting. Energy efficiency should be promoted in all existing and new buildings where it is practically and economically feasible.

To measure the increase in energy efficiency compared to the energy use and consumption conditions in the baseline year, the following factors must be taken into account, corresponding to three key stages in the life cycle of an electricity system (see Figure 4):

1) Energy conversion efficiency of the electricity generating system;
2) Efficiency in the transmission, distribution, and final delivery of electricity to users; and
3) End-use electricity efficiency based on the portfolio of end-use technologies in Belize.

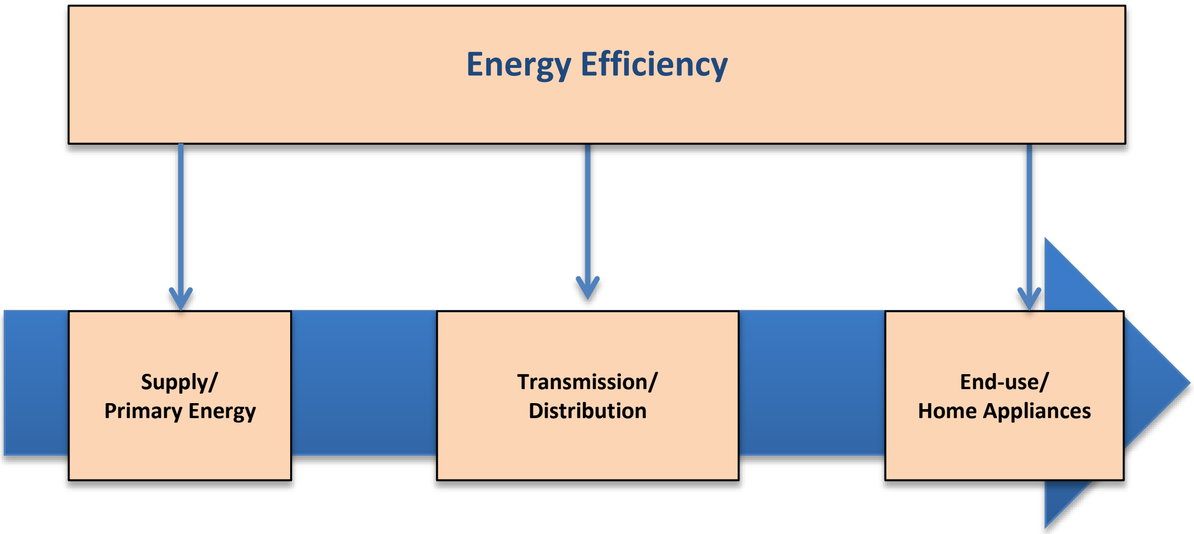

Figure 4. Areas of Energy Efficiency Improvement in the Energy System

For each of these three factors, efficiency is measured differently. In addition, distinct opportunities for energy efficiency Improvements can be found at these three stages.

The first area for intervention is at the moment of conversion of primary energy sources into electricity. Here, the type of renewable power generation technology and its conversion efficiency is a determining factor. Energy conversion efficiencies improve over time with increased investments in research and development (R&D) and with the introduction of new features or modifications to existing energy technologies.

The second opportunity for efficiency improvement is the proper selection of transmission and distribution technologies and the operation and maintenance of related infrastructure (in the case of grid-connected energy generating technologies, the aim is to reduce distribution losses to the extent possible). In recent years, increased investments have been made in developing and advancing energy storage technologies to improve the usability and efficiencies of generated power. An alternative strategy is to avoid the need for a grid system and related losses by deploying decentralized power systems at the point of consumption.

The third opportunity for efficiency improvements is intervening at the demand side, which is highly influenced by the portfolio of energy end-use technologies and appliances.

In summary, to achieve energy efficiency improvements in a power system, technology choices can be made in: 1) Energy Conversion and Supply Technologies, 2) Electricity Transmission, Distribution, or Storage Technologies, and 3) End-use Technologies and Appliances.

Table 5 illustrates indicative technologies, providing conversion efficiencies and capacity factors for several technologies. This arbitrary sampling of renewable energy technologies serves as a means to demonstrate all the factors that have to be taken into account for efficiency in the supply side of an energy system.

Table 6. Efficiencies and Capacity Factors of Energy Technologies

Energy Source	Conversion Technique	Typical Efficiency	Capacity Factor	Comments
Gas	Steam Turbine	80–95%	60%	
Sun	PV	20%	10–15%	Depends on irradiation level
Sun	CSP	15%	25%	Use of storage increases capacity factor
Wind	Wind	50%	15–25%	On-/offshore difference
Hydro	Hydroturbine	90%	20–80%	Run-of-river vs. dam

Energy efficiency in the transmission and distribution sector will depend on how reliable the system is. During the course of transmission and distribution, a system will have energy losses, which in turn decrease the efficiency of the delivered energy. To improve this area, optimizations and other improvements in the system can be made. Also, options can be considered if the energy can be produced at the source where it is consumed, increasing efficiency in the system.

Energy efficiency as the end-use represents the efficiency provided by the appliances purchased and used by consumers. This is the only factor for which the consumer has absolute control over purchasing, from efficient air conditioning systems to microwaves and washing machines. This factor serves the demand side of energy management.

When focusing on performance and efficiency in the industrial sector for process heating systems, the main goals are reduction of energy losses and increase of energy transferred to the load. In Belize, locally extracted crude is burned to generate process heat for food processing and other applications.[39] The residential sector uses liquefied petroleum gas (LPG) for cooking and, in some cases, for hot water heating.[40] Restaurants and hotels also use LPG for cooking and water heating.[41] It is therefore important to know which aspects of a heating process have the highest impact. Energy efficiency improvement opportunities regarding heat can be grouped into five categories:[42]

- Heat generation: includes the equipment and the fuels used to heat a product;
- Heat containment: methods and materials used that can reduce energy losses;
- Heat transfer: methods for improving how heat is transferred to the load or charge to reduce energy consumption, increase productivity, and improve quality;
- Waste heat recovery: the exercise of identifying sources of energy loss that can be recovered for more useful purposes, and address ways to capture this additional energy use potential; and
- Enabling technologies: addresses common opportunities to reduce energy losses by improving material handling practices, effective sequencing and scheduling heating tasks, seeking more efficient process control, and improving the performance of auxiliary systems.

Despite overlaps among the five categories presented above, these groupings provide a basis for discussing how industrial heating systems can be improved and where stakeholders can seek further information for opportunities that apply to their system. Section 2.7.1.3 provides suggestions on how to monitor and evaluate heat production and consumption in the industrial sector in Belize.

Within the fuel sector, energy efficiency measures applied to improve fuel consumption rates can provide multiple benefits including energy security, environmental protection, and economic development in Belize. Future targets in the fuel sector can deliver savings in greenhouse gas emission, and improve energy efficiency in the sector when switching to low-carbon energy sources such as biofuels or biofuel blends, for example with ethanol. Section 2.7.2.3 discusses how to monitor and evaluate fuel consumption rates in the transport sector in Belize.

2.4.2.1.1 Energy Efficiency in the Residential Sector

In the residential sector, a distinction should be made between energy consumption in urban versus rural areas, as access to modern energy sources and quality of service varies greatly between these areas. It is recommended that Belize be divided by region according to its geographic characteristics, using the following division and evaluation:[43]

- Residential
    - Urban
    - Rural
        - High Income
        - Medium Income
        - Low Income.

Energy use in the residential sector also must be divided (at a minimum) into the following categories:[44]

- Lighting
- Cooking
- Water Heating
- Heating
- Food Conservation
- Ventilation and Refrigeration
- Water Pumping
- Other Uses.

Energy efficiency improvement can be measured by assessing the composition of energy end-use appliances in typical or representative households across Belize. A reference year or base year is critical for future energy analyses. The data composition for the base year can be obtained and assessed through dedicated surveys and helps to identify and quantify the energy consumption by year per home. Furthermore, compounded indicators such as energy intensity indicators can be used to measure efficiency improvements in a manner that is more attainable.

2.4.2.1.2 Energy Efficiency in the Commercial, Services, and Public Sector

This sector is similar to the residential sector, with energy consumption used mainly for air conditioning (heating and refrigeration) and for water heating. The first disaggregation should be that of consumers by subsector, according to the type of activity. The following schematizes how each sector should be divided and evaluated:[45]

- Commercial, Services, and Public
    - Wholesale and Retail Commerce
    - Hotels and Restaurants
    - Schools
    - Health and Social Assistance
    - Public Administration and Defense
    - Water and Sanitation
    - Public Lighting

- Other Services.

The categories of uses or energy services in the commercial, services, and public sector are:[46]

- Illumination
- Cooking
- Water Heating
- Food Conservation
- Ventilation and Refrigeration
- Water Pumping
- Other Uses.

For the base year, it is necessary to calculate the specific consumption or energy intensities per use, e.g., consumption per unit of level of activity. To set future targets, the process of substitution or competition between sources and technologies for each use of energy must be considered. For this sector, the principal substitutions take place in water heating for sanitary uses, heating, and cooking. Renewable energy options include the use of solar energy in water heating and the use of heat pumps in heating and air conditioning systems; in cooking, one must consider the energy consumption in restaurants and hotels.[47]

2.4.2.1.3 Energy Efficiency in the Industrial Sector

Energy consumption in industry will depend on the type of product produced, the technology applied, and the configuration of different production plants. Depending on the industry, this sector can be grouped as follows:[48]

- Industry
  - Food
  - Beverages
  - Wood
  - Non-Metallic
  - Metals
  - Machinery and Equipment
  - Other Manufacturers.

The categories of use in the Industry sector are:[49]

- Illumination
- Steam
- Direct Heat
- Cold Process
- Electrochemical Processes
- Non-Productive Uses.

Substitution within this sector occurs in the use of stream and direct heat. It is necessary to consider in the analysis those industries that produce energy residues, such as bagasse, sawdust, shells, etc., which have low cost for the industry and are also renewable. The most common measures of efficiency in this sector are the use of efficient engines, variable speed drives, regulation of combustion, improvements in insulation, and the use of co-generation systems, among others.[50]

2.4.2.1.4 Energy Efficiency in the Transport Sector

This is a very complex sector to study in Belize. The statistics available in the country are incomplete, non-systematic and out-of-date. In the case of road transport, there are no unified data on vehicle fleet registries, detailing basic variables such as the active vehicle fleet by type, engine technology (e.g., Otto engines, diesel engines, LPG), vehicle age, engine capacity, etc. A good method for measuring energy demand can be determined by applying the Vehicle, Kilometers, and Rate of Consumption (VKR), where consumption by means of mobility can be obtained by multiplying the following parameters:[51]

- V = number of vehicles (active fleet), by
- K = average number of kilometers traveled per year per vehicle, by
- R = specific consumption in liters/100 km.

Consumption of Net Energy (C,m,M) can be estimated by multiplying the number or fleet of vehicles with an engine M, times the kilometers traveled per year, times the specific consumption of the vehicle:[52]

Consumption of Net Energy C,m,M = (V x K x R) m,M

- C = Category: passengers or cargo
- m = Means: automobiles, buses, motorcycles, trucks, etc.
- M = Type of engine: Otto, diesel, and LPG
- V = Fleet or number of vehicle with an engine M, expressed in units
- K = Kilometers traveled by year
- R = Specific consumption, expressed in liters/100 kilometers.

To be able to carry out this task, a database is required of information relating to vehicle fleet, engine type, kilometers traveled per year, and specific consumption. Once this task is completed, it will be possible to know the nature of the fleet in circulation for a specific year, which can be classified as follows:[53]

- Transport
  - Road
    - Passengers
      - Automobile
      - Pick-up Truck 4x4
      - Taxi
      - Motorcycle
      - Bus
    - Cargo
      - Pick-up Truck
      - Small Truck
      - Large Truck
      - Tractor-trailer Truck.

Once the fleet has been determined, there are two alternatives to gain access to the information that refers to specific consumption and the average distances traveled per year. The first is to search for this information, mainly specific consumption. Sectoral experts can provide this information, making it possible to determine the consumption and characteristics of the fleet, including the average age, brand, and model of the vehicle, and the quality of fuels. In this approach, the last variable to be determined is the average distance traveled by vehicle year. It is necessary to adjust the consumption for each category of means of transport, in order to obtain the total consumption of the transport sector, which is calibrated with respect to fuel sales that are contained in the national energy balance.[54]

The other alternative is to prepare surveys that can be carried out at fueling stations. To determine the average distances traveled per year, questions can be asked regarding, for example, the time in months or kilometers that a driver makes oil changes to the engine of the vehicle, or the specific consumption (kilometers traveled per liter of fuel). As in the first approach, estimates of consumption by means of travel, once these have been aggregated, must coincide with the sale of fuel from the energy balance.[55]

For private forms of transport such as buses or truck fleets, it may be possible to access the principal companies and request data regarding the fleet, annual distance traveled, and/or specific country statistics that are registered in company annual reports. To carry out the prospective of energy in the transport sector, it is recommended to have the evolution of the vehicle fleet (usually estimated on the basis of economic models, which link the evolution of GDP/inhabitant and the inhabitants per vehicle with the fleet).[56]

After the evolution of the fleet is considered, it is possible to analyze the penetration of the different types of engines that compete with each means of transport. For this, it is necessary to analyze the possibility of alternate vehicle engines such as LPG, natural gas, flex-fuel, and electric cars, with specific percentages of policy objectives or with substitution models.[57]

Finally, a hypothesis relative to the evolution of the kilometers traveled by type of vehicle must be established. The modernization of the vehicle fleet and the increase in distances traveled, or the expansion of other means of transportation, must be taken into account in yearly distances traveled and/or tons of cargo among means of mobility.[58]

With all these variables and their changes, one can apply analytical methods that will allow to calculate the energy demand of the transport sector. To measure energy efficiency in the transport sector, the following suggestions are proposed:

- **Measure energy demand applying the Vehicle, Kilometers, Rate of Consumption (VKR) method by 2020**

- **Measure the Consumption of Net Energy (C,m,M) for the transport sector by 2020**

2.4.2.1.5 Energy Efficiency in the Agricultural Sector

Energy consumption in the agriculture sector must be measured by taking into account specific geographical characteristics to determine the types of crops, the productivity of soils, and applicable technologies, which would have different energy requirements. The type of crop or agriculture can be categorized as follows:[59]

- Agriculture
    - Temporary Crops
    - Permanent Crops
    - Forest
    - Other Agricultural Activities

According to the production levels of each type of product, one can categorize these in subsectors for specific crops: sugar cane, bananas, citrus, cocoa, etc. Alternatively, this can be categorized based on the production technology (conventional planting and direct planting) or by size of exploitation (in the case that commercial producers are the stakeholders in charge of energy requirements). Different energy uses in this sector can be categorized as follows:[60]

- Agricultural Stakeholder and Machinery
- Fixed Machinery
- Water Irrigation and Pumping
- Heat (Drying or Process Heat)
- Cold Process.

The main variable of energy consumption in this sector is the surface under cultivation. The most common source of energy in this sector is diesel, used in different agricultural equipment. This is a limitation on the scope of application of energy efficiency and substitution measures between energy sources. A good area to focus in the agriculture sector is Strategic Focus 3 (Clean Energy Production) using biodiesel blends, increasing the added value and creating a market for domestic production. The production of biodiesel in Belize could serve as a closed-loop production, since a fraction of the biomass produced can be used for blending, another fraction would serve other purposes, and a final fraction would be used to power agricultural equipment, which requires diesel as fuel.[61]

2.4.2.1.6 Energy Efficiency Metrics and Improvements

The objective of this section is to improve and recommend the metrics for measuring energy efficiency as Strategic Focus Area 1. From Table 4 above (Belize Energy Efficiency Targets for 2020 and 2030), the baseline used is measured as a compounded metric in GJ/capita/yr. There is a challenge in the metrics to be used since the end-use services are all different. Using the unit GJ/capita/year makes it possible to measure total energy consumption in a given sector divided by the total population of Belize in a given year. This enables the comparison among different types of energy carriers (electricity, heat, or fuels) and allows for the set-up of a national energy balance, once more detailed data and statistics become available. However, this unit does not allow for the clear distinction and assessment of progress between electricity versus heat or fuel consumption in each respective sector.

To improve the metric and measure the efficient use of energy in the end-use sectors, the particular targets set per sector can be summarized as follows:

- In the **transport sector**, energy consumption (GJ/capita/year) must be **15%** more efficient by 2030 compared to 2014 (based on a population of 358,889 in 2014).[62] This translates into a reduction in the sector's energy consumption of **1,232 terajoules per year (TJ/year)** (assuming a population of 500,000 in 2030), down from a total of **5,893 TJ per year** in 2014.

- In the **industrial sector**, energy consumption (GJ/capita/year) should be **30%** more efficient by 2030 compared to 2011 (based on a population of 332,084 in 2011).[63] This translates into a reduction in the sector's energy consumption of **1,016 TJ per year** (assuming a population of 500,000 by 2030), down from a total of **2,248 TJ/yr** in 2011.

- In the **residential and commercial buildings sector**, energy consumption (GJ/capita/year) should be **30%** more efficient by 2030 compared to 2011 (based on a population of 332,084 in 2011).[64] This translates into a reduction in the sector's energy consumption of **341 TJ** (assuming a population of 500,000 by 2030), down from a total of **754 TJ** in 2011.

- In the **public lighting and buildings sector**, energy consumption (GJ/capita/year**)** should be **50%** more efficient by 2030 compared to 2011 (based on a population of 332,084 in 2011).[65] This translates into a reduction in energy consumption of **2,405 TJ per year** (assuming a population of 500,000 by 2030), down from **3,195 TJ per year** in 2011.

Assuming the same rate of energy consumption in 2015 as in the reference years of 2011 and 2014, total energy consumption in 2015 would equate to **35.08 GJ/capita/year** across all end-use sectors. This translates to **12,920 TJ per year** of energy demand in 2015 (based on a population of 368,310).[66]

A measurement per capita can express the productivity of individuals in Belize, and it is a useful tool as a first starting point for an analysis since it is information that is available. In order to measure national targets for energy efficiency, it is advised that MPSEPU use TJ per year as the metric.

This would be an easier approach and a more effective metric to measure and compare energy efficiency year to year in all sectors. As more information becomes available, it is recommended to use a more accurate metric to measure energy efficiency. Nevertheless, all this requires surveys and audits in order to gather energy input data to gather the amount of TJ per year of energy consumed.

2.4.2.2 Strategic Focus Area 2: Renewable Energy

The main objective of Strategic Focus Area 2 (Renewable Energy) is to shift the energy matrix for electricity, heat, and mechanical power away from fossil fuels. To propose renewable energy targets, we consider using the scenario presented in Section 5.2.3 (Scenario 3: RPEG Scenario). This scenario is based on the result of a competitive selection process for the least-cost generation capacity to address projected electricity demands in the short to medium term.

2.4.2.2.1 Electricity Sector: Monitoring and Evaluation

As indicated in Table 3 above, Belize's electricity target for 2030 is currently 97%. As a result of a *Request for Proposals for Electricity Generation (RPEG)* issued in October 2013, the Public Utilities Commission (PUC) released in March 2015 the results of a competitive selection process for least-cost generation capacity to address projected electricity demands in the short to medium term. All proposals were subjected to a comparative evaluation process (taking into account costs, LCOE, and dispatch capacity) over the review period 2016–2030.[67] We chose this scenario because it is the best and most realistic scenario listing the anticipated renewable energy projects.

The amount of renewable energy from this scenario illustrates a more macro view. Based on Figure 38 (Penetration Scenario for Renewable Energy, 2000–2030), we can observe that the total electricity demand for 2030 is approximately 2,300 GWh, and the fraction of renewable energy for 2030 is approximately 2,000 GWh out of 2,300 GWh of total electricity demand. Therefore, based on Scenario 3:

- **87% of the total electricity demand in Belize should originate from domestic renewable energy resources by 2030.**

This new target offsets the imports from Mexico, putting Belize at a better advantage by having 97% renewable energy production capacity originating from domestic sources and not closing the electricity gap between supply and demand.

2.4.2.2.2 Renewable Energy Metrics and Improvements

To improve the metrics for measuring net energy improvements for renewable energy and clean energy production, we can observe Table 3 above. The total national energy can be converted into a macro-level number. To obtain data at the macro level, the total baseline energy consumption can be calculated with the available data. The total **X amount of power produced (GJ/yr)** can be extracted from available sources as well as the **X amount of fuel fraction consumed (TJ/yr)**. Therefore, one can obtain the **heat requirement (TJ/yr),** which would be the remaining part minus the losses. This form of metric can be useful in analyzing energy improvements, since it is straightforward, making sure the total energy sector is covered.

2.4.2.2.3 Fuels: Monitoring and Evaluation

As can be observed from Table 3, by 2030, Belize's current fuel targets include producing at least **30 million gallons of ethanol** from biomass resources and producing at least **750,000 barrels of biofuels** other than ethanol. This latter target potentially includes diesel, jet fuel, or other liquid fuels derived from sustainably obtained biomass resources in Belize. An additional target is to generate at least **150 million cubic meters (m^3) of biogas** and at least **50,000 tons of solid biomass fuels** in the form of pellets, mill or sawdust, or other formats from forestry, municipal solid waste, and agricultural residues.

Although heat consumption in Belize is not mapped out, it is of interest to the Ministry because it can represent a significant source of energy demand in the industrial sector, among others. Heat also can be produced through other technologies and means as a way to reduce industries' dependence on fossil fuels, making production activities cleaner.

An interesting aspect here is the focus on biofuel supply instead of focusing specifically on reducing dependence on imported fossil fuels. When reviewing the targets set for fuels production and supply in Belize by 2030, however, it is not possible to verify or confirm whether these targets are attainable with current commercially available technologies and conversion processes, given the absence of a proper nationwide assessment of the country's sustainably harvestable or collectable biomass resources for conversion into energy carriers.

2.4.2.2.4 Fuel Metrics and Improvements

When considering power generation projects for biomass co-generation (sugar and electricity) and biofuel co-generation (ethanol and electricity), gaps in the biomass sector should be taken into account, as well as the need for interventions such as:

- What is the available fraction of biomass in Belize?
- Is there a continuous supply of sugar cane?
- Is there a power purchase agreement (PPA) in place?
- It there a market for ethanol production with X amount/gallons of ethanol/year?
- Is there a mandate for mixing ethanol?

For the transport sector, Figure 16 (Forecast for 2012–2030 and Ethanol Supply Scenarios) was considered in order to forecast and project gasoline demand. From the figure, 10% ethanol blending (E10) by 2030 and motor gasoline were considered as the most realistic scenario. For 2020, gasoline demand is projected at 0.6 million gallons, and E10 at 0.25 million gallons. For 2030, gasoline demand is projected at 0.9 million gallons and E10 at 0.48 million gallons. Therefore, Belize can set the following target:

- **50% ethanol production to cover 52% of gasoline demand by 2030.**

Projects with E10 already have been implemented with large biomass resources. The technology is viable given the right technology and projects. Ethanol blends can increase the added value, as well as contribute to clean production and create a market for domestic production, which would fall under Strategic Focus Area 3. Mandates for diesel blends also can increase the interest in investments. Possible regulation targets can be:

- E10 blending mandate by 2020
- E20 blending mandate by 2030.

As mentioned previously, the most common source of energy in the agriculture sector is diesel fuel, used to power various agricultural equipment. A good area to focus in the agriculture sector is Strategic Focus Area 3 (Clean Energy Production) using biodiesel blends, to increase the added value and create a market for domestic production. The production of biodiesel in Belize could serve as closed-loop production since a fraction of the biomass produced can be used for blending, another fraction would serve other purposes, and a final fraction would be used to power agricultural equipment, as an alternative to diesel fuel.

In the transport sector, there is a need to set up the policy infrastructure and to develop requirements for E10, E20, and E50 in order to establish and create a market for this type of fuel. Consideration for mixing ethanol before or at fuel stations must be taken into account, as well as the capacity of the current vehicles in Belize to transition to an ethanol-gasoline mix market.

A fraction of vehicles in Belize's transport sector run on diesel fuel. Blending diesel with clean energy requires the use of biodiesel, a technology that is relatively unknown in the country and requires further investigation. In the United States, the ASTM specification for Diesel Fuel Oils (D957-97) identifies five different grades of diesel, as described in Table 7. [68]

Table 7. Diesel Fuel Oils in the United States

Diesel type	Description
Grade No. 1-D and Low Sulfur 1-D	A light distillate fuel for applications requiring a higher-volatility fuel for rapidly fluctuating loads and speeds, as in light trucks and buses. The specification for this grade of diesel fuel overlaps with kerosene and jet fuel, and all three are commonly produced from the same base stock.
Grade No. 2-D and Low Sulfur 2-D	A middle distillate fuel for applications that do not require a high-volatility fuel. Typical applications are high-speed engines that operate for sustained periods at high load.
Grade No. 4D	A heavy distillate fuel that is viscous and may require fuel heating for proper atomization of the fuel. It is used primarily in low and medium engines.

Source: See Endnote 68.

To consider a future sustainable transport sector in Belize, there should be a transition in the fuel market; otherwise, the sector will remain dominated by internal combustion engine vehicles. Beyond the liquid fuel transition, the report recommends that the Government of Belize also look into shifting to electric vehicles, depending on the renewable energy capacity in the country. A short-term target for this area would be:

- Measure diesel demand
- Evaluate the biomass resource for biodiesel
- Consider applicable technologies for biodiesel in Belize (discussed later in this report).

2.4.2.2.5 Heat: Monitoring and Evaluation

Presently no heat reduction or improvement targets are established for 2030 in Belize. Because little to no data are available to determine current heat production, it is not possible at this time to draw a baseline for measuring progress over time. Significant research is warranted to start mapping out how heat is produced and consumed in the country prior to setting any targets that can be measured and monitored in a practical and cost-effective way.

The heat sector faces challenges in Belize due to the lack of information and data pertaining to this sector. Currently, the industrial sector uses 100% of its fuel for process heat. As mentioned in a report from Castalia and the Inter-American Development Bank, compared to a BAU scenario, under the National Sustainable Energy Scenario (NSES) Belize would reduce fuel consumption 19% by 2033. The following targets should be considered for the *2030 Sustainable Energy Roadmap*:

- **Set targets for the remaining time frame till 2030 by 2018**

Numerous available renewable energy technologies can produce heat, among them solar technologies with heat origin, geothermal heat pumps, and biomass using bagasse for process heat. The most suitable technology will be determined by the amount of demand for heat overall and by sector (TJ of heat needed/year) on a macro level. For Belize to improve energy use in the heat sector, the following actions are recommended:

- Auditing and surveying the amount of heat demand
- Replacing heat demand for each sector
- Evaluating the stationary fuel component to evaluate the conversion factor and to determine how much heat can be extrapolated.

2.4.2.3 Strategic Focus Area 3: Clean Production – Monitoring and Evaluation

Strategic Focus Area 3 (Clean Production) focuses on upgrading production systems using the output from agriculture and forestry for the production of food, feed, fiber, chemicals, and fuel, including heat and electricity. To achieve this focus area, the GoB should evaluate what should be measured: the amount of products per unit coming from biomass.

The strategy is to increase input while at the same time increasing output, as well as creating or enhancing industries to produce energy products other than food in the most efficient manner possible. Achieving this strategy requires:

- Proper assessment of the available biomass energy resource in Belize
- Quantity of biomass that can be produced in millions of gallons
- Continued sustainable availability and supply of the resource in the medium and long term
- Adequate planning of Belize's power generation capacity expansion
- Measuring the amount of primary available feedstock in place to be converted into energy products.

Completing these requirements will then allow the GoB to achieve realistic future sustainable energy targets. Additionally, the demand for gas (LPG and natural gas) has to be evaluated. A general target that can be set for this strategic area is:

- **Supplying 50% of the demand with domestic biomass production by 2030.**

It is important to note that this is an arbitrary target value. It is known that there exists a potential to expand Belize's biomass resource, so in time one can evaluate if the target is viable. The approach is more of a political or mission statement that is not based on real numbers. The target is considered with the view that investors might take action if such a target is in place.

Strategic targets can be set in order of priority as follows:

- Level 1 targets – strategic target of what is to be achieved by 2030 on the macro level (50% of demand and energy products to be supplied preferably with biomass resources)

- Level 2 targets – realistic targets that can be verified with recently collected data on biomass resource.

2.4.2.4 Strategic Focus Area 4: National Capacity

Strategic Focus Area 4 (National Capacity) focuses on enhancing the national capacity of skilled labor in the renewable energy, clean energy, and clean production activity. Task 2 of the EUEI PDF project "Capacity Building – Assessment of Renewable Energy Workforce Training Needs in Belize" covers the analysis and need for investments to provide a skilled technical and engineering workforce. As indicated in the Task 2 report, based on assessments of the workforce, industry needs, and the supply of education and training, the consultant team recommends the following strategic approach to capacity and skills development in the renewable energy sector in Belize:

- A stronger orientation to industry demand, including better assessments of workforce data, occupational needs, and skill demands, and improvements in industrial attachments.

- Prioritizing investments in engineering associate's degree programs and technical training at ITVETs (Institutes for Technical Vocational and Education Training), with the goals of:
  - Strengthening general knowledge and practical skills in engineering and technical vocations (for students and instructors alike)
  - Increasing the number and competence of skilled graduates 1) for the industrial sector as a whole and 2) in order to build a foundation for specialized training in renewable energy technologies
  - Ensuring linkages between renewable energy and climate change education.

  For the technical training:
  - Selecting three technical institutions in three regions by means of a public call for proposal to champion technical capacity building for renewable energy in Belize.

- Supporting more multi-company and public-private partnerships to co-finance or co-provide laboratories, equipment, and specialized renewable energy training courses, including mid-career and extension-school courses and train-the-trainers programs.

- Building partnerships with and making better use of regional and international training providers, stipends, and scholarships.

- Promoting certification programs for plant operators, electricians, and welders.

- Supporting the operation and use of off-grid, solar PV and mini-grids by investing in targeted training and capacity building in rural communities.

- Investing in a mobile laboratory and in multimedia tutorials (videos) to bring technologies and education closer to people and to avoid travel.

- Providing travel and living stipends for those seeking associate education in Belize City.

- Improving public information and matching platforms for vacancies, training, and scholarship opportunities, and supporting the exchange of technical knowledge and educational innovations.

- Promoting the image and attractiveness of careers and training in science, technology, engineering, and math — especially at ITVETs, and especially for girls and women.

- Providing targeted training on basic renewable energy technologies, their impact on climate mitigation and adaptation, and on capacity-building needs and opportunities, to private sector companies and to public officials (e.g., at the MPSEPU, MOEYSC, the Ministry of Economic Development, BELTRAIDE, the PUC, and BEL).

- Ensuring the quality and coordination of capacity-building initiatives by giving the mandate to an inter-ministerial steering committee (e.g., the Energy Council).

This approach aligns with the major national goals of Horizon 2020, the National Growth and Sustainable Development Strategy, and the Belize Education Strategy and will serve the occupational and skills needs of the implementation of the Belize *2030 Sustainable Energy Roadmap*.

As stated in the Task 2 report, under the most ambitious scenario, Belize needs to increase training of 1) technicians and operators, and 2) associate engineers; by 2030, more than 90 people will need to be trained each year in order to cover the National Capacity Targets. Based on Figure 6 from Task 2, "Capacity Building – Assessment of Renewable Energy Workforce Training Needs In Belize," and on the assumption of the consultants of different renewable energy projects coming online in the future, the following targets are recommended:

- Increase the number of trained engineers to 4 by 2020
- Increase the number of trained engineers to 8 by 2030
- Increase the number of trained associate engineers to 23 by 2020
- Increase the number of trained associate engineers to 39 by 2030
- Increase the number of technicians/operators to 60 by 2020
- Increase the number of technicians/operators to 85 by 2030.

2.4.2.5 Strategic Focus Area 5: Infrastructure

The goal of Strategic Focus Area 5 (Infrastructure) is to provide universal access to affordable, modern energy services, including having a resilient power grid. Both rural electrification and regional electricity interconnection fall under this area.

2.4.2.5.1 Rural Electrification

Rural electrification was addressed under Task 4, "Off-grid Rural Electrification Assessment and Strategy," of the EUEI PDF project, which focused on enhancing planning activities for providing energy carriers to rural communities in Belize. The Task 4 report suggests the following targets:

- Phase out kerosene and candle lighting by 18% in the residential sector by 2020
- Shift away from electricity to solar lighting by 40% in the residential sector by 2030
- Shift away from electricity to solar lighting by 20% in the residential sector by 2030
- Shift away from electricity to solar and geothermal technologies for cooling: 25% geothermal cooling and 25% solar cooling by 2030
- Electrification of >95% of households by 2020
- Electrification of >98% of households by 2030.

Belize's high energy costs, system losses, and large demand mean that energy efficiency can be improved, resulting in significant cost savings for the country. Improving efficiency of power generation and reducing system losses is a crucial first step. Technical losses in generation and distribution are estimated at 11% to 13%.[69] The resilience of the national grid can be measured based on the penetration rate of renewable energy in the grid, using the following metric: 1) peak Instantaneous penetrations of renewable-based electricity, 2) penetration based on peak load, 3) penetration based on system capacity, and 4) penetration based on energy. An analysis has to be conducted in order to assess:

- Whether Belize's power system can supply electricity to meet customer demand with high levels of renewable energy, including variable wind and solar generation;
- Grid integration using models with unprecedented geographic and time resolution; and
- Synergies, constraints, and operational issues associated with a transformation of Belize's electricity sector.

2.4.2.5.2 SIEPAC and Regional Grid Interconnection

Another way that Belize could improve reliability and efficiency in its grid is to trade electricity as needed with neighboring countries. Belize should pursue medium- to long-term projects to strengthen interconnection transfer capacities with the Central American Electrical Interconnection System (SIEPAC), which can help bring efficiency gains through economic dispatch, avoid service interruption during emergency operating conditions, and trade electricity when it is economically reasonable by shared reserve margins and exploitation of complementarities in demand and supply.

An interconnection to the grid in the region to export energy would fall under Strategic Focus Area 3 (Clean Production), where the production in the system is upgraded using local output. SIEPAC is an initiative to create an integrated regional electricity market among the six Central American countries of Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama. The objective of SIEPAC is to enable potential gain from integration, and to include a new regional transmission line and institution to support a regional electricity market.[70] (See Figure 5.)

Belize is not part of SIEPAC. A trans-national interconnection and electricity market between Belize and its neighboring countries could enhance investment opportunities for large-scale renewable energy projects. Private investment in the power sector is allowed in some countries but is not possible in others. A challenge that would need to be assessed if Belize wants to interconnect regionally would be:

- **Analyze the different electricity industry structures and evaluate the different degrees of government ownership and control.**

Figure 4. Route of the SIEPAC Line Through Central America

2.4.3 Summary of Newly Proposed or Adapted Targets

Table 8 summarizes the new targets that should be considered for inclusion in Belize's *2030 Sustainable Energy Roadmap*. The targets take into account the five Strategic Focus Areas, which center on energy efficiency improvements in selected end-use sectors, and on ensuring increased renewable energy supply to address projected energy demand by 2030. These strategies focus on low-carbon economy, homes and buildings, and transport; sustainable energy, and Belize adapting well to climate change.

Table 8. New Sustainable Energy Targets to Consider for Inclusion in the 2030 Sustainable Energy Roadmap

Strategic Focus Area	Target	Description
Energy Efficiency (EE)	1	Measure energy demand applying Vehicle, Kilometer, Rate of Consumption (VKR) method by 2020
Energy Efficiency	2	Measure consumption of Net Energy (C,m,M) for the transport sector by 2020
Renewable Energy (RE)	3	Supply 87% of electricity demand from renewable energy by 2030
Clean Production	4	Establish an ethanol market and use 50% of production to replace 52% of gasoline demand by 2030
Clean Production	5	Set a mandate for E10 by 2020
Clean Production	6	Set a mandate for E20 by 2030
Clean Production	7	Increase the production of biomass supply to 50% of demand with domestic production
Clean Production	8	Increase the number of trained engineers to 4 by 2020
National Capacity	9	Increase the number of trained engineers to 48 by 2030
National Capacity	10	Increase the number of trained associate engineers to 23 by 2020
National Capacity	11	Increase the number of trained associate engineers to 39 by 2030
National Capacity	12	Increase the number of trained technician/operators to 60 by 2020
National Capacity	13	Increase the number of trained technician/operators to 85 by 2030
National Capacity	14	Phase out kerosene and candle lighting starting from 18% of households in the residential sector
Infrastructure/RE	15	Shift from electricity to solar lighting: electricity lighting (60%) and solar lighting (40%) in the residential sector

Strategic Focus Area	Target	Description
Infrastructure/RE	16	Shift from electricity to solar lighting: electric lighting (75%) and solar lighting (25)% in the commercial and services sector
Infrastructure/RE	17	Shift to solar and geothermal technologies for cooling: electric cooling (50%), geothermal cooling (25%), and solar cooling (25%)
Infrastructure/RE	18	Supply electrification for 98% of households
Infrastructure/RE	19	Analyze the different electricity industry structures and evaluate the different degrees of government ownership and control

All of the targets outlined in Table 8 cover a Strategic Focus Area, as discussed in Section 2.3.4. The targets are based on the analysis performed in Section 2.4.

Targets 1–2 are more of a mission statement, making them more of arbitrary targets not based on numbers. Targets 3–7 are proposed based on a monitoring and evaluating assessment, and considering the data and information in place. Targets 3–4 are based on realistic scenarios that take into account projections for a 2030 scenario. Targets 5–7 are based on the assumption that if an ethanol mandate were implemented, this would create a market for clean production technologies and supply part of the future fuel demand. Target 7 is more of a mission statement, making it more of an arbitrary target not based on numbers. Over time, it will be seen if the target can be achieved or not.

It is important to point out that better targets can be set once further data is gathered, energy audits are completed, measuring metrics are set, and renewable energy data assessments are completed. As suggested actions, this report recommends that MPSEPU implement an energy management program, assigning an energy management coordinator to gather information and audit the residential, commercial, services, and public sectors, as well as the industrial, transport and agriculture sectors. To set realistic energy efficiency targets, MPSEPU should set an accurate energy consumption baseline, and then set specific reduction targets. Distribution of fossil fuel and renewable energy technologies should be tracked (in GWh) to measure how much of the total is from renewable energy resources.

Targets 9–19 were extracted from the other tasks belonging to the EUEI PDF project under Task 2, “Capacity Building – Assessment of Renewable Energy Workforce Training Needs in Belize,” and Task 4, “Off-grid Rural Electrification Assessment and Strategy.” These targets cover Strategic Focus Areas 4 and 5. (For more information, please refer to these reports, which were submitted to MPSEPU.)

2.4.4 International Commitments and Implications for Future Indicators

2.4.4.1 Belize’s Current Commitments for Switching from Conventional to Renewable Transport Fuels

It is imperative to keep in mind that Belize first has to achieve its national commitments and targets—such as data gathering, auditing, setting measuring metrics, and performing renewable energy data resource assessment—before achieving international commitments. For this reason, the international targets and commitments discussed in this section were not included in Table 8.

The level of policy commitments made by Belize is an important indicator of the viability of achieving the set goals by 2030. Table 9 lists the voluntary commitments or pledges regarding targets to switch to alternatives to conventional fuel use for transportation made by Belize at the Rio+20 United Nations Conference on Sustainable Development, among other international forums.

Table 9. Current Commitments by Belize Regarding Shifting Away from Conventional Fuels

	Required Target	Adopted/Pledged Fuel Use Target	Current Fuel Use
SIDS DOCK Membership	Switching from conventional fuel use by 25% in 2033		

Since the transportation sector is the largest consumer of fuel in Belize, reducing oil consumption from this sector is a much greater challenge than we can assume initially. It will require the development of a strong legal framework.

Table 10. Suggested Instruments for Gathering Data and Measuring Progress in the Reduction in Conventional Fuel Use for Transport

Type of Function	Instruments
Disincentives	• Reductions in oil consumption from transportation by increasing the cost of driving with petroleum based fuel taxes • Eliminate subsidy for petroleum-based fuels • Increase taxes or forbid the use of vehicles with more than 20 years
Incentives	• Increase the popularity and promote the importation of alternative motor vehicles through tax benefits/credits or deductions
Support activities	• Introduce pilot projects to testing electric vehicles in the context of SIDS • Introduction of pilot project to testing different types of vehicles (electric, hybrid, etc.) and alternative fuels

2.4.4.2 Recommended Indicators for Measuring Reductions in Conventional Fuel Use for Transport in Belize

Table 11 lists some recommended indicators for measuring and monitoring the reduction in use of conventional fuel for transportation in Belize. These should be double-checked once more detailed national statistics are gathered and there is a better view of available statistical capacities in Belize.

Table 11. Recommended Indicators for Measuring Fuel Use in the Transport Sector

Indicators	Components
Import of vehicles	• Total of energy-efficient vehicles imported • Total of vehicles with more than 20 years replaced
Number of beneficiaries of tax deduction/credit/benefits	• Total number of persons with the benefit
Greenhouse gas emissions from transport sector	• Greenhouse gas emissions from vehicles

Efforts should be directed toward initial implementation of rational and accessible indicators, because currently the level of data available in Belize for complex and more detailed indicators is not readily available. This issue is clearly reflected in Section 2.9, where the level, quality, and complexity of indicators increase by the availability of quality primary data. This is applicable to all indicators proposed throughout this report. In this report, the indicators proposed should be considered only as indicative values. Only after the implementation of suggested instruments or activities to improve the conditions to enable Belize to gather primary data and monitor progress, it may become possible to develop and use more complex indicators to evaluate implementation interventions and to monitor progress toward achieving the set 2030 targets.

2.4.4.3 Belize's Current Commitments Regarding Energy Efficiency

The level of policy commitments made by Belize is an important indicator of the viability of achieving the set goals by 2030. Table 12 summarizes the country's energy efficiency commitments or pledges made at the Rio+20 UN Conference on Sustainable Development in June 2012 and at other international fora.

Table 12. Current Commitments by Belize Regarding Energy Efficiency Improvement

Document	Required target	Sector	Baseline EE Rate
UN Sustainable Energy for All	Double the global rate of improvement in energy efficiency	Multiple	
Sustainable Energy Programme – Strategy and Work Plan 2015-2020	15% by 2030 (compared to 2014)	Transportation	16.42 GJ/cap/yr (2014)
Sustainable Energy Action Plan 2012-2033, as part of the MESTPU's Strategic Plan 2012-2017[71]	30% reduction in energy intensity per capita by 2033 (compared to 2011)	Multiple	

2.4.4.4 Recommended Indicators to Measure Energy Efficiency Performance Levels in Belize

Indicators are useful because they show policymakers where energy savings can be made.[72] In the case of energy efficiency, indicators serve as a relevant tools for understanding the interactions and interrelations among economic variables, energy, emissions, and human activities.

Figure 6 illustrates the varying levels of detail provided in energy efficiency indicators.[73] The amount of data required to assess and measure quantitatively these indicators has a critical role, and it increases significantly when the level of aggregation becomes more detailed. Before assessing Belize's energy efficiency indicators, it therefore is necessary to establish a "mechanism" that allows MPSEPU to access and gather the data required to measure the indicators. Additionally, the data must be consistent, validated, and comprehensive.

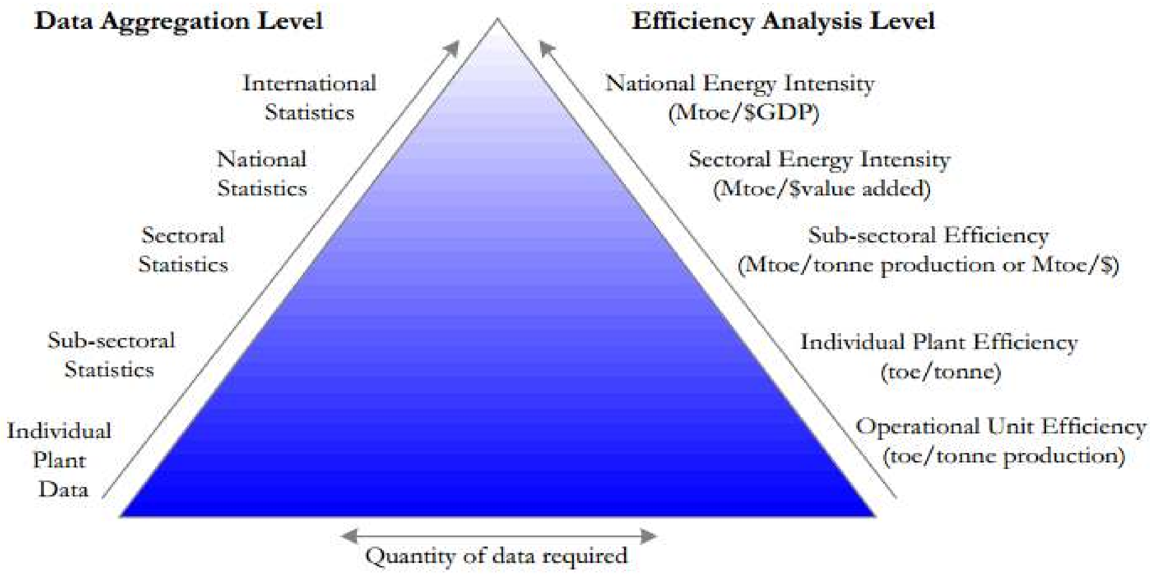

Figure 6. Energy Efficiency Analysis Levels Based on Quantity of Data

Table 13 lists some recommended indicators for energy efficiency performance and monitoring in Belize. These should be double-checked in more detail once national statistics are gathered and there is a better view of available statistical capacities in the country. For the time being, the currently used energy efficiency target and indicator is in line with indicator number 2, as shown in Table 13.

Table 13. Recommended Energy Efficiency Indicators

#	Indicators	Components
1	Energy intensity: manufacturing, transportation, agriculture, commercial and public services,	• Energy use in each sector and by manufacturing branch • Corresponding value added

	residential sector	
2	Energy consumption per capita	• Energy use (total primary energy supply, total final consumption, and electricity use) • Total population
3	Efficiency of energy conversion and distribution	• Losses in transformation systems, including losses in electricity generation, transmission, and distribution
4	Net energy import dependence	• Energy imports • Total primary energy supply

2.4.4.5 Belize's Current Commitments Regarding Renewable Energy

The level of policy commitments made by Belize is an important indicator of the viability of achieving the set goals by 2030. Table 14 lists the voluntary commitments or pledges regarding renewable energy targets made by Belize at the Rio+20 UN Conference on Sustainable Development, among other international fora.

Table 14. Current Commitments by Belize Regarding Renewable Energy Generation and Use

Document	Required Target	Adopted RE Target	Baseline Data
SIDS DOCK targets	50% by 2033		45% (2012)
2013 CARICOM Energy Policy Targets[74]	47% of renewable energy supply by 2027	229.3 MW installed capacity by 2027	82.5 MW (2012)
National Energy Policy Framework 2012	95% of energy supply to originate from renewable sources by 2030		N/A
Sustainable Energy Action Plan 2012-2033, as part of the MESTPU's Strategic Plan 2012-2017[75]	Reduce dependence on imported fuels by 50% by 2020		N/A
	At least triple the amount of modern energy carriers derived from waste material; become a net electricity exporter by 2020		N/A
Sustainable Energy Programme – Strategy and Work Plan 2015-2020	Provide 97% of domestically generated electric power from renewables by 2030		

There is a need to introduce a strong legal framework to secure the fast deployment of renewable energy technologies in Belize. Table 15 summarizes some potential instruments for gathering and measuring progress on renewable power generation.

Table 15. Suggested Instruments to Enable Belize to Gather Data and Measure Progress on Renewable Power Generation

Type of Function	Instruments
Incentive policies	• Implement a multi-million economic stimulus package for renewable energy projects deployment in SIDS. • Devote substantial resources to R&D in the energy sector, addressing themes such as OTEC, hydrogen and fuel cell technology, energy efficiency, and renewable energy.
Support activities	• Perform a scoping analysis of all actors operating in the field of promoting, facilitating, and deploying sustainable energy technologies to SIDS, in particular the ones addressing Transfer of Technology needs. • Establish strategic partnerships with other key actors/stakeholders to build upon past efforts, platforms, and successes booked • Perform a detailed energy sector diagnostic to understand per SIDS what the conditions and performance is, who the critical actors are, and what their nature and responsibilities are within the sector.

2.4.4.6 Suggested Indicators for Measuring Renewable Energy Performance Levels in Belize

Table 16 lists some recommended indicators for renewable power generation performance and monitoring in Belize. These should be double-checked once more detailed national statistics are gathered and there is a better view of available statistical capacities in Belize.

Table 16. Recommended Renewable Energy Power Generation Indicators

Indicators	Components
Resources-to-production ratio	• Total estimated renewable energy resources • Total energy production from renewable energy sources
Renewable energy shares in electricity generation	• % of primary energy supply, final consumption and electricity generation, and generating capacity by renewable energy • % of total primary energy supply, total final consumption, total electricity generation, and total generating capacity
Greenhouse gas emissions from electricity generation	• Greenhouse gas emissions from electricity generation

2.5 Institutional Energy Governance

2.5.1 Current Status

It is recognized that improved energy governance is critical to facilitate the transition toward a sustainable energy future in Belize.[76] Establishing a common vision and developing a coherent set of targets based on sound technical assessments are essential to put forward a plausible pathway and action plan that can be carried out by all stakeholders in the country. Consequently, the GoB, in recognition of the twin challenges of Energy Security and Climate Change, endorsed in January 2012 a draft National Energy Policy (NEP), which is intended to put sustainable energy at the center of Belize's Development Agenda.

The formerly named Ministry of Energy, Science & Technology and Public Utilities (MESTPU) was established in 2012 to spearhead and guide the sustainable energy efforts. After the November 2015 general elections, it was restructured to be the Ministry of Public Service, Energy and Public Utilities (MPSEPU). The Energy Unit of the Ministry is responsible for the implementation of the Belize 2030 Sustainable Energy Roadmap. The Energy Unit currently has six technical staff, including the Director of the Energy Unit, Mr. Ambrose Tillet. (See Figure 7.)

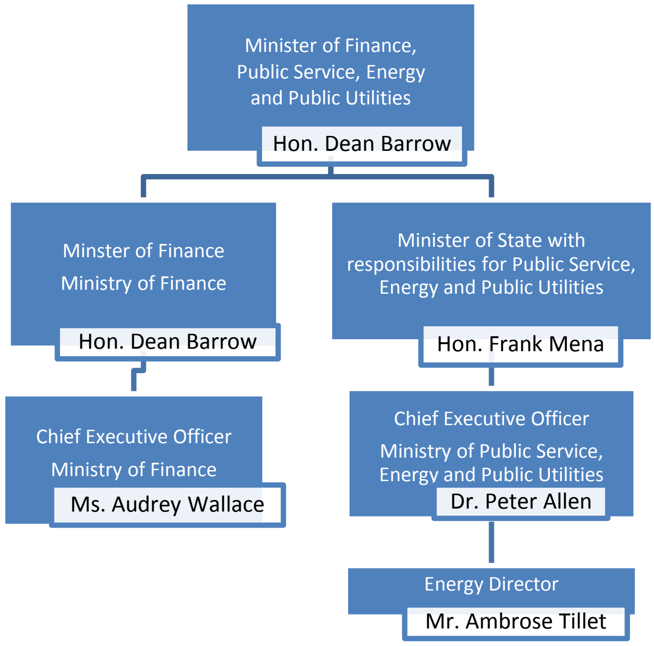

Figure 7. Energy Unit Organizational Structure

Of the proposed five strategic roadmap elements, two—Policy & Planning and Energy End-Use (Buildings & Appliances)—are partially staffed and active. By default, Policy & Planning supports the Energy Director in developing the programs for all work areas. There currently are no dedicated staff for the other three proposed elements: Energy Access and Infrastructure, Transport and Logistics, and Renewable Energy, Agriculture and Industry.

Three major projects currently are being prepared or implemented. The ESD-Caraibes is the principal project under the Buildings & Appliances work area. Meanwhile, one staff is assigned to serve as Project Management Team Leader to prepare two other projects: Energy Resilience and Climate Adaptation Project (ERCAP) and the program of activities under the EDF-11 National Indicative Programme.

2.5.2 Establishing a Governance Structure for the Roadmap Implementation

Although the Energy Unit of the Ministry is responsible for implementing the Belize *2030 Sustainable Energy Roadmap*, this will require the engagement and action of several ministries and government agencies due to the close interlinkages between policy areas and ministerial mandates. As part of Task 1 of this EUEI PDF project, a proposal is made to establish a new Energy Council as an inter-ministerial governance body focused specifically on energy. As outlined in Figure 8, the Energy Council would be composed of four Working Groups focusing on Energy Planning and Mitigation, Universal Access, Efficient Energy End-Use, and Industrial Policy. These Working Groups would be responsible for operational and tactical decision making and implementation. Governance and strategic decisions relating to sustainable energy would be made at the Energy Council.

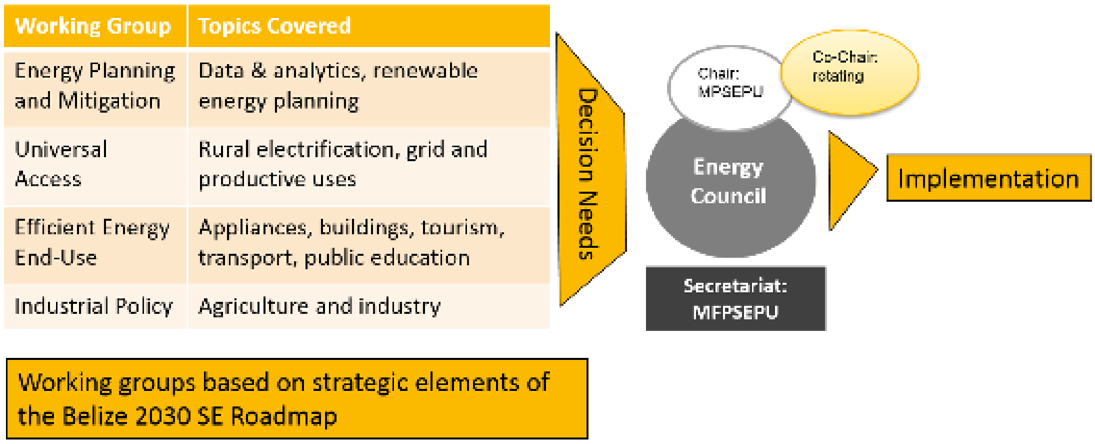

Figure 8. New Energy Council Structure

Chaired by MPSEPU, the Council would have a rotating co-chair and would be composed of Chief Executive Officers or heads of organizations (or their assigned representatives) who are involved in the success of meeting Belize's energy goals.[†] It is proposed to include all ministries that are affected and/or that need to engage in the implementation of the 2030 Sustainable Energy Roadmap. Participating ministries would include: Ministry of Public Services, Energy and Public Utilities; Ministry of Works, Transport and National Emergency Management; Ministry of Education (Science and Technology), Culture, Youth and Sports; Ministry of Economic Development, Petroleum, Investment, Trade and Commerce; Ministry of Agriculture, Fisheries, Forestry, the Environment and Sustainable Development; Ministry of Labour, Local Government and Rural Development; Ministry of Tourism and Civil Aviation; and Ministry of Natural Resources and Immigration.

The four proposed Working Groups would be composed of experts and technical staff from the affected ministries, and can invite external stakeholders for consultations. The Working Groups would be responsible for operational analysis and implementation and for preparing options and recommendations for decision making in the Energy Council, with the following goals:

- Energy Planning: to address the implementation of energy resource mappings; to lead data and policy analysis for the sector; and to implement or guide further research and analysis as seen necessary.
- Universal Access: to address the implementation of rural electrification, productive uses, and the grid, coordinated by the Energy Unit.
- Efficient Energy End-use: to address the implementation of energy efficiency projects and activities, technology innovations, and consumer awareness.
- Industrial Policy: to address the coordination in the field of agriculture and industry, overseen by the Energy Unit.

Under this approach, the Energy Council would coordinate closely with the Belize National Climate Change Committee. This would occur by having overlapping members partake in the Energy Council and associated Working Groups to foster knowledge sharing. It is advised to monitor and consider the potentials for cooperation and a merger of both committees.

[†] Recognizing the potential for ministry title and responsibility changes in the future and the permanent nature of the Council, the Energy Council would include CEOs responsible for the associated portfolio described above. The CEO responsible for Climate Change from the Ministry of Agriculture, Fisheries, Forestry, the Environment and Sustainable Development would be expected to participate.

3 Belize's Energy Sector Diagnostic

3.1 National Energy Balance

Belize's total installed electricity generation capacity at the end of 2014 was 106 MW, up 77% from 60 MW in 2000. This growth is attributed to the installation of 19 MW of hydropower capacity in 2010, and of 22 MW of bagasse-fed biomass-to-energy power generation capacity in 2009. Meanwhile, electricity consumption in Belize totaled 404 gigawatt-hours (GWh) in 2014, an increase of 171% compared to 129 GWh in 2000. The peak demand was recorded at 84.3 MW in 2014.

In 2014, hydropower and biomass power remained the two main renewable electricity generation sources, with shares of 65% and 24.4% respectively, while non-hydro renewables accounted for 26% of renewable generation.[77] Analysis suggests that renewable energy could represent 89% of electricity supply, electricity consumption could decrease by 24%, and stationary fuel consumption could decrease by 19%—combining to lower greenhouse gas emissions by some 2.4 million tons.[78]

Since the energy situation has not changed dramatically in Belize since 2010[‡], it can be assumed that the transport sector continues to account for about 47% of total energy consumption, followed by the industrial sector at about 27%, and the residential, commercial, and service sectors collectively at around 26%.[79] The national energy balances for 2013 and 2014 are available in Annex 3.

3.1.1 Current Primary Energy Supply and Use

Although Belize is one of the four Caribbean nations that currently exploit and export crude oil, the country's consumption of fossil fuels often outweighs primary energy production. Fossil fuels still need to be imported for both power generation and for use as transport fuel. This imbalance diminishes the stability of fuel supply for power generation for residential and commercial purposes and affects the transportation system in particular, where about 45% of Belize's primary energy supply is consumed.[80]

Belize continues to import 100% of the fuels consumed in-country, at an annual cost of USD 32 million, or about 2% of the country's gross domestic product (GDP).[81] As of 1 January 2015, Belize's crude oil proven reserves were around 6.7 million barrels.[82] The transportation sector is a major user of petroleum products and is responsible for more than 85% of the country's fossil fuel use of about 6,000 barrels of oil per day.[83]

Belize's current primary energy originates from four main sources: fossil fuels (75.5%), traditional biomass and bagasse (22.7%), hydropower (7.4%), and imported electricity (4.4%).[84] The country imports 100% of its refined fuels, and Belize National Energy (BNE) produces approximately 2,800 barrels of oil per day. Belize also imports a relevant amount of electricity from Mexico.

3.2 Power Sector

Under the Belize Electricity Act, Belize Electricity Limited (BEL) has a legal monopoly to generate, transmit, distribute, and supply power to the entire country.[85] Owned partly by the government (70.2%), partly by the Social Security Board (26.9%), and partly by approximately 1,500 shareholders (2.9%) (see Figure 9), the company is regulated by the PUC and sells power at an average rate of USD 0.22 per kWh, lower than the Caribbean regional average of USD 0.33 per kWh.[86]

[‡] This assumption is based on the small difference of 40,000 GWh between 2010 energy balance and IRENA data from 2014; see "Energy Balance" in Annex 3 of this report.

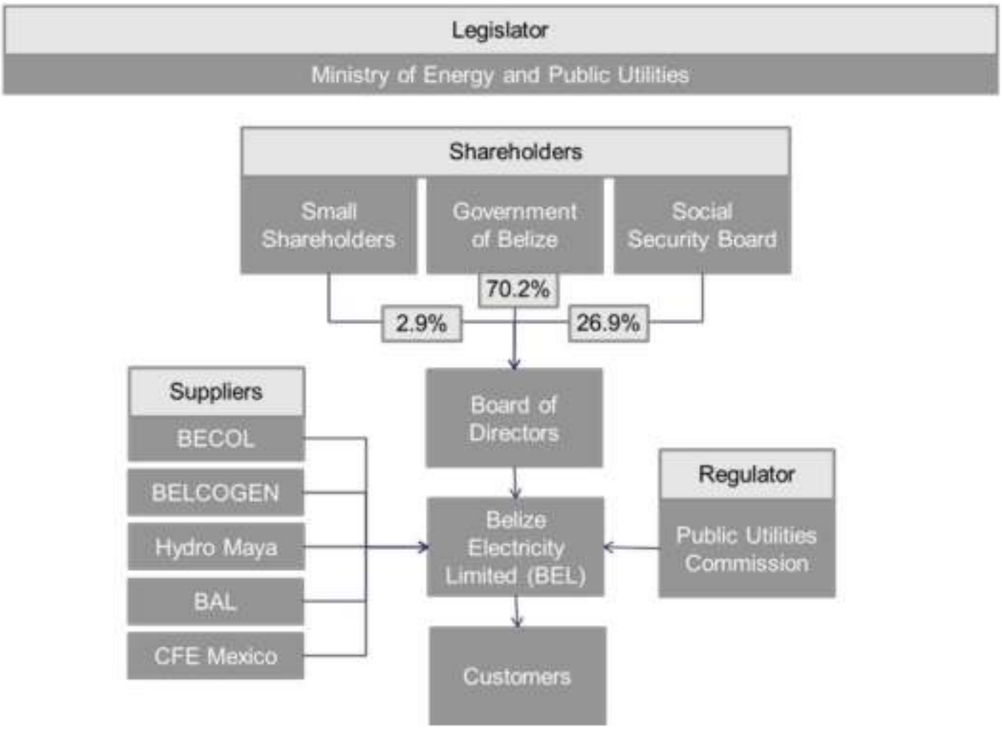

Figure 9. Key Stakeholders in the Power Sector of Belize

3.2.1 Current Power Generation, Distribution, and Use

The country's total installed power generation capacity is 154 MW, of which 24 MW is owned by BEL, about 80 MW is owned by independent power producers (IPPs), and on average about 50% (some 50 MW in 2015) originates from Mexico, where it is supplied by the Federal Electricity Commission (Comision Federal de Electricidad – CFE).[87] BEL interconnected to the Mexican grid in 1998. Belize's peak demand was about 76 MW in 2009, 82 MW in 2012, and 84.3 in 2014.[88]

The latest data indicate that electricity consumption surpasses production by at least 34%. (See Figure 10.) This gap in demand is satisfied with electricity imports from Mexico.

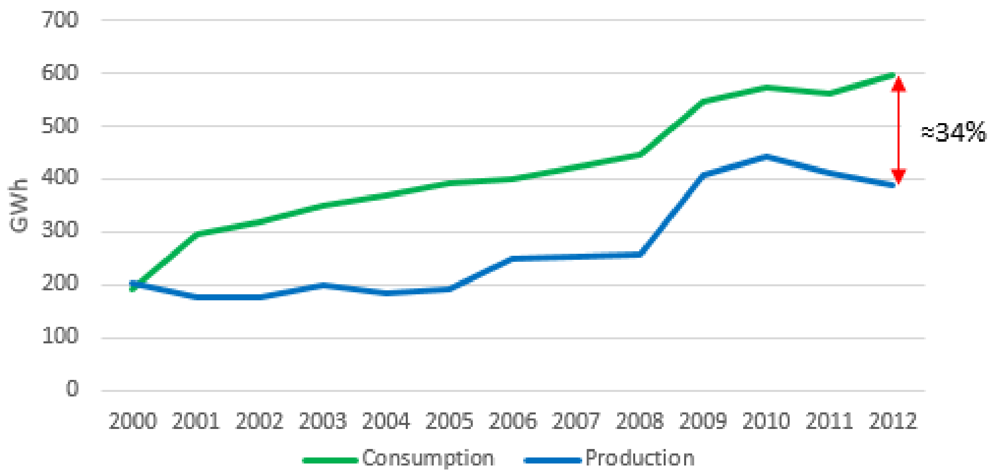

Figure 10. Total Electricity Production and Consumption in Belize, 2000–2012

Electricity consumption increased steadily between 2000 and 2008, and then spiked by about 100 GWh, accompanied by increased generation output from hydro and biomass sources. (See Figure 11.) This has led to a temporary reduction in electricity imports from Mexico. However, due to recent droughts, hydropower output decreased while overall demand continued to grow.

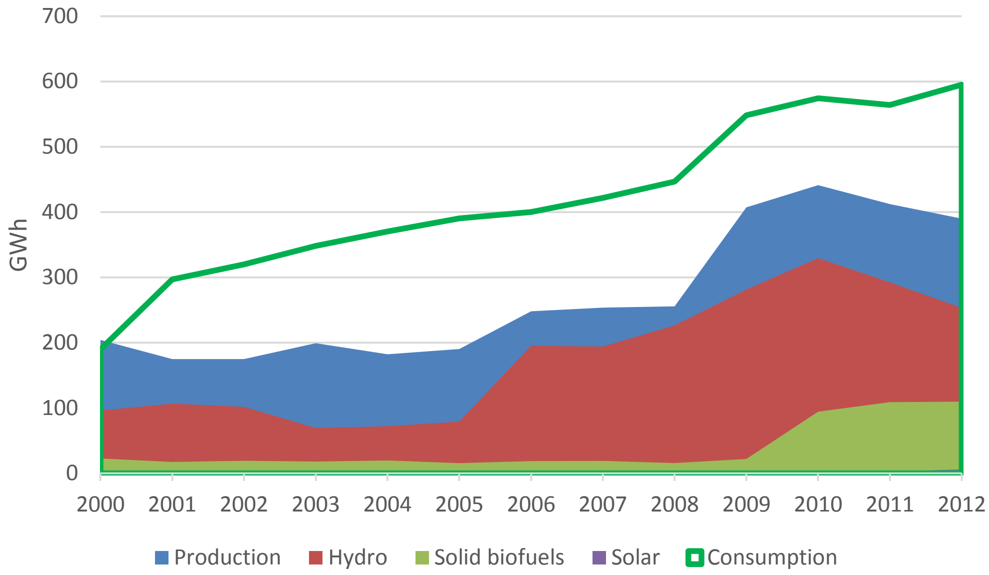

Figure 11. Renewable Electricity Generation versus Total Electricity Production and Consumption in Belize, 2000–2012

Hydropower, biomass (solid biofuels, co-generation from bagasse), and solar PV are the main renewable technologies currently connected to the grid in Belize. (See Figure 12.) The share of renewable generation in the country's energy mix was around 58% in 2000 and reached around 95% in 2012. (See Figure 13.) Today, at least 91% of total domestically generated power originates from renewable energy sources. The remaining diesel-fueled power generation relates to the few remaining areas that are not connected to the national grid, including Caye Caulker, where BEL serves as power generator and supplier, operating small diesel generators.

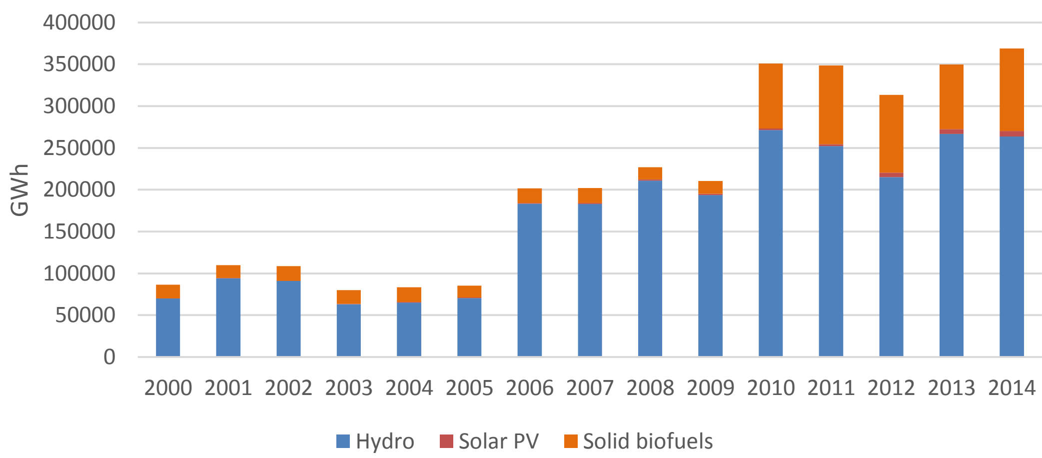

Figure 12. Renewable Electricity Generation in Belize by Technology Type, 2000–2014

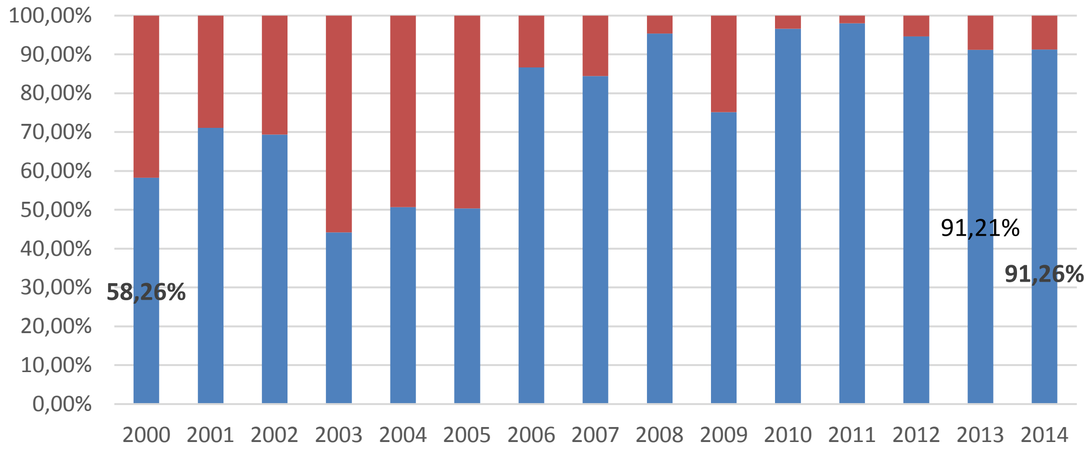

Figure 13. Renewable Share of Domestic Electricity Generation in Belize, 2000–2014

The installed renewable electricity capacity comprises hydro (55 MW), solar (0.48 MW), and biomass-to-energy (27.5 MW) power generation systems.[89] Belize's hydropower installed capacity includes 25.5 MW at the Mollejon Hydro Plant, 19 MW at the Vaca Hydroelectric Facilities, 7.0 MW at the Chalillo Hydroelectric Dam, and 3.5 MW at the HydroMaya Dam. According to the potentials by technology provided by Castalia, solar and biomass possess a huge potential that can help Belize to become a net electricity exporter.[90] In addition, there is still some MW available of hydropower.

3.3 Transportation Sector

Presently 100% of the fuel used in the transportation sector in Belize is imported. Unfortunately, no recent studies have been executed to capture the latest fuel supply and consumption trends in the country's transport sector.

As of 2010, transport fuels accounted for 40% of the energy demand in Belize and for 50% of the country's greenhouse gas emissions.[91] The transportation sector also was the largest energy consumer, accounting for 46.8% of total secondary energy consumption in 2010.[92] Within the sector, gasoline accounted for 47% of consumption; diesel accounted for 36.9%; and kerosene (used for aviation fuel), crude oil, and liquefied petroleum gas (LPG) accounted for 16.1%.[93] Approximately 18.4 million gallons of gasoline was consumed in Belize in 2010.[94]

Figure 14 shows the latest available data from 2013, when the transport sector represented 54% of total fuel consumption.[95]

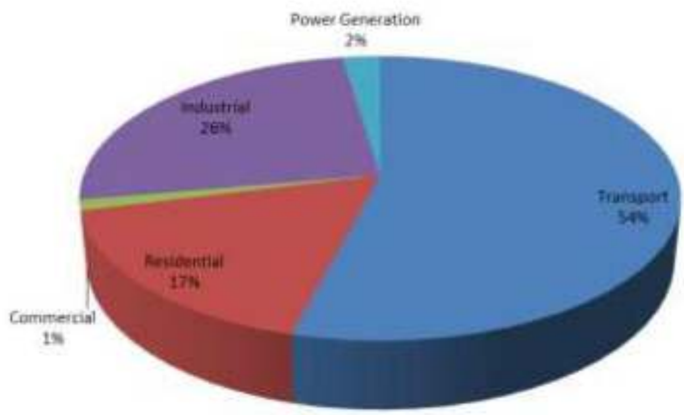

Figure 14. Shares of Fuel Energy Use in Belize by Sector, 2013

To supply the transport fuel demand, Belize imported two grades of gasoline for road transport, regular (octane 87) and premium (octane 91), as well as a small volume of high octane for aviation.[96] Between 1995 and 2001, the total number of licensed private cars and trucks in the country increased by between 5% and 8% on average.[97] (See Table 17.)

Table 17. Number of Licensed Vehicles in Belize, 1995–2001

Vehicle Type and Service		1995	1996	1997	1998	1999	2000	2001	Average Annual Growth
Public Service	Passenger O/Bus	404	435	447	211	640	638	642	8%
	Taxi	1,727	1,765	1,918	1,901	1,927	2,192	2,191	4%
	Passenger boat	278	317	476	541	553	727		27%
Private	Cars	7,250	7,517	8,098	8,028	8,960	8,896	9,939	5%
	Pick-up trucks	6,867	7,387	8,847	8,485	9,826	10,198	11,158	9%
	Cycles	679	607	670	513	504	527	518	-3%
	Van	2,242	2,459	2,761	2,854	3,044	2,992	3,474	8%
	Other	1,764	1,782	2,157	2,680	2,575	2,317	4,758	24%
Goods	Pick-up trucks	247	284	190	862	283	171	195	-3%
	Dump	302	307	257	252	120	151	264	-2%
	Tractor	317	304	384	288	245	251	243	-3%
	Other	1,694	1,738	3,348	1,911	2,449	2,286	3,570	16%
Total		23,493	24,585	29,077	28,286	30,619	30,619	36,952	

Source: See Endnote 97.

Data from 2007 suggest that the total number of registered vehicles in Belize was 54,225.[98] Extrapolating this trend to 2030 suggests that some 90,000 vehicles might be demanding fuel by then. (See Figure 15.) Currently, nearly 65% of households do not own a vehicle, and the public uses mainly taxis, minivans, and buses as their means of transport, making the public transport sector essential for economic and social advancement.[99]

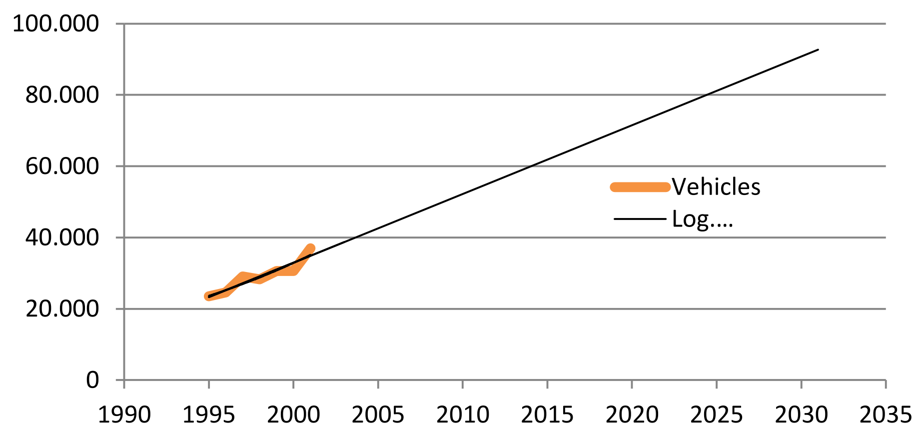

Figure 15. Projected Increase in the Number of Licensed Vehicles in Belize, 1995–2030

Since 2000, import taxes have been charged depending on the vehicle type. Trucks used for work are taxed at 31% for four cylinders and 37% for six cylinders.[100] Cars are considered luxury items and are taxed at an even higher rate depending on the engine size (i.e., four and six cylinders at 57% and 65%, respectively).[101] In the transportation sector, a policy that dictates the use of biofuels, particularly ethanol, may be an option to lower the dependence on gasoline and diesel imports and to reduce emissions.

Figure 16 shows the trend in gasoline consumption in Belize from 1986 to 2012 and also provides a BAU forecast for 2012–2030.[102] Based on an Organization of American States (OAS) study, cellulosic ethanol production potential can supply and surpass the total gasoline demand. Since the gradual introduction of ethanol to the local market requires sensitization and gradual acceptance, ethanol mixture scenarios are shown in line with biofuels policies across the region. In most cases, an E10 (10% ethanol blend with gasoline) is deemed viable without the need for retrofits of vehicles and without losing engine or vehicle warranties. More ambitious targets could be set for E20 or E30; however, further detailed analysis is required to determine ethanol's technical potential in Belize.

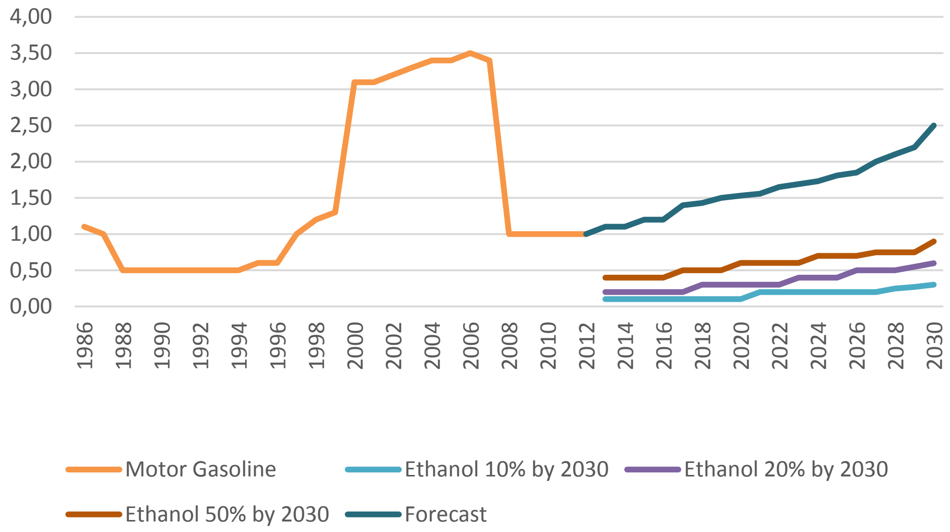

Figure 16. Gasoline Consumption for 1986–2012, Forecast for 2012–2030, and Ethanol Supply Scenarios

Belize has the potential to improve fuel efficiency to 20 miles per gallon. If 25% of its gasoline-powered vehicle fleet is replaced with smaller vehicles, this could lead to a reduction in total gasoline imports of approximately 3.8%, saving USD 2.1 million annually.[103] Replacing 25% of gasoline-powered vehicles with hybrid-electric vehicles would lead to a reduction in gasoline imports of 5.34%, saving USD 3 million annually. But switching to hybrids on the basis of fuel savings is not a viable option based on the current price tag differential between hybrids and conventional vehicles and on the current price level of oil.[104]

Road transport accounted for 49% of Belize's total net greenhouse gas emissions in 2012.[105] In 1994, 1997, and 2000, emissions from transport accounted for 44.2%, 44.6%, and 51.4%, respectively, of the total energy-related activities.[106] Table 18 shows CO_2 emissions from the transport sector in Belize for these years.[107]

Table 18. CO_2 Emissions in the Transport Sector in Belize, 1994, 1997, and 2000

Year	1994	1997	2000
		(Gigagrams)	
Domestic Aviation	11.87	15.65	20.85
Road	263.58	275.94	330.55
National Navigation	35.51	57.03	77.54
Total	**310.9**	**348.6**	**428.9**

Source: See Endnote 107.

Figure 17 illustrates the greenhouse gas emission trend in the transport sector toward a 2030 scenario. The trend illustrates that emissions will keep rising in the transport sector if there is no shift to a sustainable transport sector.

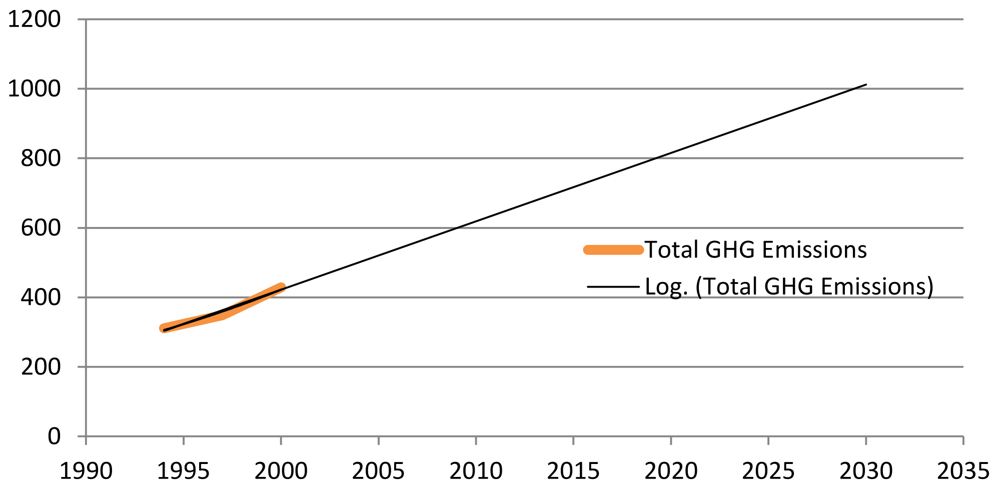

Figure 17. Greenhouse Gas Emission Trend in Belize's Transport Sector, 1995–2030 (in Gigagrams)

At a price of USD 25 per ton of CO_2, the cost of energy sector emissions or cost of carbon in 2010 was over USD 7.5 million of the total energy cost, inclusive of the cost of carbon.[108] Based on the Belize Intended Nationally Determined Contribution (INDC), the country is committed to limiting the increase in global average temperature to 1.5 degrees Celsius (^{o}C). In the transport sector, Belize's contribution is to achieve at least 20% reductions in conventional transport fuel used by 2033 and to promote energy efficiency in the transport sector through appropriate policies and investments.[109]

Improvements include:[110]

- Undertaking a traffic management study aimed at reducing traffic congestion in urban areas and along Phillip Goldson Highway into Belize City
- Improving public transportation
- Upgrading maintenance of bus fleets
- Improving scheduling
- Upgrading the industrial fleet
- Promoting the use of biofuels.

3.3.1 Current Fuel Supply and Consumption

Belize currently imports all refined oil products such as gasoline, diesel, kerosene, and aviation gasoline from the United States or Venezuela (under the PetroCaribe Agreement).[111] Gasoline and diesel also are imported indirectly when local vehicles travel across the border to Mexico and Guatemala.[112] In 2010, approximately 44,384,091 gallons of refined oil products were imported.[113] The main petroleum-based products of importance for Belize are gasoline, diesel, and kerosene. Table 19 lists Belize's imports of these products from 2000 to 2007.[114]

Table 19. Imports of Gasoline, Diesel, Kerosene, and Butane to Belize, 2000–2007

Imports	2000	2001	2002	2005	2006	2007
	Gallons per year					
Gasoline	30,093,805	26,915,361	24,422,917	13,049,547	12,492,175	12,589,986
Diesel	22,164,678	22,085,284	21,635,079	19,827,857	20,367,853	23,086,587
Kerosene	6,223,804	3,999,039	4,429,834	N/A	N/A	N/A
Butane	N/A	N/A	N/A	289,590	2,691,671	1,296,408
Total	**58,482,287**	**52,999,684**	**50,487,830**	**33,166,994**	**35,551,699**	**36,972,981**

Source: See Endnote 114.

In 2009, Belize consumed 7,000 barrels of oil per day, with the transport sector alone consuming 2,100 barrels per day. There has been a shift in public transportation fuel usage to LPG-fueled buses, leading to an increase in LPG demand.[115] All LPG consumed was imported from Mexico and El Salvador until Belize Natural Energy (BNE) started supplying LPG in 2011.[116] Natural gas in the form of butane or propane also is used as an alternative form of fuel. According to the report *Energy Sustainable Development toward a National Energy Strategy for Belize Energy Sector Diagnostic*, 75% of bus companies in Belize use butane as fuel.[117]

3.4 Energy Use in Major Economic Sectors

Belize's economic growth path appears to be characterized by volatility. The country's small economic size, high dependence on exports and imports, and exposure to natural disasters all make the country vulnerable to trade shocks and other external factors, and create output volatility that can affect long-term growth. The economy decelerated to 1.7% growth in 2015, down from 4.1% in 2014, driven by the weather-related poor agricultural sector output. Over the medium term, growth is expected to gain momentum, and real GDP growth should hover around 2.5% a year, as tourism and non-oil exports are expected to pick up.[118]

Energy consumers in Belize, including commercial and industrial entities, use fossil fuel for other non-transport applications. The country's residential and industrial sectors are the largest consumers in absolute terms.[119] The industrial sector burns crude oil or diesel to generate heat for food processing and other applications. LPG is used for cooking and water heating in the residential sector, as well as in the commercial sector in restaurants and hotels.[120]

Figure 18 illustrates the end-use of stationary fuels by sector.[121] Most of the LPG is used for cooking in the residential and commercial sector, and a small fraction is used for water and other heating purposes. The industrial sector, on the other hand, uses 100% of the fuel to supply heat energy for productive uses.

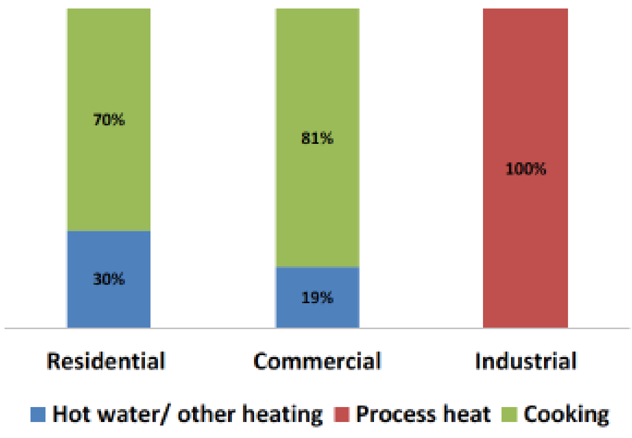

Figure 18. End-Use of Stationary Fuels by Sector in Belize

3.4.1 Agricultural Sector

Agriculture is one of the main pillars of the Belizean economy and generates most of the employment in the country's rural areas.[122] In 2006, the agricultural sector employed approximately 30% of the workforce, contributing to 15% of GDP and 75% of foreign exchange earnings.[123] The World Bank estimates that agriculture is the most important economic sector in Belize in terms of income generation, employment, food security, and poverty alleviation.[124]

Agriculture in Belize is composed of three main sub-sectors: 1) an export sector for sugar, banana, citrus, and marine products; 2) a small farming sector producing food mainly for local consumption; and 3) a well-integrated large-scale commercial sector.[125] Just three commodities generate more than BZD 292 million: citrus products, sugar, and bananas. Other export earners include papaya, red kidney beans, root crops, vegetables, poultry, beef, and pigs.[126]

3.4.1.1 Current Status of Biomass in Belize

Biomass resources are widely available across several sectors in the economy or are generated by various human activities.

Figure 19 provides a snapshot of the ecosystems distributed in Belize, offering a quick overview of where agricultural activities take place in the country.[127] The purpose of showing this map is to understand that in order to produce a biomass energy resource map, there is need for multiple sources to create different maps similar to this one, and then to layer them to make cross references in order to produce a quality map with information that can be used effectively to select the best possible sites for renewable energy project development.

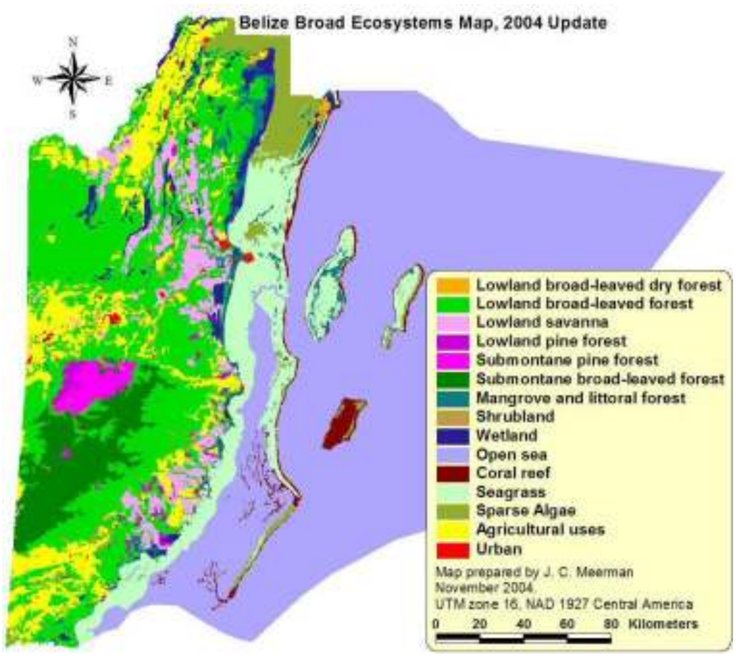

Figure 19. Belize Broad Ecosystems Map

One important biomass option in Belize is sugarcane bagasse, the fibrous material that remains after the juice is extracted from the cane. Belize already has an installed capacity of 27.5 MW of biomass production, with a potential to expand to 40 MW. (See Table 20.)

Table 20. Biomass Potential in Belize

Stakeholder	Land Available for Crops	Bagasse Produced (2015) (Metric Tons)	Total Capacity Potential (MW)	Total Installed Capacity (MW)
Santander	8,000	N/A	40	27.5
Belize Sugar-cane Farmers Assn.	70,000	367,781.34		
Forestry Department	5,000-10,000	N/A		
Agricultural Department	N/A	N/A		

The Santander Group has established a sugar mill in Belize and has the potential to provide energy to the local market. They manage 8,000 acres for sugarcane plantation, as well as a 16 MW mill production with a capacity of 32 MW. According to sources in Santander, they can double the production for sugar cane by 2017. The Belize Sugar-cane Farmers Association has a total of 70,000 acres of sugar cane cultivated. The amount of sugarcane is measured by volume-landfilled distance to determine the tons of biomass produced. The Forest Department of Belmopan manages, taxes, and records timber extraction. The timber extracted is used for construction, furniture, charcoal production, and plywood. Because both bagasse and forestry waste can be used to power a steam turbine, this biomass could be an important source of energy in Belize.

The main challenge with sugarcane bagasse co-generation is that the fuel is only available during sugarcane growing season, or about half of the year. A power plant in Belize could provide reliable baseload power during the harvest season, but it would need to run on a complementary fuel during the off-sugarcane season. An alternative to this is for the bagasse to be pelleted and stored for use as fuel during the off-season to have year-round bagasse generation.

Other agricultural wastes such as bananas, grains, citrus, cassava, and coconuts also contain fibrous materials that potentially could be used for power generation. These type of waste materials require further research, and currently no large volumes of supply are located near the existing biomass plants in Belize. Using a new type of energy crop as a biomass feedstock would require establishing a new industry, as well as careful assessment of the environmental and food-price impacts.

By using the unused waste from sugarcane production, other crops, and waste, Belize could add 40 MW of biomass energy to its current electricity production. Payments for independent bagasse power generation facilities such as Santander would need to be guaranteed to provide adequate incentive for sugar producers to improve generation efficiencies and sell excess power to the grid. Belize has huge potential for biomass and bioenergy. The Government of Belize has been supporting the development of biomass, but it needs to set up policies and regulations to achieve a successful industry sector. Policies related to tax incentives and disincentives could support the development of biomass industrialization. Four principles of biomass industry must be followed: fulfill local demand, ensure added value, promote investment, and encourage environmental responsibility.

3.4.2 Industrial Sector

The industrial sector of Belize, aside from oil extraction, can be categorized as “light industry.” This entails industries such as agro-processing or food, and to a minor extent textiles processing or assembly of secondary products or components.

These generally are not energy-intensive, and the product mix is generally diverse. In many cases, space cooling and lighting take up a substantial part of the electricity use in industrial facilities in Belize, but for some, such as in food processing, several processes are used that require significant amounts of energy, in particular heat. This heat is, in most cases, generated by using crude, heavy fuel oil (HFO), and diesel in industrial boilers. Therefore, the majority of the crude consumption in the residential, commercial and industrial sector needs to be assigned to industry. (See Figure 20.) As more data become available, more sector-specific analysis and results can be shown regarding fuel use in the industrial sector.

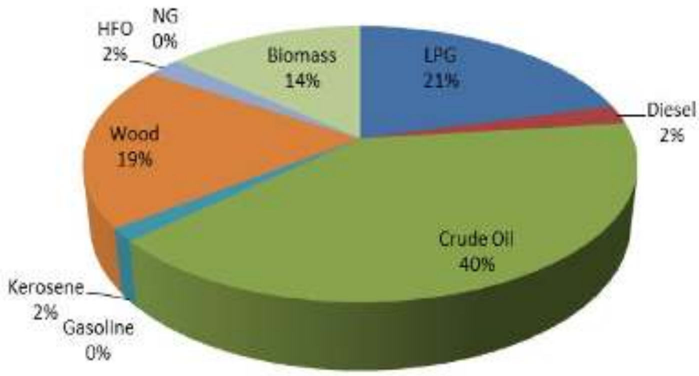

Figure 20. Fuel Use by Type in the Residential, Commercial, and Industrial Sectors of Belize, 2013[128]

3.4.2.1 Hydrocarbon Industry

Following the local discovery of oil in 2005, Belize has become one of the four oil-producing nations in the Caribbean together with Barbados, Suriname, and Trinidad and Tobago. BNE is Belize's only petroleum-producing company and is pumping approximately 5,000 barrels of oil per day from 10 wells.[129] (See Figure 21.) Since the discovery and production of domestic crude oil, most industrial boilers in Belize have switched from using diesel or HFO to crude.[130]

Oil produced from the Spanish Lookout Oilfield is sold domestically (to use as fuel oil for large boilers and generators) and internationally.[131] Oil produced from the Never Delay Oilfield is sold only internationally, not locally, due to its high sulfur content.[132] All international sales and shipments of crude oil are made to Shell Trading in Houston, Texas, USA.[133] The sale price is determined through sales agreements between BNE and Shell Trading using a five-day weighted average of the spot market price of crude oil at the time of each shipment. The same price is used for local sales.[134]

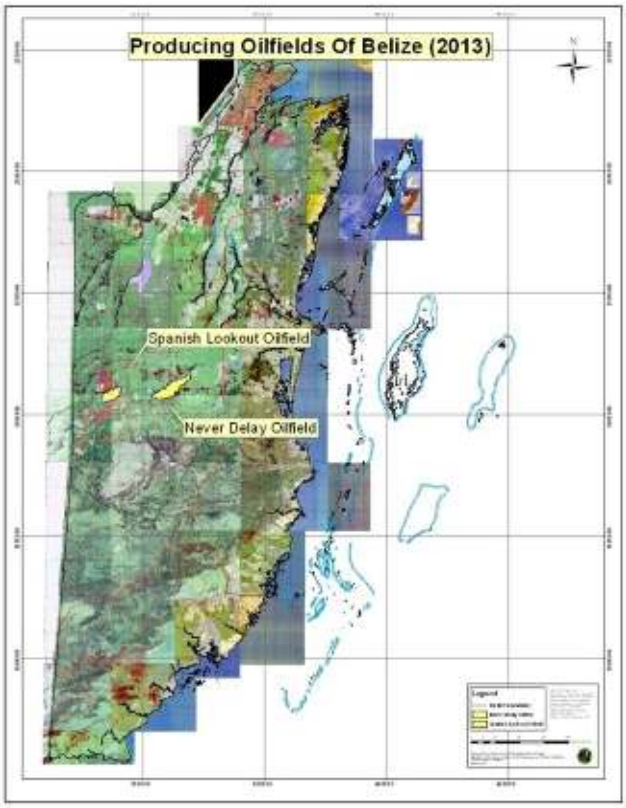

Figure 21. Producing Oil Fields of Belize

There are around 18 companies with petroleum contracts in Belize (see Figure 22), including: BCH International Inc., BelGeo Ltd., Belize Natural Energy, Blue Creek Exploration Ltd., Island Oil Belize Ltd., Miles Tropical Energy Ltd., Northern Spirit Resources Inc., OPIC Resource Corporation, Perenco Limited, PetroBelize Ltd., Princess Petroleum Ltd., Province Energy Belize Limited, RSM Production Corporation, SOL Oil Belize Ltd., Spartan Petroleum Corporation, US Capital Energy Belize Ltd., West Bay Belize Ltd., and ZMT International Inc.[135] These companies have up to 8 years to explore for oil, and 25 years to undertake production and to pump oil commercially from the ground. If during the eight years no oil is found, then the contract self-terminates.[136]

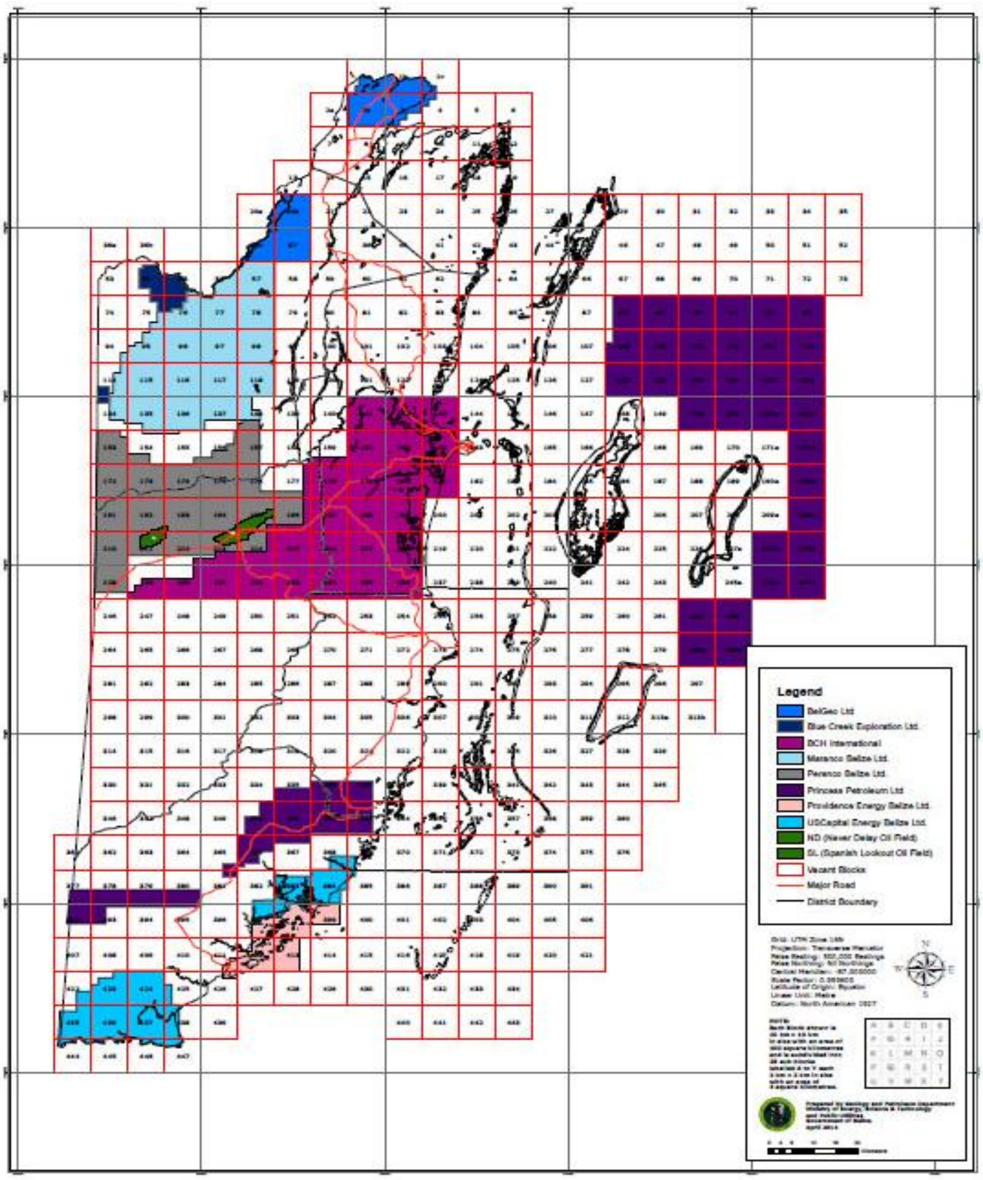

Figure 22. Belize Petroleum Contract Maps

3.4.3 Tourism Sector

According to the Belize Government, the country's vision is "to develop the tourism sector as a national priority, with a primary focus on responsible tourism, aimed at marine activities, natural history, and adventure markets."[137] Because the tourist sector comprises restaurants and hotels that generally are categorized under the commercial sector (but in some cases also under the services sector), it is estimated that the tourism sector was responsible for 25.8% of total energy consumption in 2010.[138] Tourism was the second most important sector of Belize's economy prior to the discovery of oil in 2005. In 2011, the tourism sector accounted for 12.5% of the country's GDP.

In 2011, the National Sustainable Tourism Master Plan (NSTMP) was developed through an extensive stakeholder consultation process. The NSTMP aims to achieve a set of quantitative and qualitative targets by 2030 through seven strategically defined outputs; for details, see the report.[139]

3.4.3.1 Hotels and Tour Operators

Belize is in a challenging position in terms of tourism competitiveness with neighboring countries, especially with regard to energy costs. The development of indigenous renewable energy resources for electricity generation, transport, and other tourism-related uses appears to be a key strategy to enable Belize to become a more competitive country in the sector. This is because most of the country's tourism destinations are located in remote areas or on the cays near the coastline. In Caye Caulker, for example, all fuel for power generation and transportation must be barged at high cost.

However, any intervention should be preceded by a resource potential study that gives priority to low (competitive) cost and firm energy options for electricity generation. Renewables can play an important role in supporting the sector. For example, heat demand (e.g., using solar water heaters) and cooling demand (e.g., using solar cooling systems) could be covered with the use of indigenous renewable sources. A nationwide energy efficiency improvement program for the sector is a must.

3.5 Residential, Commercial, and Government Buildings

The residential sector is responsible for 29% of primary energy demand in the building sector of Belize. By far the dominant energy function in the country's residential sector is space cooling. Air conditioning accounts for 36% of national electricity consumption, with large commercial buildings accounting for 53% of the air conditioning load, small commercial buildings for 29%, and residential buildings for 14%.[140] Government facilities account for the remaining 4%, with large and small industrial facilities accounting for less than 1% combined.[141] (See Figure 23.)

Plug and process loads are responsible for 30% of national electricity consumption.[142] Approximately 30% of the demand comes from commercial, residential, and industrial sectors.[143] The remaining 10% demand comes from government facilities.[144]

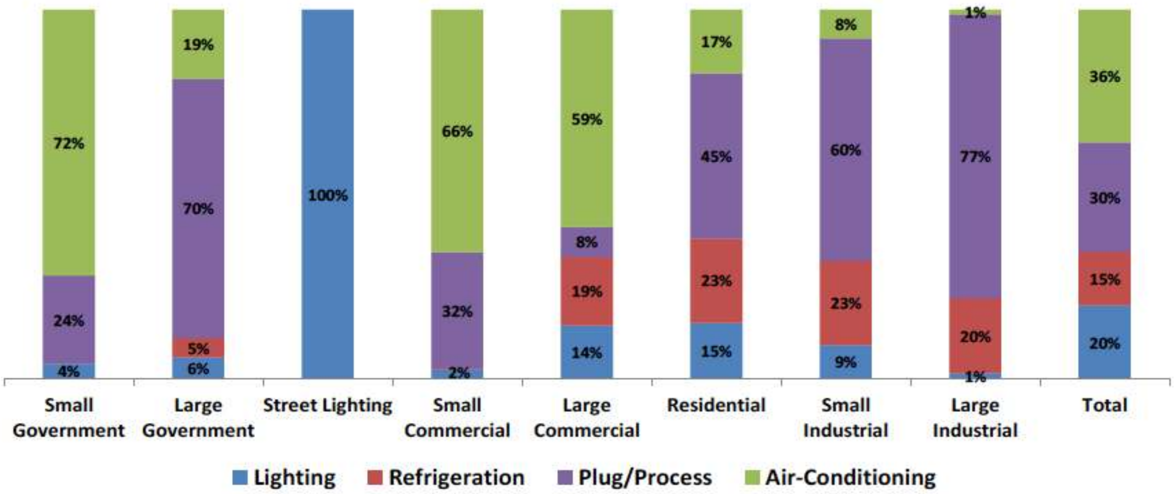

Figure 23. Electricity Use by Sector in Belize

3.5.1 Energy Use in Residential Buildings

The residential sector accounts for 29% of Belize's 65,000 electricity customers and for 146,000 megawatt-hours (MWh) of annual electricity consumption.[145] Consumption varies depending on the size and income level of the household, so patterns may be different from consumption patterns of individual residential customers.[146] As shown in Figure 24, plug-and-process load is responsible for 45% of electricity consumption, whereas air conditioning, refrigeration, and lighting account for 17%, 23%, and 15%, respectively.[147]

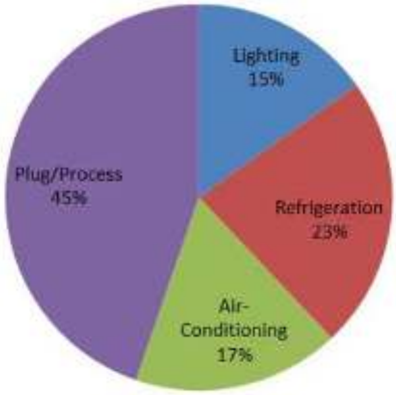

Figure 24. Distribution of Electricity End-Use in Residential Buildings

3.5.2 Energy Use in Commercial Buildings

The commercial sector is divided into two sub-sectors: the small commercial sector and the large commercial sector. The small commercial sector includes small offices, storefronts, restaurants, and other businesses. This sector has 16,709 customers and 78,800 MWh of annual electricity consumption, and is responsible for 16% of the national electricity demand.[148] Figure 25 illustrates the distribution of electricity end-use in small commercial buildings.[149] Air conditioning is the largest electricity consumer, responsible for 66%; plug-and-process load accounts for 32%, and lighting for just 2%.

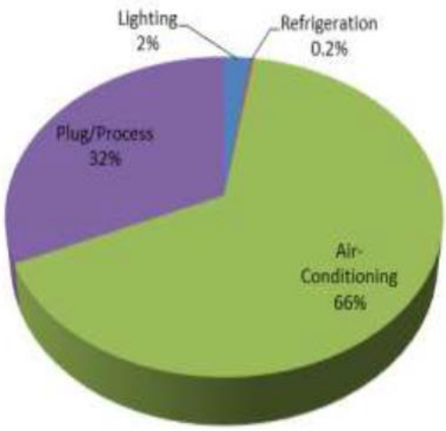

Figure 25. Distribution of Electricity End-Use in Small Commercial Buildings

The large commercial sector is composed of offices, large retail facilities, hotels, and some light industry. This sector has 1,284 customers and 163,800 MWh of annual electricity consumption, and is responsible for 32% of the national electricity demand.[150] Figure 26 illustrates the distribution of electricity end-use in large commercial buildings.[151] Air conditioning is the largest source (59%) of electricity consumption in large commercial buildings, followed by refrigeration (19%), lighting (14%), and plug-and-process (8%).

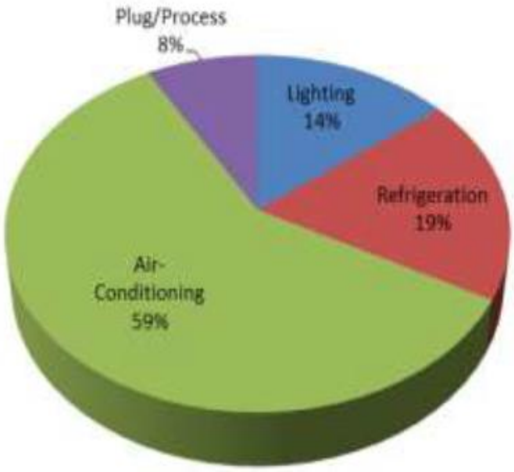

Figure 26. Distribution of Electricity End-Use in Large Commercial Buildings

3.5.2.1 Heat and Other Energy Carriers

It is generally known that LPG is the most commonly used fuel for water heating and cooking purposes in commercial buildings in Belize; however, no historical heat consumption data or information are available to determine the volume and type of energy sources used over time, to assess the consumption rates and trends in the sector. Furthermore, depending on the type of the commercial activity (which includes, among others, hotel resorts), some can have large demand for other end-uses of heat, for instance for spas, saunas, laundry facilities, and other activities that are typically considered part of the hotel services.

3.5.3 Energy Use in Government Buildings

3.5.3.1 Electricity

The government-building sector is divided into two categories: small government sector and large government sector. The small government sector includes government offices, sport facilities, schools, clinics, and army facilities.[152] It has a total of 989 customers and 5,800 MWh of annual electricity consumption, and is responsible for 1% of the national electricity demand.[153] Figure 27 illustrates the distribution of electricity end-use in small government buildings.[154] Air conditioning is accounts for 72% of the electricity consumed, followed by plug-and-process (24%) and lighting (4%).

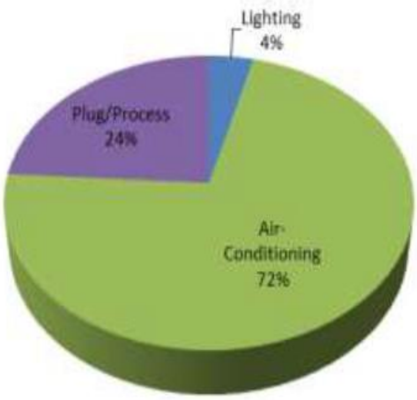

Figure 27. Distribution of Electricity End-Use in Small Government Buildings

The large government sector includes stadiums, hospitals, government ministry offices, and others. It has a total of 177 customers and 5,800 MWh of annual electricity consumption, and is responsible for 1% of the national electricity demand.[155] Figure 28 illustrates the distribution of end-use electricity in large government buildings.[156] Plug-and-process accounts for 70% of electricity consumption, followed by air conditioning (19%), lighting (6%), and refrigeration (5%).

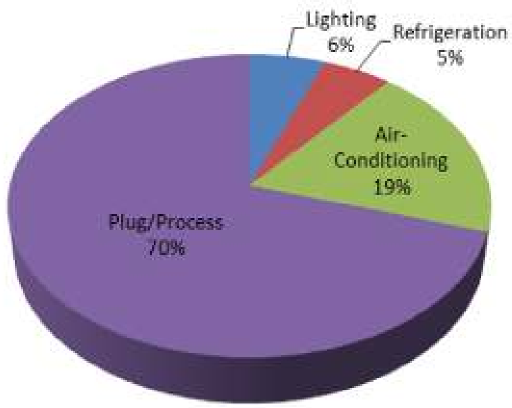

Figure 28. Distribution of Electricity End-Use in Large Government Buildings

3.5.3.2 Heat and Other Energy Carriers

There are no data or information available regarding the use of energy sources such as LPG, butane, or other energy carriers for cooking or other heating purposes in government buildings.

3.6 Rural and Isolated Regions

The electrification rate in Belize is around 90%. Many rural and isolated communities remain without access to reliable sources of electricity due to the high cost of grid connection. The Government of Belize acknowledges the important links between electrification and human development, and access to electricity is considered a priority in rural and isolated communities in the hinterlands. In rural areas, energy is by far the largest source for costs of any productive activity, especially in industrial production and for costs associated with the transport of agricultural commodities.[157]

3.6.1 Rural Electrification in Belize

Belize faces challenges in providing affordable electricity access for all, particularly in rural areas, which results in substantial electricity deficits and high-energy poverty rates.[158] To ensure reliability and electrification, the Ministry has requested the development of a rural electrification study and plans to consider the deployment of small-scale renewable systems, particularly solar PV and self-generation units of hydropower, wind, and biomass. This work is captured in the report that covers Task 4 of this EUEI PDF project, “Off-grid Rural Electrification Assessment and Strategy.” The aim of Task 4 is to assist the Government of Belize in planning activities for providing energy carriers for rural communities in Belize.

3.6.2 Other Energy Needs in Rural and Isolated Regions

Despite the current efforts to electrify rural communities, there are still many households without electricity services. Many rural communities located in areas that are not accessible to the network can benefit from renewable energy technologies. Cost-effective off-grid solutions should be applied as solutions for these communities, enabling them to satisfy other energy needs such as for Internet, refrigeration, radio communication, etc. Often it is cheaper for households and businesses to self-supply electricity from renewable sources rather than using diesel generation or connecting to the grid. Renewable energy technologies play a key role in enabling innovation, development, and deployment of decentralized approaches to tackle the challenge of universal access to modern energy services.

3.7 Key Findings and Recommendations

Although this chapter provides a general snapshot of the energy sector of Belize, there remain substantial gaps in data and energy analysis for understanding energy production, supply, and consumptions patterns in the various sectors of the economy. Most data and information are sourced from publicly available sources and are generally outdated and cannot be verified.

There is a critical need for a systematic primary energy data collection and statistics management system to continuously update energy statistics and to enable the use of energy indicators to understand the latest energy dynamics in Belize (see the Task 3 report of this EUEI PDF project). Periodic energy sector diagnostics are necessary to understand the latest conditions and performance, and in particular to be able to assess progress made in the implementation of activities toward achieving the goals and targets set for 2030.

4 Technologies and Solutions to Consider

This chapter follows the Trias Energetica concept in the analysis and prioritization of interventions, as this concept provides a clear order of interventions based on the logic that the best and most cost-effective way to address energy challenges is 1) by avoiding the need for energy, 2) by addressing the remaining energy demand by prioritizing the use of renewable energy sources, and 3) by using generated energy as efficiently as possible, regardless of its source.

4.1 Energy Avoidance and Savings

Although energy savings is not commonly addressed as a separate category of interventions in roadmaps, one reason for doing this is to highlight the difference between “energy avoidance and savings” and “energy conservation and efficiency” measures, following the Trias Energetica concept. In this Roadmap, activities that lead to complete changes in the way a product, service, or need is created or addressed, and that thereby completely or partially avoid the need for energy, are considered energy-savings measures. For example, purchasing a new hybrid vehicle to go 20 miles from home to work represents an improvement in fuel efficiency compared to a regular car over the same distance. But deciding to move close to the workplace, which can be reached in 10 minutes by walking, results in complete avoidance of the need for a vehicle to drive for 20 miles on gasoline.

Energy-saving measures are mainly linked, among others, to behavioral changes, re-design of buildings and products, and re-thinking the way businesses provide services that lead to avoidance of energy needs (no generation of kWh or gallons of fuels). In contrast, energy conservation and efficiency recognizes an existing energy carrier (electricity, heat, or fuel) that serves a particular purpose and targets its conservation and efficient use.

4.1.1 Behavioral Changes

One of the most familiar energy-saving measures is targeting and triggering behavioral changes. A growing body of evidence in academic literature highlights the potential for energy savings triggered by measures targeting behavioral changes of consumers. However, there are still challenges ahead, including the key difference between consumer behavior and consumption practice.[159] Behavioral changes can be triggered via: changing the opinion and mindset of people (i.e., giving them access to data and information on new types of services), alternative mobility, the introduction of new multi-functional products, innovative building and structure designs, and many more issues that do not relate directly to the energy sector but that may lead to drastic shifts in energy consumption. The Internet, as the main source of modern communication, can play a pivotal role in this area.

4.1.1.1 Internet as a Tool for Energy Savings

In this information age, the Internet is central to many people's life and businesses, it allows people to communicate effectively through many means (calls, emails, chats, messages, etc.), and it provides access to unlimited data and information. This can be used as an effective means to avoid energy consumption by replacing traditional energy-consuming activities and by effecting a change the mindset of entire communities through access to information. The ease of access and the low cost of the Internet makes it a very useful tool to address energy savings.

Examples of the potential of the Internet as a tool for energy savings include:

Avoid home-work commute: Instead of sitting for hours in traffic to commute from home to work and back, the Internet offers the opportunity for people to work from home and avoid the usage of vehicles, reducing gas consumption and increasing productivity, which in time also saves energy.

Avoid use of energy consumed in products and activities: Modern devices such as laptops, tablets, and smart phones offer the opportunity to share data, reports, and other information digitally, instantly, and across the globe, avoiding the need to use paper, printers, copy machines, mailing services, and other types of products that required energy to be produced, or activities that consume energy. Furthermore, these devices serve as all-in-one devices that include digital agendas, cameras, phone, text, data processing, and many other functions that replace traditional products, tools, and services, which otherwise would have demanded energy.

Transform entire communities' perspective about the use of energy: Through social media campaigns and other digital media, effective energy-saving measures have been incentivized and a growing awareness about the need to reduce energy use has been achieved.

4.1.2 Smart Metering

Reducing energy consumption and cost by avoiding the need for electricity for plug/process and air conditioning in buildings (see Section 3.5) is a key area of intervention for residential, commercial, and public building owners across Belize.

Smart meters create the conditions for people to access real-time data and information about energy consumption patterns.[160] (See Figure 29.) The meters collect energy data, which is then downloaded for use. Smart metering systems applied in buildings change the context in which energy is used within the building. They allow building users, but also energy providers, to properly understand energy use and can accurately measure natural gas and electricity consumption, enabling consumers to track usage over time and to make changes in energy consumption patterns. Smart meters also can help energy suppliers communicate with their customers, sending cheaper tariff options and information updates. (See Annex 1 for more details.)

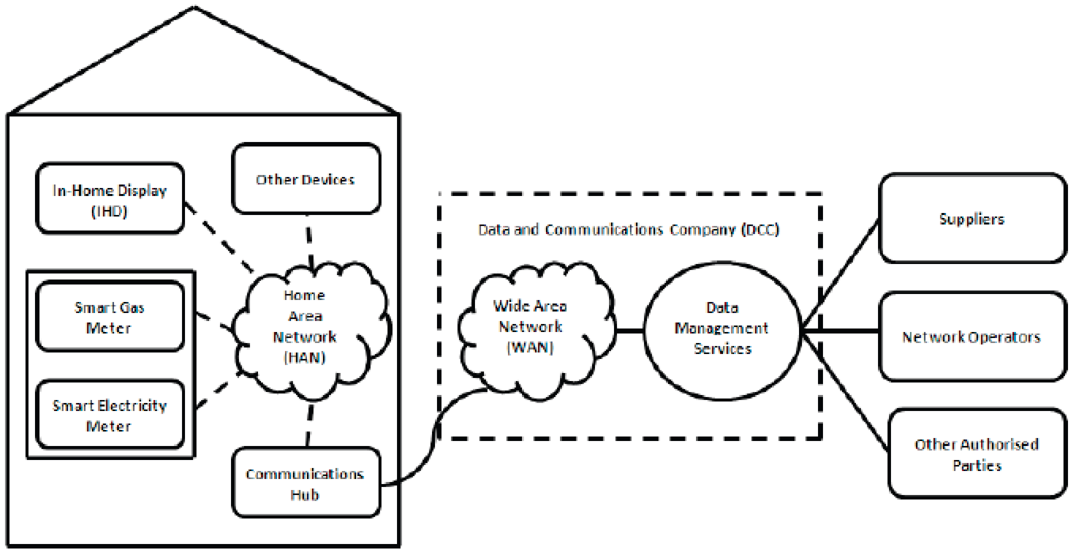

Figure 29. Illustration of a Smart Meter Program

Currently there is not sufficient practice and evidence in commercial or government buildings in Belize (where the majority of the power is consumed for the use of office devices and air conditioning) to demonstrate the potential of smart meters for energy savings. It therefore is recommended to start with a demonstration project to learn and observe the benefits that can be accrued from using smart metering applications.

4.1.3 Alternative Mobility

Fuel consumption in Belize is a key area for intervention as it currently is dominated by the use of imported gasoline, diesel, and fossil fuels for use in transportation and as stationary fuels. Prior to engaging in measures to increase fuel efficiency or to reduce environmental impact and import dependency by shifting to fuels derived from domestic renewable energy sources, it is worth considering other types of sustainable mobility means applicable to Belize.

Currently many Belizeans depend on the use of private vehicles, which run on gasoline or diesel. The objective behind alternative mobility is to trigger the imagination and innovative ideas that can help to identify and develop completely different means of mobility and drastically reduce energy needs (e.g., carpooling, the use of bicycles, incentivizing the use of mass public transit, etc.).

4.1.4 Re-thinking Products and Business Models

Many small and medium-sized enterprises (SMEs) and businesses in Belize struggle to compete on the international market. Globally, consumers are becoming more aware of the social and environmental impacts of businesses and more selective and demanding with regard to the types of products and services they request. Green economy, lean manufacturing, sustainable production and consumption, corporate social responsibility (CSR), and many other terms or systems have been created to enable businesses to showcase their best intentions and efforts to produce high-quality products and services while simultaneously reducing their social and environmental impacts.

Designing products that can fully be recovered and reutilized for the production of the same or better-quality products is an increasingly important requirement in the global market. Biodegradable products fit within this concept, as they can be designed and manufactured to serve a purpose for a predefined period of time, and then can be recovered and degraded back into organic compounds, serving as a nutrient-rich source for nature to thrive, rather than leading to contamination.

Compared to the continued use of conventional products, this represents a significant improvement in energy consumption, as conventional products that are not designed for reuse need to be recycled. The separation, treatment, and conversion of material streams such as plastics, glass, and metals into useful secondary lower-grade products is very energy-intensive, resulting in lower-value products and still leading to contamination and other impacts over time.

Belize, with its abundance of biomass resources, is well positioned to explore innovative ways to use organic materials to produce high-end biodegradable products that can be exported to niche and premium markets. Investigating eco-design and sustainable manufacturing approaches, and exploring the costs and benefits of incentivizing local start-ups and SMEs in creating new business models, will not only result in the design of high-quality products, but also enable developers to become profitable, competitive, and sustainable while creating energy savings.

4.1.5 Energy Savings Opportunities in Belize

As described earlier, a variety of energy savings opportunities and solutions can be considered for application in Belize. The purpose behind presenting the energy savings options in this report is to inform and create awareness that there are plenty of out-of-the-box solutions and technologies available to address energy consumption patterns in Belize. There is a critical need to investigate energy-savings opportunities such as: behavioral changes through the use of smart metering systems; the possibilities offered through effective use of the Internet; alternative mobility means beyond the scope of sustainable transportation; and the design and manufacturing of innovative products and services and new business models that may trigger the creative thinking of decision makers and discussion among unconventional stakeholders and partners to provide ideas and solutions to the energy development challenges in Belize.

Ideas and technologies recommended for further investigation and application in Belize are:

The Internet can be used as an effective means to avoid energy consumption by replacing traditional energy-consuming activities and by effecting a change in the mindset of entire communities through access to information. The ease of access and the low cost of the Internet make it a very useful tool to address energy savings. This is exemplified by opportunities such as:

- **Promote a work-from-home culture**: Instead of sitting for hours in traffic to commute from home to work and back, the Internet offers the opportunity for people to work from home and avoid the usage of vehicles, therefore reducing gas consumption and increasing productivity, which in time also saves energy.

- **Create incentives to increase access to multi-functional products and devices**: Modern devices such as laptops, tablets, and smart phones offer the opportunity to share data, reports, and other information digitally, instantly, and across the globe, avoiding the need to use paper, printers, copy machines, mailing services, and other types of products that required energy to be produced, or activities that consume energy. Furthermore, these devices serve as all-in-one devices that include digital agendas, cameras, phone, text, data processing, and many other functions that replace traditional stand-alone energy-consuming products, tools, and services, which otherwise would have demanded additional energy.

- **Use social media to transform entire communities' perspective about the use of energy and trigger behavioral change:** Through social media campaigns and other digital media, effective energy-saving measures can be incentivized and public awareness on behavioral changes can effectively be communicated to conserve energy.

- **Explore the opportunities for application of smart metering systems in public buildings:** Through demonstration projects, smart metering can be tested and its benefits and effectiveness assessed. Properly functioning smart metering systems provide instant data and information about energy consumption patterns and trigger behavioral change of the owner or building occupants to conserve energy.

- **Promote and incentivize the use of alternative mobility options:** The objective behind alternative mobility is to trigger people to opt for alternative means of mobility that prevent the need for additional energy consumption. This includes activities as carpooling, biking, walking, or use of mass public transportation options.

- **Create or upgrade infrastructure for alternative means of mobility:** During urban planning processes, new bike lanes and other infrastructure can be planned to lead to improvements in bicycle, pedestrian, and transit service alternatives.

- **Introduce sustainable design criteria in national building codes and procedures:** The objective of sustainable design of buildings is to reduce, or avoid, depletion of critical resources (energy, water, and raw materials), prevent environmental degradation caused by facilities and infrastructure throughout their life cycle, and create environments that are comfortable, safe, and productive. A variety of internationally accepted building certification programs, such as ASHRAE, LEED, and others, can be applied in Belize.

- **Promote eco-design, innovation, and sustainable production and consumption to conserve energy:** Belize, with its abundance of biomass resources, is well positioned to explore innovative ways to use organic materials for producing high-end biodegradable products to be exported and sold in niche and premium markets. Investigating eco-design and sustainable manufacturing approaches, and exploring the cost-benefits of incentivizing local start-ups and SMEs in creating new business models, will not only result in the design of a high-quality product, but also enable businesses to become profitable, competitive, and sustainable while creating energy savings.

4.2 Use of Renewable Energy Resources

As the second step of the Trias Energetica hierarchy, this section categorizes renewable energy technology solutions targeted for each of the three main energy carriers: electricity, fuel, and heat.

4.2.1 Electricity

4.2.1.1 Renewable Energy Resources for Electricity Generation

To address the gap between domestic electricity production and consumption, Belize has relied on power imports from Mexico. The amount required is always dependent on the available verified renewable energy resources in Belize.

The U.S. Department of Energy's (DOE) Energy Transition Initiative has highlighted the potentials of various renewable energy sources in Belize, including hydro, wind, biomass, and solar.[161] (See Table 21.) In addition to the U.S. DOE's assessments, the Worldwatch Institute's Caribbean Sustainable Energy Profiles state that Belize has 70 MW of hydropower capacity potential, of which it has utilized 78%; has medium potential for wind generation, although it has not yet been quantified; large potential for biomass power and waste-to-energy, with 27.5 MW of capacity already installed; and 42 MW of solar potential, compared to a current utilization rate in Belize of just 1%.[162]

Table 21. Renewable Energy Power Generation Potentials in Belize

Renewable Energy Technology	Capacity Potential (MW)	Installed Capacity (MW)	Renewable Share of Generation Mix in 2012
Hydro	70–84	51.5	39%
Wind	20	0	0%
Biomass	40	27.5	12%
Solar	42	0.08	0.1%
Total	56.8%	˜80	

Source: See Endnote 162.

It is important to highlight that, based on a recent analysis by Worldwatch (see Task 3 Report under this EUEI PDF project), the quality of the primary data used for estimating the renewable energy resource potential for Belize is, in most cases, not verifiable, accurate, or consistent. The conclusion is that none of the data presented is based on actual measurements (using adequate and calibrated equipment and instruments) and/or was not done through a coherent data collection and processing methodology that is verifiable and adequately reflects the real situation in Belize. Caution therefore is warranted when referring to the data presented throughout this report.

Due to this situation, it is highly recommended to prioritize the installation of proper measurement equipment and the establishment of primary data collection tools and systems to enable Belize to provide invaluable information about day-to-day performance as well as, more importantly, long-term trends for energy planning purposes, and to explore the potential of its renewable energy resources.

4.2.1.2 Grid-connected Renewable Generation Technologies

Despite the challenges related to primary energy data availability and quality, further qualitative assessments and judgments are made regarding technologies deemed suitable for Belize. The GoB report *Towards Energy Efficiency, Sustainability and Resilience for Belize in the 21st Century*, mentions two major ethanol production projects that are in the planning stage.[163] The Libertad Sugar Factory was brought to Belize by a Mexican consortium with the intention of producing ethanol for export, but little development has occurred to date.[164] A second ethanol bio-refinery and co-generation plant, in the Big Falls area of Belize District, is to utilize 30,000 acres of sugar cane, with a capacity to produce 30 million gallons of ethanol per year and generate 25 MW of electricity, of which 9 MW would be sold to the national grid.[165]

Bagasse

Belize Sugar Industry (BSI) Factory produced approximately 403,675 tons of bagasse in 2010 from 1.167 million tons of sugar cane.[166] About 75% of the produced bagasse, alongside 229,420 gallons of heavy fuel oil, was used in steam turbines producing 91,961 MWh of electricity and 456,270 tons of low-pressure steam.[167] The electricity generated by the steam turbines was supplemented by an additional 5,748 MWh supplied by diesel generators to complement the electricity needs of BSI and Belcogen (55,077 MWh).[168] The remaining 48,632 MWh was sold into the grid.[169]

The Belcogen co-generation plant collects 82 tons of bagasse per hour, from the original 275 tons of sugar cane per hour, which is processed by BSI. From 82 tons per hour, Belcogen is able to produce 13.5 MW of electricity for the grid, including 8 MW of electricity and heat required for sugarcane processing.[170]

4.2.1.3 Belize's National Grid and Regional Interconnection

According to Belize's renewable electricity target for 2030, the country has set ambitious targets to shift from being a net electricity importer to becoming a net electricity exporter by 2030. One of the strategies being considered is the further integration of Belize into Central America's evolving grid interconnection system, SIEPAC. The premise is that regional electricity integration could lead to the identification of lower-cost power generation options and electricity prices that stimulate competition among Central American countries and Mexico, but also from the perspective of attracting investors into Belize to invest in future additional (renewable) power generation capacity and achieve higher penetrations of variable renewable energy resources to export to the Central American electricity market and beyond.

4.2.2 Fuels

Biofuel technologies can play a key role in the development of a low-carbon economy in Belize. The ultimate goal is to become a net exporter of biofuels before 2033.[171] One of the five pillars considered for the 2030 Belize Sustainable Energy Roadmap is to upgrade production systems for processing agriculture and forestry outputs to co-produce biofuels and/or electricity.

4.2.2.1 Ethanol

According to a study done by the OAS in 2009, there is potential for a cellulosic ethanol market in Belize. Currently, approximately 717,469 metric tons per year of cellulose feedstock is available, composed of residues from cultivation, harvesting, and processing activities within the agricultural and forestry sectors, as well as organic and biodegradable waste from municipal solid waste (MSW) management activities.[172]

This amount of cellulose feedstock is enough to develop a mid-size cellulosic ethanol plant (500,000–700,000 tons/year) that can yield about 39.0–46.3 million gallons per year based on 2008 technology; with 2012 technology improvements, it can yield approximately 50.2–68.9 million gallons per year.[173] The estimated cost of producing cellulosic ethanol in Belize can be between USD 1.64 and USD 2.89 per gallon under 2008 conditions.[174]

Belize has the potential to produce 37.4 million gallons of ethanol per year, assuming that it uses 100,000 of the available 809,000 hectares of land suitable for agriculture, and yielding one-half of the lower end of Brazil's current yields.[175] This production potential is about 25% more than current gasoline consumption.[176] Ethanol production from sugar cane can provide up to 15 times more employment than extracting and refining petroleum for vehicle fuels.[177]

Belize has the potential to produce 1,000 GWh per year of electricity with its current available biomass resources, including bagasse but excluding animal and sewage waste.[178] Belize District has the potential to supply 15% of its current electricity demands, assuming that one-third of the total 350,000 tons of municipal solid waste generated in Belize City and the surrounding areas is used for power generation.[179]

4.2.2.2 Emerging Technologies to Consider for Fuel Supply in Belize

Algae-based Biofuels

Algae can serve as a feedstock for a wide variety of biofuels, including biodiesel, ethanol, biobutanol, biogasoline, and biohydrogen. Algae is an interesting feedstock to consider for Belize, due to its high lipid content and high harvesting yields. Among the benefits of algae is that harvesting cycles are only

1 to 10 days, compared to yearly crop cycles for most competing feedstock sources including palm oil, soybeans, and *Jatropha curcas*. There are claims that algae can yield about 5,000–20,000 gallons per year per acre, a volume 7 to 31 times that of conventional biodiesel feedstock.

An additional benefit is that CO_2 emissions from other industrial processes can be captured and used in bio-reactors to grow algae. In this way, an integrated, closed-loop-cycle carbon sequestering solution is provided to power plants or agro-processing industries in the country. Furthermore, waste water originating from industrial or conventional wastewater treatment plants can be used as feedstock for growing algae while removing nutrients from the wastewater stream. These are examples of mutual beneficial solutions that allow for integration of industrial processes and open up opportunities for new innovative business development in Belize.[180]

4.2.2.3 Sustainable Transportation

The Government of Belize is committed to improving sustainability in the transportation sector. The pathway toward sustainability demands a collaborative approach in which organizations work together to share knowledge and learn from each other.

Dependence on fossil fuel-based transportation systems leads to negative effects such as air pollution and high infrastructure costs. Alternatives such as biodiesel, electric utility and passenger vehicles, "The Veggie Car," mass transit options, and incentives for carpooling, car sharing, and efficient vehicles can help reduce these environmental impacts, while also helping to promote other benefits such as physical wellness through increased daily activity (e.g., walking and biking). All these technologies or alternative means of transport can contribute to making transportation in SIDS more sustainable.[181]

The European Union Council of Ministers of Transport defines "sustainable transportation" as:[182]

- Transportation that allows for the basic access and development needs of individuals, companies, and society as a whole to be met safely and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations;
- Transportation that is affordable, operates fairly and efficiently, offers a choice of transport mode, and supports a competitive economy, as well as balanced regional development; and
- Transportation that limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and uses non-renewable resources at or below the rates of development of renewable substitutes, while minimizing the impact on the use of land and the generation of noise.

The Ministry responsible for transport in Canada defines "sustainable transportation" as:[183]

- A transportation system and transportation activity in general, must be sustainable on three counts—economic, environmental and social. Practically, this means ensuring that decisions are no longer made with the environment as an afterthought.

The "needs" for sustainable transportation that must be preserved for future generations are not clear and are usually related to economic development, social and human development, and environmental and ecological health. Unfortunately, different stakeholders and groups have different interests, making the definition of "transportation needs" complicated.

For example the transportation sector does consume resources that can be depleted: energy, human and ecological habitats, atmospheric carbon loading capacity, and individuals' available time. But solutions that reduce depletion of one of these may exacerbate depletion of another. Moreover, transportation decisions tend to be made in the service of larger policy goals: economic growth and job creation, the character and intensity of land use, and socioeconomic and geographic transfers of wealth.[184]

4.2.2.4 Sustainable Transportation and Environment Pillars

Sustainable transportation and environment pillars include, among others:[185]

Vehicle Efficiency. Vehicle efficiency essentially translates as kilometers per liter or miles per gallon (MPG). In order to introduce these technologies in SIDS, the adoption of fuel economy standards needs to be mandated by SIDS governments. Enhancements in vehicle technology, such as regenerative braking and automatic "start/stop technology," should be deployed to increase overall fuel efficiency, among other technologies.

Alternative Fuels. A key aspect to make the transport sector in SIDS sustainable is by replacing fossil fuel-based transportation technologies with alternatives such as all-electric vehicles, gas/electric hybrids (including plug-in hybrids), and other technologies that can significantly improve fuel efficiency while offsetting the use of imported fossil fuels. The future may also include vehicles powered by hydrogen and natural gas.

Travel Activity. Altering travel patterns and providing multimodal transportation alternatives are key solutions for reducing travel in cars. This may be accomplished via pricing measures, improvements in bicycle, pedestrian and transit service alternatives, and (in the long term) changes in land use. Many of these options should be assessed in a SIDS context.

Transportation System Performance. Improving the transportation system's performance through the use of operational strategies and new traffic technologies is one of many options for SIDS that need a mass transportation system or have one in place. These include synchronized and adaptive signal timing at intersections; Active Traffic Management (ATM) systems providing variable speed limits and dynamic lane control; traffic incident and emergency management systems; transit signal priority systems; real-time traffic and multimodal travel information; dynamic routing; integrated corridor management; smart transit and parking systems; electronic and open-road toll collection, and more. Intelligent Transportation System (ITS) technologies are an integral part of the strategies and their successful operation.

Of the many sustainable transportation technologies suitable to SIDS, two examples include: intelligent vehicles, which are being developed in the market and manage spacing between adjacent cars with the potential to greatly increase the capacity of existing infrastructure; and telecommuting/ telecommunications, a change in mobility that is being driven by demographics as well as by innovations in technology that are making it possible for people to work from home and prevent the need to commute.

Table 22 provides a summary of new technologies that will be available in the short term.[186] However, the lack of R&D and assessment of most suitable transportation technologies for Belize make it very challenging to provide a qualitative assessment.

Table 22. New Technologies That Will Be Available in the Short Term to Achieve Sustainable Transportation

Some Emerging Technologies	
Biofuels-based pavements	Improvement to reduce rolling resistance for pavements
Carbon nano fiber reinforced cement	Inherently low emission vehicles (ILEV)
Carbon-neutral roadways	ITS technologies for traffic management
Car plug-in stations	ITS technologies for vehicular spacing & speed (IVHS)

Some Emerging Technologies	
Design for deconstruction	Natural gas and/or biofuel fueling stations
Electrified freight railways (if applicable)	Online electric vehicles (OLEV)
Electric vehicles (EVs)	Pavement heat exchangers
Glass highways	Photo-catalytic concrete (self-cleaning concrete)
Glass materials in highways	Solar highway energy generation
Green cement	Solar roadway marking and signs
High-speed rail passenger systems (if applicable)	Solar, wind power in jersey barriers
Heated bridge decks	Sustainable roadway rest stops
Hydrogen highways	

Source: See Endnote 186.

4.2.2.5 Summary of Findings

Overall, there are limited if any available statistics regarding sustainable transportation for Belize. However, because of the country's land availability limitations and population density, smart solutions will be needed and should be mandated through new and innovative regulations and policies to improve the quality of vehicles imported to Belize. There also is a need to assess the introduction and deployment potential and/or rate of electric and hybrid vehicles, as well as to evaluate the potential introduction of state-of-the-art mass transport technology to provide a comprehensive and integrated solution.

With regard to maritime and air transportation, currently the only possibilities are the use of biofuels for jets and a focus on improving cargo facilities in ports to reduce local environmental impacts and prevent waste dumping from ships in Belize waters. The international nature of the transport sector limits Belize's ability to take unilateral action to "green" air and maritime freight transportation.

4.2.3 Heat

This section first analyses the end-uses of heating and cooling applications and then identifies measures to optimize heating and cooling systems and efficiencies in the power generation and fuel production areas.

4.2.3.1 Heating and Cooling Needs

There are a variety of cooling technology options for cooling, heating, and power. Belize's entire energy efficiency program can benefit from a comprehensive strategy on heating and cooling. In particular, the country needs to look into the enormous potential of recoverable heat (often called waste heat or excess heat), which can be a byproduct of industrial processes or services such as data centers, supermarkets, or energy-intensive industries. It is critical to develop a *Heat Roadmap for Belize*, providing a clear assessment of the recoverable heat potential that, at some point, could meet the entire space heating demand in the country.

In addition, it is necessary to look at synergies between the electricity sector and the heating and cooling sector, in particular with regard to renewable energy sources. This implies looking at the potential of thermal storage to utilize off-peak electricity, for example. Literature suggests that thermal storage is many times cheaper than electricity storage. Fortunately, the technologies needed to make heating and cooling more efficient are already available and are helping to reduce energy bill for end-consumers in many parts of the world.

4.2.3.2 Heating Needs in the Agricultural Sector

Some important components of industrial energy systems are:

Steam systems: Steam is an important intermediate energy carrier in manufacturing industry and is most often raised in boilers[§], in which fuels are combusted. The heat is transferred to pipes, which in most boilers are organized into three sections: an economizer where the water is preheated to near the evaporation temperature; an evaporation section where the water is evaporated to create saturated steam, and a super heater, where the steam is further heated to the required temperature. The steam is then distributed through steam pipes to the places where the heat is required. Heat is transferred to the production processes through condensation (normally this steam is only slightly superheated), and the condensate is recycled to the boiler. High-pressure superheated steam also can be used to drive rotating equipment, using steam turbines.

Heat exchangers: Heat exchange between two flows occurs frequently in industrial processes. A simple example is a process where the heat of the hot outgoing flow can be transferred to a cold incoming flow. There are many types of heat exchangers. The amount of heat transfer is proportional to the heat exchanger area and the temperature difference between the flows. Furthermore, it depends on the physical properties of the fluid media, the surface characteristics of the heat exchanging area, the fluid velocities, etc. The heat exchange between two liquid flows requires much less area than between two gases (at the same temperature difference).

Motor drives: Electricity in manufacturing industry is used predominantly for motor drives. The three main types of equipment that are driven by these motors are: fans, used for the transportation of gases (without a substantial pressure increase); compressors, used for bringing gases to elevated pressures; and pumps, used for the transportation of liquids. Electric motors have high conversion efficiencies, typically above 90% for industrial motors. However, important energy losses occur in the total system that is driven by the motor.

Separation processes: In many sectors, especially in the food industries, separation processes are important. These include:

- Evaporation, the evaporation of water or another liquid from a mixture or solution in order to make the latter more concentrated. An example of an evaporation process is to produce concentrated milk out of raw milk (e.g., as a first step to make powdered milk). Simple evaporation would be very energy-consuming: the energy requirement would be equal to the heat of vaporization of water (approx. 2.5 GJ/ton). However, in practice evaporation is done in a number of stages where the water vapor in a stage is used to heat the next stage through condensation. In theory, the heat required for an n-stage evaporation process is 1/n-th of the heat required for a single-stage process.

- Drying, the further evaporation in order to completely or nearly completely remove the remaining liquid. An example is the further drying of condensed milk in order to get powdered milk. This is done in drying towers where the condensed milk is sprayed into heated air.

- Distillation, which is done to separate components of a mixture of liquids and gases by making use of differences in evaporation temperatures of the substances comprising the mixture. Distillation is used, for instance, in refineries for separation of crude oil into fractions. An important, very-low-temperature separation process is the production of oxygen through air separation.

[§] An alternative way of steam raising is in CHP-plants (see Section 5.4). Also, steam is generated by heat recovery from production processes.

- Membrane separation, an emerging separation process that may require less energy than alternatives. Membrane separation is used, for instance, to separate a mixture of carbon dioxide and hydrogen.

Technologies such as low/zero-carbon and energy-efficient heating and cooling for buildings have the potential to reduce CO_2 emissions and increase efficiency. Technologies such as solar thermal, combined heat and power (CHP), heat pumps, and thermal energy storage are all commercially viable today. Active solar thermal (AST) can provide space and water heating, as well as cooling needs. CHP systems are mature and a useful transitional technology, while micro-CHP, biomass CHP, and even fuel cell systems may develop as important reduction options.

Heat pumps for cooling and space water heating also are mature, highly efficient technologies that take advantage of renewable energy sources. Thermal storage includes sensible (hot water, underground storage), latent ("phase change" materials), and thermo-chemical storage. Thermal storage can maximize the energy savings and energy efficiency potential of other technologies, facilitate the use of renewable energy and waste heat, and improve flexibility. Table 23 shows key characteristics of heating and cooling technologies.[187]

Table 23. Key Characteristics of Heating and Cooling Technologies

Technology	Typical Size (kW)	Efficiency	Capital Cost (per kW)	Fuels	Fuel Cost
Heat pumps (electric)	2.5-10	200-600	Low-medium (air conditioning)/medium high (space/water heating)	Electricity	Medium-high
Heat pumps (gas-engine driven)	15	120-200	Low-medium	Gaseous fuels	Low-medium
CHP	1-15	70-90	Medium-high	Coal, liquid fuels, gaseous fuels, bioenergy, hydrogen	Low-medium
Absorption/absorption chillers	N/A	70-120	Medium	Gas, oil, bioenergy, solar, waste heat	Low-medium
Solar thermal	2.5-10	100	Low-high	Solar	N/A

Source: See Endnote 187.

4.2.3.3 Heating and Cooling Needs in the Tourism Sector

Hot water demand is the most common application for solar water heaters (SWH). In countries with high solar insolation and low seasonal variation (i.e., Caribbean countries), SWH can supply a high percentage of total demand of hot water for the tourism sector. In terms of processed heat, solar commercial and industrial process heating applications provide hot water for buildings and industries with low-temperature process heating needs, such as hotels, restaurants, car washes, laundries, food processing, water treatment, and desalination. There is a wide variety of application for technologies based on solar, e.g., hot water and air heating and cooling, swimming pool temperature regulation, etc.

4.2.3.4 Heating and Cooling Needs in the Power Sector and Fuel Supply Sector

Co-generation, also known as combined heat and power (CHP), refers to a group of proven technologies that operate together for the concurrent generation of electricity and useful heat in a process that generally is much more energy-efficient than the separate generation of electricity and useful heat. Belize is currently taking advantage of this technology. However, the potential is much bigger, and it should be expanded in the country.

There are other technological possibilities, such as the use of biomethane/biogas as a heating fuel. Various bio residues and wastes can be used as feedstock, including, for example, animal manures and other agricultural residues. These can help local communities reach energy self-sufficiency, especially in isolated or rural areas.

4.2.3.5 Recommendations for Heating and Cooling in Belize

In recent decades, Belize has experienced a dramatic increase in fuel consumption for heating and cooling, automobile transport, industrial activities, and electricity generation, making it increasingly critical to introduce energy efficiency and renewables in the cooling and heating sector. If consumers are not given adequate incentives to address the cost of energy use, they are unlikely to make optimal decisions from an economic and environmental perspective. Key barriers that need to be addressed include: high initial costs, market risks for new technologies, and information uncertainty (technical, regulatory, policy). It therefore is critical to develop and implement policies that incentivize consumers and help to eliminate these barriers.

All stakeholders need to understand their responsibilities in the long-term vision for the sector so that technologies and industry support structures are put in place in a timely fashion to meet deployment goals.

4.3 Energy Efficiency

The last step of the Trias Energetica concept involves using energy as efficiently as possible, regardless of its source. Major sectors for energy conservation and energy efficiency improvement in Belize include: the transport sector, industry and commercial buildings, households and institutions, and agriculture.[188]

This section explores several energy conservation and efficiency measures that can be adopted to achieve the targets set in the 2030 Sustainable Energy roadmap. The majority of the measures described are extracted from the Belize Sustainable Energy Strategy (2015), which undertook an extensive assessment to identify and select relevant and applicable energy conservation measures (ECMs) for Belize. The sections below include descriptions of the technologies, solutions, and systems employed in these energy efficiency measures, as well as discussion of how energy savings potential is assessed for each.

4.3.1 Energy Efficiency in Buildings

4.3.1.1 Sustainable Building Design

Sustainable building design has both direct and indirect positive impacts on the environment, society, and economy. The main objectives of sustainable design are to reduce (or avoid) depletion of critical resources (energy, water, and raw materials), to prevent environmental degradation caused by facilities and infrastructure throughout their life cycle, and to create environments that are comfortable, safe, and productive. Retrofitting can be an important step to achieve a more cost-effective building.

One of the main challenges to sustainable building design in Belize is a lack of knowledge among architects, contractors, policy makers, and users. There is an immediate need to build capacities in the sector and to introduce new building codes as well as government capacity to oversee the implementation of these new codes.

4.3.1.2 Replacing Conventional Light Bulbs with LEDs

Lighting accounts for 20% of national electricity consumption in Belize. Street lighting accounts for over half of the total lighting load, and large commercial and residential sectors account for most of the remainder. Based on assessments in the Belize Sustainable Energy Strategy (2015), lighting ECMs have the potential to reduce lighting electric load by 43%.[189]

4.3.1.3 Reducing Cooling Loads and Upgrading Air Conditioning Systems

As described earlier, air conditioning accounts for 36% of national electricity consumption in Belize. Large commercial facilities represent 53% of air conditioning load; residential and small commercial structures account for 14% and 29%, respectively; and government facilities account for most of the remainder, at 4%, with large and small industrial facilities accounting for less than 1% combined. Based on assessments made in the Belize Sustainable Energy Strategy (2015), air conditioning and building envelope ECMs have the potential to reduce cooling electric load by 33%.[190]

4.3.1.4 Installing Roof Insulation

With large commercial facilities accounting for 53% of the air conditioning load in Belize, thermal insulation is an important technology that can reduce energy consumption by preventing heat gain through the building envelope. This, in turn, reduces energy demand for cooling of buildings and thus is a mitigation measure to reduce greenhouse gas emissions.

4.3.1.5 Improving Refrigeration

Refrigeration accounts for 15% of national electricity consumption in Belize. Large commercial facilities account for 41% of total refrigeration demand, with residential demanding an additional 45%, and industrial facilities drawing the remaining 13%. Government and small commercial facilities combined demand about 1% of national consumption. Refrigeration ECMs have the potential to reduce refrigeration electric load by 38%.[191]

4.3.1.6 Upgrading Industrial Plug and Process Load

Plug and process loads account for 30% of national electricity consumption in Belize. The commercial, residential, and industrial sectors each represent about 30% of demand, with the remaining 10% coming from government facilities. Although all sectors have an opportunity to reduce plug and process load electricity, the industrial sector is targeted for ECM improvements because individual industrial plug loads typically demand more power and are used more frequently, and therefore can be upgraded at a more attractive cost-to-benefit investment ratio. As detailed below, plug and process ECMs have the potential to reduce industrial electric load by 8%.[192]

4.3.2 Fuel Efficiency

4.3.2.1 Stationary Fuel Consumption

Historical fuel consumption in Belize has been limited mainly to the transport, power generation, industrial, and residential sectors. Commercial fuel consumption comprises only 1% of overall consumption. The present report evaluates energy efficiency measures for industrial, commercial, and residential buildings only and does not consider the transportation or power generation sectors.

Within the sectors evaluated, crude oil is the most commonly used fuel, particularly in the industrial sector. LPG is most commonly used in the residential and commercial sectors for water heating and cooking. Fuel consumption estimates were taken from the Energy Balance produced by MESTPU; however, the present analysis has reallocated the Initial MESTPU estimates on fuel use within the industrial sector to 90% crude oil, 5% diesel, and 5% HFO, based on observations made during site energy audits. Not unsurprisingly, following the recent discovery and production of domestic crude oil in Belize, most industrial boilers have switched over to crude from diesel or HFO.

Outside of transport and power, the typical end-uses of fuel in Belize include energy for cooking, domestic hot water production, and industrial process heat. As such, the energy efficiency measures proposed target these end-uses, and primarily target savings for crude oil and LPG.

4.3.2.2 Alternative Mass Transportation

Buses are the main system of public transportation used in Belize. However, the lack of railways limits today's transportation alternatives. Nowadays a wide range of alternatives for mass transportation system are available. However, before attempting to provide any recommendation, it is important to assess the specific transportation infrastructure conditions in Belize, and to evaluate the potential use and viability of these new technologies (e.g., bike lanes, subway, self-driving automobiles, city cars, modern train systems/railways).

4.4 Guiding Principles for Screening and Selection of Technologies

4.4.1 Currently Proposed Portfolio of Technologies

The existing Belize Sustainable Energy Strategy (2015) proposes several electricity generation, supply, and end-use technologies and presents a National Sustainable Energy Scenario (NSES) that suggests Belize's potential to secure 89% of the electricity supply from renewable energy sources, to decrease electricity consumption by 24%, and to decrease stationary fuel consumption by 19%, combining to lower greenhouse gas emissions by 2.4 million tons over the period 2014–2033.[193]

A more careful review of the technologies proposed resulted in a screening and selection process based on: 1) whether there is sufficient renewable energy resource quantity and quality, 2) whether the technology is mature and is an established commercially operated technology, and 3) whether the technology can generate electricity at or below the cost of the relevant economic and commercial benchmarks.[194] These are common criteria to consider when selecting technologies for further consideration in defining future technology pathways.

A key challenge in Belize is the lack of primary data and baseline historical information to properly perform energy analysis and to assess technologies for their suitability and sustainability in the country. The present resource assessment drew on data originating mainly from publicly available sources presented in project documents and from other sources where the primary data cannot be verified or judged for its quality. Several resource potential assessments are based to a large extent on publicly available secondary data from international databases and references, and on estimations. This requires some level of caution when preparing forecast scenarios and making recommendations for decision making.

The maturity of technologies is judged qualitatively, and technologies are selected based on whether they are deemed commercially suitable for Belize in the year 2014. References to sources or literature confirming the qualitative judgments are required to increase the level of validity. Some level of caution is required when preparing forecast scenarios and making recommendations for decision making.

The economic and commercial viability of a technology is assessed based on the cost of power, where the criteria for selection is whether the cost of electricity is cheaper compared to the cost of power it replaces. The Belize Sustainable Energy Strategy report cautions that an adequate and comprehensive evaluation needs to consider the following additional factors: 1) whether the renewable energy technology serves as firm capacity or not, 2) whether the renewable generation is distributed centrally or is decentralized, and 3) the cost of competing supply.[195]

A key aspect of ensuring that the 2030 Sustainable Energy Roadmap's projections and recommendations are as good as possible is 1) making sure the energy analysis and projections are based on sound assessments using objective verifiable data, evaluation, and selection criteria, and 2) ensuring that selected technologies adhere to sustainable development principles.

Energy technology assessment with a specific emphasis on achieving sustainability is inherently a complex and dynamic process that requires a holistic and interdisciplinary approach. In Belize's context specifically, there is no formal and coherent approach in place for energy technology assessment and selection from a sustainability perspective. There is no formal comprehensive or well-integrated technology assessment approach for evaluating the appropriateness and sustainability of each technology considered for application in Belize. Policymakers, energy planners, and senior decision makers therefore face difficulties in making informed and reasoned decisions about the appropriate technology options to transfer and deploy in Belize.

4.4.2 Recommended Guiding Principles for Technology Selection

The following guiding principles are suggested as part of this technology screening and selection method for Belize:

Guiding Principle #1:

(1) An energy technology is considered ***technically feasible***:

   a. Above all, when a primary *renewable energy resource* is positively identified in the *territory* of Belize and the technology's basic intentional design is to convert that particular primary energy source into an energy carrier or energy service; and

   b. The energy technology has passed the basic stages of its development, which includes the Research, Development, Demonstration, and Deployment stages to determine whether the technology is readily deployable.

This definition allows for the evaluator (Energy Council) to follow a rationale whereby, first of all, clarity is required regarding the availability of a particular type of renewable energy resource (e.g., wind, solar, biomass, geothermal, etc.) that can be determined by performing renewable energy source assessments (see the Task 3 report of this EUEI PDF Project). Since Belize has a clear delineation of its sovereign territory and jurisdiction (where limits are determined by the Exclusive Economic Zone – EEZ), the renewable energy source has to be positively identified within the territory of Belize to guarantee that the energy technology to be applied is subject to the prevailing legal and regulatory regime of Belize. Furthermore, an understanding of the basic design, function, or energy conversion process is needed to confirm that the identified primary renewable energy source can indeed be converted into an energy carrier or energy service with that particular technology.

In principle, technologies that are in the very early stages of commercialization, or that require very large, upfront capital investments or substantial outside expertise to operate, are likely to face additional deployment barriers. Therefore, it is important to determine in what stage of technology development a particular energy technology is. This is necessary to be able to assess the potential additional challenges or efforts needed to make the technology fully technically operational and deployable to be used (additional information could be requested regarding, for instance, clarity on operations and maintenance (O&M) standards and certifications, and a certain level of technology warranty by the technology provider).

Guiding Principle #2:

(2) An energy technology is consistent with the concept of ***sustainable development***:

a. When the technology enables project developers in Belize to continuously find a proper balance between social and economic priorities while protecting the environment to satisfy the current and future energy needs of the community; and

b. When the technology enables the transition toward a low-carbon economy to contribute to the mitigation of climate change, which represents one of the greatest threats to Belize's capacity to achieve sustainable development.

An energy technology cannot, during its production or installation, and use (life cycle), leads to public health problems (as, for instance, being a source of radioactive or hazardous waste). It may not lead to increased risks and accidents on the job, or lead to the displacement of communities without proper mitigation efforts or compensation that affect the physical environment and the community both socially and economically. The energy technology must be as environmentally benign (harmless to the environment) as possible while enabling the creation of job opportunities, supporting diversification of the economy, and promoting continuous innovation. Lastly, energy technologies need, to the extent technically possible, to result in limited greenhouse gas emissions during their life cycle (i.e., production and use) in order to contribute to the mitigation of climate change.

Guiding Principle #3:

(3) An energy technology is better tailored to Belize's ***conditions*** and ***needs***:

a. When the technology is applicable to conform to Belize's *carrying capacity* (its physical limits and conditions) and is *socially and culturally accepted* by the island community; and

b. When the technology contributes to offsetting Belize's dependency on imported electricity and fossil fuels to guarantee reliable and affordable power generation and transport.

The carrying capacity of Belize is the maximum capacity (determined mainly by available space) of the island's ecosystem to support a community indefinitely without destroying this same ecosystem. Especially in a small, low-lying country such as Belize (where space is very valuable), an energy technology should not demand significant or critical land or space that competes with more critical land uses for the community (e.g., fuel versus food), nor should it lead to the destruction of sensitive ecosystems that provide essential ecosystem services to the community (such as provision of food or fresh water).

At the same time, there should be a general acceptance of an energy technology being introduced in the community. This is normally guaranteed by the early and proper involvement of key stakeholders. Although at this stage it is not viable to gather input from all of Belize's communities regarding their respective perspectives on energy technologies, via the literature and past project experiences one can gather general indications of the social or cultural acceptance of certain technologies (this acceptance is generally driven by the access to information, the awareness level, gender issues, and exercised religions in the community). (To gather insights regarding rural and isolated communities' perspectives on energy technologies and solutions to be considered suitable, see the outcomes of the Task 4 report of this project.)

Furthermore, communities in Belize need reliable, affordable, and clean energy services. In this report, reliability is determined by whether the technology is always dispatchable as base load, and by whether the technology and energy source are, even in cases of intermittent sources, predictable. Furthermore, one of the most critical challenges to the sustainable development of Belize is its continued dependency on imported fossil fuels for power generation and, primarily, transportation.

This means that energy technologies have to be able to offset the dependence on imported fossil fuels in a cost-effective manner, which is determined mainly by the capital investment/turn-key investment cost of the technology, the energy conversion efficiency or yield, and the LCOE. Cost-effective energy technologies will enable Belize to reduce energy service costs in the form of electricity rates or transportation fuel prices to make energy affordable to the Belizean citizens.

4.5 Technologies and Solutions Deemed Appropriate for Belize

4.5.1 Heating and Cooling Technologies for Belize

The energy conservation from using renewable energy for heating and cooling can offer substantial benefits, such as the reduction of electricity costs, improvement of energy efficiency, and the promotion of renewable technology.

- **Active solar thermal (AST)** systems can provide space and water heating, as well as cooling needs. They can be used for water heating and cooling with thermally driven chillers. These systems are competitive in markets like Belize, where energy prices are not low and solar radiation is good year-round. AST systems do not require any energy infrastructure and are carbon-free or generate low emissions. For space cooling with air conditioning, thermally driven chillers are used to produce chilled water in closed cycles. Open cycles also can be used for direct treatment of air in a ventilation system. Solar cooling seems attractive for Belize since solar radiation corresponds with cooling demands.

- **Combined heat and power (CHP)** systems, which simultaneously produce electricity and heat, and potentially cooling, are mature and serve as a useful transitional technology. In the future, micro-CHP, biomass CHP, and even fuel cell systems may serve as an important energy demand reduction option.

- **Heat pumps** are mature, highly efficient technologies that use renewable energy from their surroundings, electricity, or gas. They provide space heating and cooling, as well as hot water in buildings, but are used predominantly for cooling.

Solar thermal, CHP, and heat pumps can be installed in most buildings and facilities across Belize to provide heating or cooling. For cooling, solar thermal and CHP require thermally driven chillers. Heat pumps, on the other hand, are standard for space cooling.

In Belize, most energy in buildings is used for cooling. For heating and cooling technologies, criteria to be considered include: 1) the annual water heating profile and annual cooling profile; 2) relative timing of thermal and electric loads; 3) space constraints; 4) emission regulations; 5) utility prices for electricity, availability, and prices of other fuels; 6) initial financing cost; 7) complexity of installation and operation; and 8) technical knowledge of technologies.

Table 24. Description of Heating and Cooling Technologies to Be Considered for Belize

Technology	Size (kW)	Efficiency (%)	Capital Cost (per kW)	Fuels	Fuel cost
Solar thermal	2.5-10	100	Low-high	Solar	N/A
CHP	1-15	70-90	Medium-high	Coal, liquid fuels, gaseous fuels, bioenergy	Low-medium
Electric heat pumps	2.5-10	200-600	Low-medium (air conditioning)/medium-high (space/water heating)	Electricity	Medium-high
Gas-engine driven heat pumps	15	120-200	Low-medium	Gaseous fuels	Low-medium

4.5.2 Integrating Solar Heat Into Industrial Processes in Belize

Most industrial processes require both heating of a fluid stream and heating of some reservoir. Belize has an important citrus industry that requires heat for operational processes. According to sources in Belize, the citrus industry uses crude oil to produce steam to process juices. The cacao industry uses propane gas to dry the product. It also uses direct sunlight, but this method can take longer and also relies on weather conditions, making the process inefficient.

Existing systems for industrial process heat are based on steam or hot water from a boiler, which mainly use fossil fuels (oil, gas, coal) or electricity generated by different sources. Solar thermal technologies can fulfill the amount of heat demand in industrial and agricultural food processes. The three groups of solar thermal technologies that can be useful for industrial process heat are solar air collectors, solar water heaters, and solar concentrators. (See Table 25.)

Table 25. Characteristics of Solar Thermal Technologies Applicable to Belize

Solar Thermal Technology	Characteristics
Solar air collectors	Can be used primarily in the food processing industry, replacing gas or oil-based drying. Can be built locally, and the costs depend on local building materials and labor.
Conventional solar water heaters	Can be categorized into flat-plate collector (FPC) or evacuated tube collectors (ETC). Can be installed on industrial rooftops to provide heat demand of up to 125 °C. Advanced systems can generate temperatures of up to 250 °C, but their price is higher than conventional systems.
Solar concentrators	Can be categorized into parabolic dish collectors, linear parabolic through collectors, and liner Fresnel collectors. These systems can generate up to 400 °C temperatures.

Almost all-industrial process heat demand requires heat in temperature ranges that can be provided by a solar thermal system. Table 26 lists sectors of industry suitable for thermal systems for industrial applications in Belize.

Table 26. Temperature Ranges Needed per Process in the Agro-processing Industry in Belize

Industrial Sector	Operation	Temperature Range (°C)
Food	Drying	30-90
	Pasteurizing	60-80
	Heat treatment	40-60
	Boiling	95-105
Beverages	Washing	60-80
	Pasteurizing	60-70
	Sterilizing	60-90

For small and medium-sized industrial plants, solar thermal technologies could replace fossil fuel-dependent technologies. A key challenge is to maximize the share of heat provided by solar heating, meaning that the heat will need storage to allow process heating during the night and non-production hours.

Key barriers for SMEs are the upfront cost and the rooftop space needed. The use of solar process heating technologies is still being researched. These types of technologies would need to be retrofitted to provide specific energy needs at specific geographical locations in Belize. Figure 30 shows how solar thermal systems can be used for process heat with a low temperature requirement; Figure 31 shows how the systems can be used as an additional source for preheating water for use in a steam boiler.[196]

Solar thermal systems also can meet cooling demands, replacing gas- or electricity-driven absorption chillers or electricity-driven, vapor-compression air conditioning systems. Absorption and adsorption chiller systems use liquid or solid refrigerants to cool the environment. In an absorption chiller, a commonly used system, solar energy is used to regenerate the absorber fluid, which contains refrigerant after it has been evaporated.

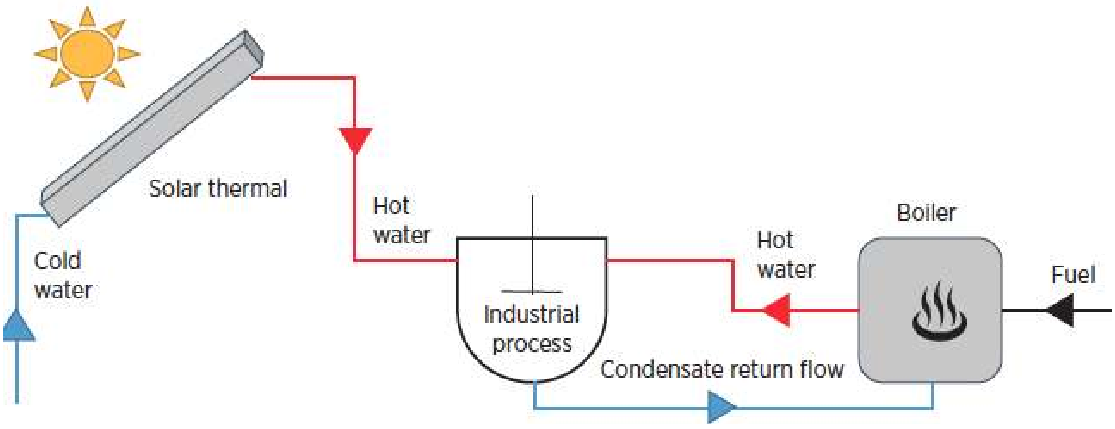

Figure 30. Solar Thermal System for Direct Heating to Process

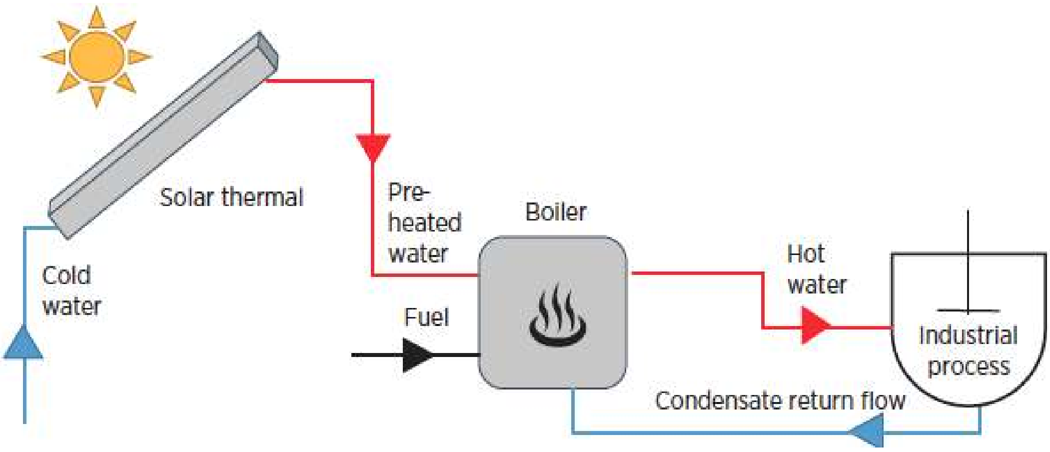

Figure 31. Solar Thermal Heat for Pre-heating of Supply Water for Steam Boilers

Figure 32 illustrates how solar thermal can be used for cooling purposes.[197] The process is very similar to a refrigerator, except that a compressor is not installed in solar cooling. The heated liquid from the solar system drives the absorption cycle.

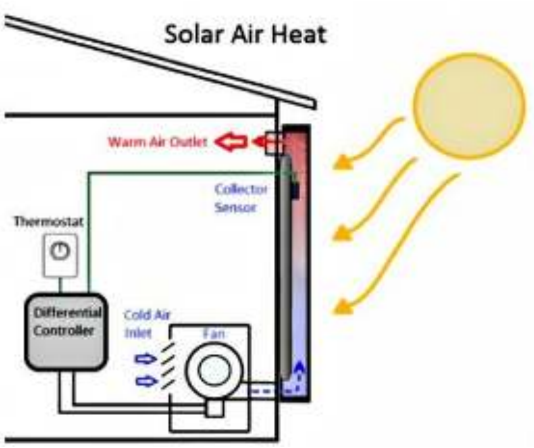

Figure 32. Solar Thermal for Cooling

Solar heating and cooling technologies can play an important role in improving Belize's sustainable energy mix. Belize's location makes it ideal to capture the sun's energy through solar thermal technologies that can collect heat efficiently and transfer it into buildings for process heat or heating and cooling purposes. However, the systems must be designed appropriately to meet a building's specific space, water heating, and cooling needs.

4.5.3 Sustainable Transport Potential

To improve mobility in a green and environmentally friendly way, it is essential to focus on energy-efficient and clean modes of transport. This includes initiatives aimed at improving the effectiveness of traditional fuels and promoting the use of cleaner energy and new technological solutions. This section discusses possible technologies for alternate fuel vehicles in Belize.

4.5.3.1 Possible Clean Fuel Technologies

Currently, all fuel for road transportation in Belize is imported and dependent on diesel- and gasoline-powered vehicles. Table 27 compares possible approaches and available technologies that can be used to improve the transport sector while also reducing greenhouse gas emissions.

Table 27. Alternative Fuel Vehicle Comparison

	BEVs	PHEVs	HEVs	Bi-Fuel	CNG/ LPG Kits	Flex-Fueled
Grid-connected	Yes	Yes	No	No	No	No
Include ICE	No	Yes	Yes	Yes	Yes	Yes
All-electricity range	50–250 miles	50–150 miles	Short	N/A		
Battery capacity	20 kWh; 50 kWh+ for high-perf. models	40 kWh or less	30 kWh or less			
Barriers	• Higher capital cost • Battery life/replacement cost • Recharge time • Lack of awareness and acceptance • Technical expertise • Lack of charging stations		• Higher capital cost • Battery life/ replacement cost • Lack of awareness and acceptance • Technical expertise	• Lack of refueling stations • Lack of awareness and acceptance • Technical expertise • Availability of fuels		

Note: BEVs = Battery Electric Vehicles, PHEVs = Plug-in Hybrid Electric Vehicles, HEVs = Hybrid Electric Vehicles, CNG/LPG = Compressed Natural Gas/Liquefied Petroleum Gas, ICE = Internal Combustion Engine

Currently, clean vehicles are generally more expensive than conventional-fuel vehicles. Without incentives, buyers in Belize may have to pay more than twice as much for a new low-emission vehicle. Attempting to address the high initial cost and increased demand, governments in other part of the world have used tax incentives and grants to reduce the price of alternative fuel vehicles. The two most predominant bio-based fuels are ethanol (derived from sugar or starch crops) and biodiesel (produced from vegetable oils or animal fats).[198]

4.5.3.2 Biofuels for Sustainable Transport

Biofuels have played a significant role in improving the sustainability of road transport worldwide. The transport sector in Belize has been identified as one of the areas to be addressed in this Sustainable Energy Roadmap 2030. The transport sector is powered by liquid fossil fuels; therefore, substitution of these fuels with biofuels will greatly contribute to reaching the overarching energy and sustainability targets.

One of the greatest promises of biofuels is their potential to provide a sustainable alternative to petroleum fuels. Blending petroleum fuels with biofuels can bring vehicle emission reduction in Belize, and could play a significant role in improving urban air quality and help out in the transition to sustainable transport.

4.5.3.3 Inadequate Demand for Alternative Vehicle Fueling Energy Storage

Specialized infrastructure is required for delivery of all alternative fuels, such as CNG, LPG, and biofuels and electricity. The requirements and practices for infrastructure for individual, public, or private fleets are the same. They require available refueling for operators traveling short and long distances.

Table 28 compares the costs of installing new alternative fuel stations and gasoline stations.[199] The infrastructure cost will depend on the type of fuel and fuel speed, and is limited by demands of these fuels. The uncertainty over the frequency of use for these fuel stations, or use rate can be a barrier to installing infrastructure and prevents providers from reaching scale.

Table 28. Comparison of Costs of installing Alternative Fuel and Gasoline Stations

Type Fuel Station	Fuel Type	Price Range for Single Station (USD)	Fuel Cost per Mile (USD)
Home charging station	Electricity	400 to 5,500	0.03
DC fast charging		50,000 to 150,000	
CNG home station	Natural gas	5,000 + Installation	0.08
CNG fast-fill station		675,000 to 1 million	
LNG fast-fill station		350,000 to 1 million	
Conventional station	Gasoline/diesel	50,000 to 150,000	0.14

Existing gasoline and diesel stations already in place, scale of fuel use, and the unfeasibility of home refueling make CNG and LNG infrastructure uneconomical for investors. Electric charging infrastructure faces similar problems. A public electric station has fewer advantages than a CNG and LNG station since more commercial vehicles can run on gas, and are needed over large traveling distances. Home electric charges are more convenient and inexpensive since they require little electrical work to install a charging station. As a result, the payback period on a public electric charging station is too long for investors without another revenue stream or some public subsidy. One alternative could be to install electric charging stations on existing gasoline and diesel stations.

Of the possible listed technologies in Table 29, BEVs, PHEVs, and HEVs face barriers with regard to the need for mechanics to obtain the required training for working with these technologies, and the capital cost for these vehicles is also high. Therefore, the clean vehicle technologies recommended for implementation are bi-fuel vehicles, CNG/LPG kits, and flexi-fueled vehicles.

Table 29. Description of Clean Vehicle Technologies

Clean Vehicle Technology	Technology Description	Barriers
Bi-fuel vehicles	Designed to operate on a dual fuel system, which can be switched between fuels such as gasoline and LPG.	• Lack of refueling stations • Lack of awareness and acceptance • Technical expertise • Availability of fuels
CNG and LPG kits	Conversion kits that allow a vehicle to be modified from a gas-powered system to use CNG and LPG	• Lack of refueling stations • Cost of infrastructure • Lack of awareness and acceptance • Technical expertise • Availability of fuels
Flex-fuel vehicles	Vehicles, which allow the use of a mixture of fuels (ethanol and methanol).	• Lack of refueling stations • Lack of awareness and acceptance • Technical expertise • Availability of fuels
Electric vehicles	Vehicles, which are powered by rechargeable battery that is charged from an electric power source.	• Higher capital cost • Battery life/replacement cost • Recharge time • Lack of awareness and acceptance • Technical expertise
Hybrid vehicles	Vehicles that combine conventional fuel such as gasoline to power vehicle, and can be switch to electric power	• Higher capital cost • Battery life/replacement cost • Lack of awareness and acceptance • Technical expertise
Fuel cell vehicles	Emerging technology that can power a vehicle by electricity generated by a fuel cell (through a chemical process) located in the vehicle.	• Higher capital cost • Battery life/replacement cost Lack of awareness and acceptance • Technical expertise • New technology

Cross-cutting linkages are necessary to consider mitigation technologies in the transportation sector in Belize. To make any definitive choice on technology, environmental impacts, cost-benefit analysis, trade, and other possible market barriers and possible funding sources must be considered. Primary issues that make alternative fuels storage uneconomical for investors include: existing fuel stations are already in place and compete well with new players; the scale of clean fuel use seems insufficient to cover fixed costs; and home refueling is unfeasible.

Reducing barriers to private finance is an important part of increasing the availability of alternative fuel vehicles. In order for investments in green transport to reach their full potential, a set of changes must be made to the current financial framework, together with the creation of market conditions that permit green transport to be economically feasible.

Finding ways to encourage private investment in alternative fuel vehicles and fueling infrastructure is critical for developing a sustainable transport sector in Belize. An essential first step is to understand the barriers that impede deployment, including the barriers for private investment. Alternative fuel vehicles and fuel infrastructure could be a key element of the transportation systems in Belize if existing market deficiencies are addressed.

4.5.3.4 Waste-to-Energy Potential

The Belize Solid Waste Management Authority (SWMA) ensures that the management of solid waste generated in the country is handled in an environmentally sound manner. There are no standard waste collection vehicles in Belize. Waste is collected in various types of vehicles including dump trucks, pick-ups, tractors trailers, and compactor trucks. Assessing the potential for municipal waste is generally easy since Belize has waste collection and a storage program in place that maintains data on waste levels. Table 30 summarizes the flow of solid waste from transfer stations to landfills and recycling in 2015.[200]

Table 30. Volume of Solid Waste Generated in Belize, 2015

Month	San Ignacio/SE- Benque Viejo TS			Belize City, TS			San Pedro, TS			Caye Caulker, TF			Burrell Boom, TS			Total Recylced	Total tonnes-to landfill	Total tonnes recylced + landfilled
	Transferred	Recycled	Sub total	Transferred	Recycled	Sub total	Transferred	Recycled	Sub total	Transferred	Recycled	Sub total	Transferred	Recycled	Sub total			
Jan-15	642.7	12.2	654.9	1659.5	23.2	1682.7										35.4	2302.1	2,337
Feb-15	528	9.8	537.8	1382.7	18.8	1401.5										28.6	1910.7	1,939
Mar-15	504.7	9.1	513.8	1581.5	17.6	1599.1										26.7	2086.2	2,113
Apr-15	597.8	9.1	606.9	1385.6	17.1	1402.7										26.2	1983.4	2,010
May-15	525	11.56	536.6	1434.5	16.58	1451.08										28.14	1967.3	1,995
Jun-15	622.9	10.31	633.2	1444.7	20.68	1465.38										30.99	2067.6	2,099
Jul-15	647.5	22.1	669.6	1613.5	22.77	1636.27	304.5		304.5							44.87	2565.5	2,610
Aug-15	504	15.06	519.1	1232.6	19.95	1252.55	386.8		386.8							35.01	2123.4	2,158
Sep-15	557.6	11.45	569.1	1861.3	20.98	1882.28	398.6		398.6							32.43	2817.5	2,850
Oct-15	601.3	3.2	604.5	1790.6	7.14	1797.74	443.6		443.6							10.34	2835.4	2,846
Nov-15	616.3		616.3	1867.2		1867.2	471.9		471.9							0	2956.1	2,956
Dec-15	764.3		764.3	1887.7		1887.7	495.4		495.4	50.5		50.5	58.1		58.1	0	3245.9	3,246
Totals	7112.1	113.88	7226	19141.4	184.8	19326.2	2490.8	0	2491	50.5	0	50.5	58.1	0	58.1	298.68	28861.1	29159
Avg/month	592.675	9.49	602.2	1595.12	18.48	1610.52	415.133	0	415.1	50.5	0	50.5	58.1	0	58.1	24.89	2405.092	2429.9167
Avg/30 day	19.7558	0.316333	20.07	53.1706	0.616	53.6839	13.8378	0	13.84	1.6833	0	1.68	1.9367	0	1.94	0.829667	80.16972	80.997222

There are currently no waste-to-energy projects in Belize, although a 2011 study outlines the potential for this.[201] The report provides waste amounts in Belize in four municipalities of the Western Corridor and investigates the waste generation per capita and the corresponding waste composition at the source (households, business, institutions, and industry) that can be used for waste-to-heat in Belize.[202] (See Figure 33.) According to sources in SWMA, in reality the waste is 35% less than what was estimated in the study results.

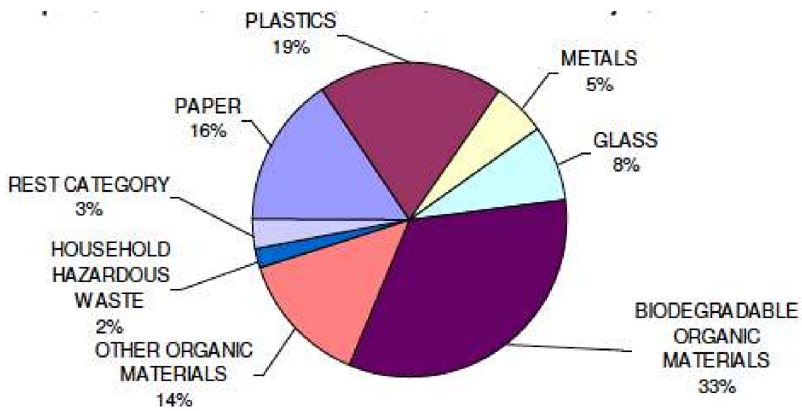

Figure 33. Composition of Total Waste in the Western Corridor Project in Belize

An estimated 33% of Belize's total waste comes from biodegradable organic waste, and 14% from other organic materials. Because organic material contains higher moisture content than paper waste (which accounts for 16% of the total waste), organic waste is not an effective fuel for use in combustion power plants. Instead, biodigesters, which expose organic wastes to heat and low-oxygen environments, can be used to convert waste into methane fuel and power a generator. Biodigesters also can be used to produce organic fertilizers that can be applied to local crops and lands, providing an important product to local communities in Belize.

Waste-to-energy would likely be able to fuel only a small to medium-sized power plant in Belize. Such a project would help in waste reduction and waste management. Nevertheless, the overall potential is limited. Biogas projects using biodigesters are suitable on a smaller scale and can be used for off-grid electrification projects.

4.5.3.5 Biomass Energy Potential

Energy can be generated from a wide variety of biological material, including residue from agriculture and forestry. This flexibility has resulted in increased use of biomass technologies. Biomass technologies break down organic matter to release stored energy from the sun. The process used depends on the type of biomass and its intended end-use. Biomass energy has a sizeable role in Belize's future energy matrix. In the short to medium term, biomass can serve as a reliable, renewable source of baseload power.

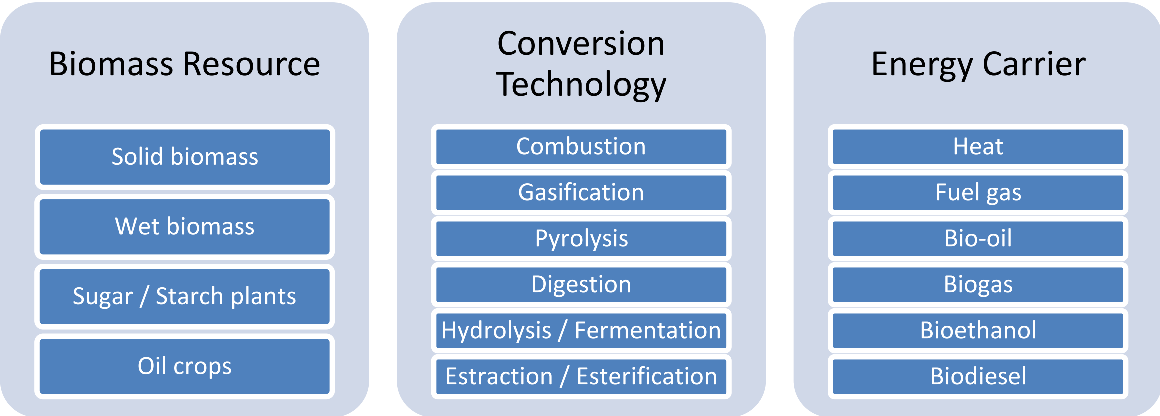

Figure 34. Biomass-to-Energy Conversion Routes

In most agricultural location, crop residue follows a regular pattern of production and can be measured proportionally to the amount of land used to grow the crop and the number of times the crop is produced each year. Crop and forestry residues can be used for heat or electricity, or they can be gasified to have the same functionality as oil and gas, but with lower net carbon emissions. Many potential sources of biomass feedstock exist in Belize, including agricultural crop residues such as sugarcane bagasse, cassava, and coconut shells, as well as woody biomass. (See Table 31.)

Table 31. Biomass Energy Resources in Belize

Resource Category	Biomass Resource
Solid biomass	Sugar cane (field)
	Sugar cane (process)
	Rice (field)
	Rice (process)
	Wood/pellets
	Municipal solid waste (MSW)
	Oranges (field)
	Bananas (field)
	Papayas (field)
	Grapefruit and pomelos (field)
	Grapefruit and pomelos (process)
	Maize (field)
	Maize (process)
	Peas (field)
	Beans
	Grass
Wet biomass	Organic waste
	Manure

Resource Category	Biomass Resource
	Poultry litter
	Sewage water
	Aquatic biomass
Sugar and starch plants	Sugar beet
	Sugar cane (process)
Oil crops	Rapeseed
	Sunflower
	Jatropha

A key barrier to developing biomass as an energy source in Belize is the logistical challenge of collecting the dispersed biomass residue in an economically efficient way. In addition, the diversion of crop residues for energy purposes has the potential to compromise soil quality for future agricultural production by removing a source of soil nutrients. Proper agricultural waste management will be crucial to achieving a sustainable outcome from using biomass in Belize.

Scaling up biomass production also can have implications for the local environment, affecting key ecosystem services and biodiversity. Large-scale production of energy crops can cause soil degradation, loss of biodiversity, overuse of chemical pesticides and fertilizers, and contamination of waterways. Large-scale production of biomass energy also can create food competition with food crops for limited agricultural land, which could drive up food prices, affecting poorer populations.

To assess the biomass resource in Belize, a model is needed to analyze the potential of cultivating crops in particular locations, looking at environmental variables such as rainfall, soil nutrient levels, average temperatures, and variables like land availability and economic costs.

Biofuels and waste can be used for power generation. Biofuels from are liquid gaseous fuels produced from biomass. Most biofuels are used for transportation, but some are used as fuels to produce electricity. The expanded use of biofuels offers an array of benefits for energy security, economic growth, and environment. Current biofuels research focuses on new forms of ethanol and biodiesel, and on biofuels conversion processes. Studies have estimated that ethanol and other biofuels could replace 30% or more of U.S. gasoline demand by 2030.[203] Biofuels derived from oilseed crops, such as jatropha, can substitute diesel to fuel thermal power plants. It is important to consider the wider impacts of biofuel production, which can be similar to those related to biomass production; such as the effect in has on food prices.

A good way to assess biomass resources is to model the cultivation crop potential in particular locations, taking into consideration environmental variables such as soil nutrient levels, average temperatures, and annual rainfall, as well as land availability and economic costs. Resource potentials may vary depending on locations in Belize and the crops considered, but they are relatively easy to assess if all the data are readily available.

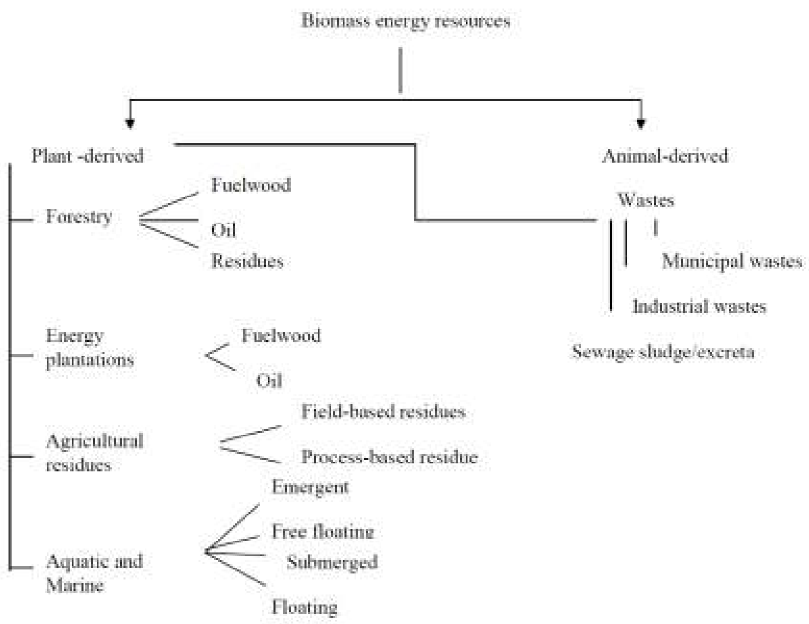

Figure 35. Classification of Biomass Resources on the Basis of Their Origin[204]

Table 32 provides a summary based on the technologies and solutions appropriate for Belize discussed in this section. It illustrates which sector each technology should be applied to, as well as the guiding principles for consideration discussed in Section 4.4.

Table 32. Pre-selection of Technologies Deemed Suitable Based on Sustainable Energy Technology Criteria

Sector	Renewable Energy Technology	Category	Guiding Principle			Notes for Consideration
			Technical Feasibility	Sustainable Development	Serves Belize's Conditions and Needs	
Heating and Cooling	Solar	Active Solar Thermal	X	X	X	In Belize, most energy in buildings is used for cooling. For heating and cooling technologies, criteria to be considered include: 1) the annual water heating profile and annual cooling profile; 2) relative timing of thermal and electric loads; 3) space constraints; 4) emission regulations; 5) utility prices for electricity, availability, and prices of other fuels; 6) initial financing cost; 7) complexity of installation and operation; and 8) technical knowledge of technologies.
	CHP	CHP	X	X	X	
	Heat Pumps	Electric Heat Pumps	X	X	X	
		Gas-engine driver	X	X	X	
Industrial Process	Solar	Solar Air Collectors	X	X	X	Existing systems for industrial process heat are based on steam or hot water from a boiler, which mainly use fossil fuels (oil, gas, coal) or electricity generated by different sources. Solar thermal technologies can fulfill the amount of heat demand in industrial and agricultural food processes. For small and medium-sized industrial plants, solar thermal technologies could
		Conventional Solar Water Heaters	X	X	X	
		Solar Collectors	X	X	X	

Sector	Renewable Energy Technology	Category	Guiding Principle			Notes for Consideration
			Technical Feasibility	Sustainable Development	Serves Belize's Conditions and Needs	
						replace fossil fuel-dependent technologies. Belize's location makes it ideal to capture the sun's energy through solar thermal technologies that can collect heat efficiently and transfer it into buildings for process heat or heating and cooling purposes.
Transport	Alternative Fuel Vehicles	BEVs	X	X	X	Considered technologies were assessed on the availability of technologies that can be used to improve the transport sector while also reducing greenhouse gas emissions.
		PHEVs	X	X	X	
		HEVs	X	X	X	
		Bi-fuel	X	X	X	
		CNG/LPG Kits	X	X	X	
		Flex-Fueled	X	X	X	
Electricity	Waste-to-Heat	Waste-to-Heat	X	X	X	Consideration based on a 2011 study outlines the potential for this. The report provides waste amounts in Belize in four municipalities of the Western Corridor and investigates the waste generation per capita and the corresponding waste composition at the source (households, business, institutions, and industry) that can be used for waste-to-heat in Belize. Waste-to-energy would likely be able to fuel only a small to medium-sized power plant in Belize. Such a project would help in waste reduction and waste management
Fuels	Biomass	Solid Biomass	X	X	X	Criteria is based on the potential sources of biomass feedstock exist in Belize, including agricultural crop residues such as sugarcane bagasse, cassava, and coconut shells, as well as woody biomass.
		Wet Biomass	X	X	X	
		Sugar and Starch Plants	X	X	X	
		Oil Crops	X	X	X	

4.6 Key Findings and Recommendations

The technologies and solutions discussed in this chapter are focused mainly on addressing fuel and heat demand in Belize and are not assessed for their suitability and sustainability requirements. This was a particular request by the Ministry to complement the existing analysis and results presented for electricity and stationary fuel production, supply and end-use technologies prepared under the Belize Sustainable Energy Strategy (2015).

To ensure that technology options are suitable for Belize and are in line with sustainability criteria, there is a critical need to use criteria and a methodology for screening and selecting appropriate technologies for Belize (see Section 4.4), based on a quantitative assessment of improved data. This methodology needs to be set up to allow the Energy Council, MPSEPU, and other critical stakeholders to identify, assess, categorize, and compile a list or portfolio of energy technologies that are appropriate (i.e., that are technically feasible, consistent with Belize's development objectives, cost-effective, environmentally sustainable, culturally compatible, and socially acceptable).

Table 33 provides an overview of recommended sustainable energy technologies for Belize over the short, medium, and long terms.[205] This initial list of recommended energy technologies was prepared to facilitate the process of developing a strategy and implementation plan for the transfer, development, and deployment of these technologies in Belize. However, these technologies have not been adequately screened for their appropriateness and compliance with sustainability criteria as the technologies in Table 32.

Without the proper quantitative analyses, and set up of proper evaluation and selection method using quantifiable and verifiable indicators, in particular when taking into account specific conditions and needs in Belize, no conclusive judgment is possible regarding the energy technologies' compliance to the definition of an *appropriate sustainable energy technology* for Belize.

Table 33. Recommended Sustainable Energy Technologies for the Short, Medium, and Long Terms

	Near-term "Adaptation" Stage	Mid-term "Commercial Scale-up" Stage	Long-term "Technology Venturing" Stage
Energy Supply Technologies and Solutions			
Wind energy	Cost-competitive wind turbines/power systems	R&D: 1) Low-wind speed wind turbines 2) Offshore wind turbines 3) New storage technology expected by 2015–2020	R&D: 1) Better and more reliable and efficient turbine technology 2) Material component development to withstand maritime salinity environment
Solar energy	Grid-parity PV systems	R&D: 1) Reduction of cost and increase of efficiency 2) New storage technology expected by 2015–2020	R&D: 1) Better and more reliable and efficient technology 2) Material component development to withstand maritime salinity environment
Hydropower	Hydro run-of-river technology	R&D: Reduction of cost and increase in efficiency of small-scale run-off technology	R&D: Concept designs
Geothermal	Mid/large-scale application of binary cycle geothermal systems (baseload source)	R&D: Improve technology and fluid characteristics of other geothermal sub-technologies	R&D: Concept designs
Bioenergy	Deployment of commercial gasification and bio-anaerobic digestion technology	R&D: Demonstration units of cellulosic ethanol	R&D: Concept designs
Ocean Energy Thermal Conversion Technology	Deployment of first commercial OTEC technology	R&D: Demonstration units of OTEC technology (land-based, floating, platform, etc.)	R&D: Concept designs
Ocean current		R&D: Demonstration units of current energy technology	R&D: Concept designs
End-use Technologies and Infrastructure			
Transportation	1) Introduction of hybrid vehicles 2) Improved efficiency of public transportation	Introduction of electric vehicles	Solar/electric vehicles
Buildings	1) Introduction of EE measures 2) Improved building codes	Introduce new materials; Solar Thermal Air Conditioning	Innovative insulation materials - Vacuum Insulated Panels
Industry	Introduction of EE measures	Introduce new pollution codes	
Electric grid and infrastructure	Introduction of EE measures	Smart grid	
Products and appliances	Introduction of new importation code	Lab facility to test imported products and appliances	

5 Technology Development Pathways

5.1 Future Electricity Demand

Future electricity demand for Belize is modeled based on data available from the International Renewable Energy Agency (IRENA). Particular attention is placed on the role and rationale of introducing renewable generation, with the aim of overcoming the country's dependence on electricity imports from Mexico.

5.1.1 Business-as-Usual (BAU) Scenario

Figure 36 provides a business-as-usual (BAU) projection of future electricity demand in Belize to 2030, based on classic parameters such as GDP, population growth, number of customers, and electricity prices. The figure includes the current input from renewables to local electricity production. Under current conditions and based on BAU, electricity consumption is projected to increase to approximately 3,500 GWh in 2030, if no actions are taken (e.g., an energy efficiency program). The share of local electricity production also is projected to increase, representing around 2,000 GWh of the total.

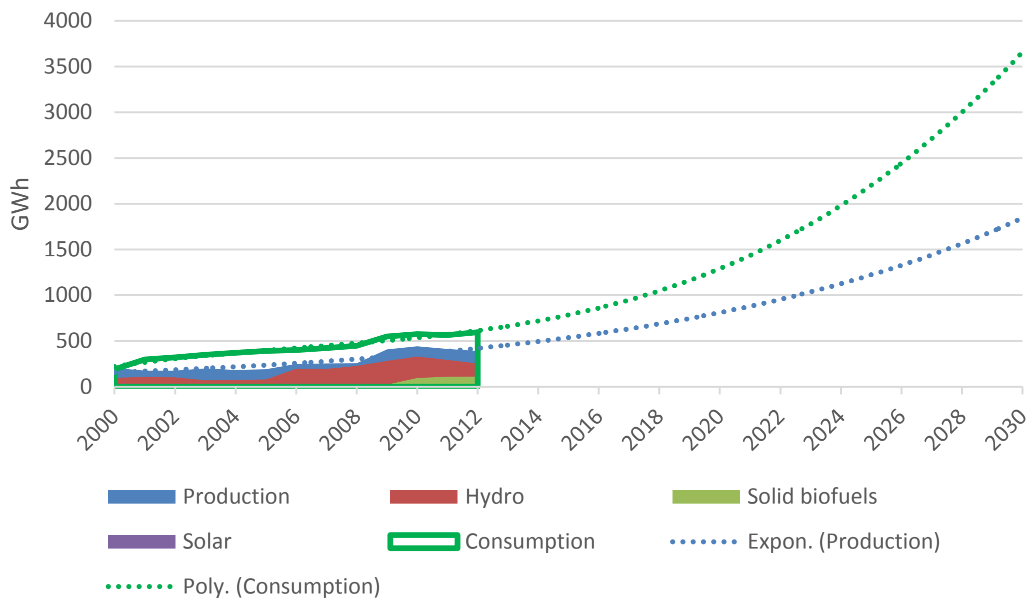

Figure 36. Renewable Energy Production and Consumption, 2000–2012, and Forecast for 2030 (BAU Scenario)

5.2 Scenarios for Future Electricity Supply

When exploring the horizon for potential renewable energy project development opportunities, several studies provide varying scenarios for renewable generation capacity potential in Belize.

5.2.1 Scenario 1: ESEE Scenario

The *Energy Savings and Energy Efficiency (ESEE)* scenario represents the potential reduction in electricity need over time for the period 2016–2030. The projection is based on the selection of technologies and solutions deemed applicable in Belize.

Figure 37 shows that, under the ESEE scenario, total electricity consumption is reduced to around 2,300 GWh, assuming that Belize applies the energy efficiency measurements described in the NEP. In this scenario, consumption can be satisfied 100% based on renewables and considering hydro and co-generation from solid biofuels as baseload.

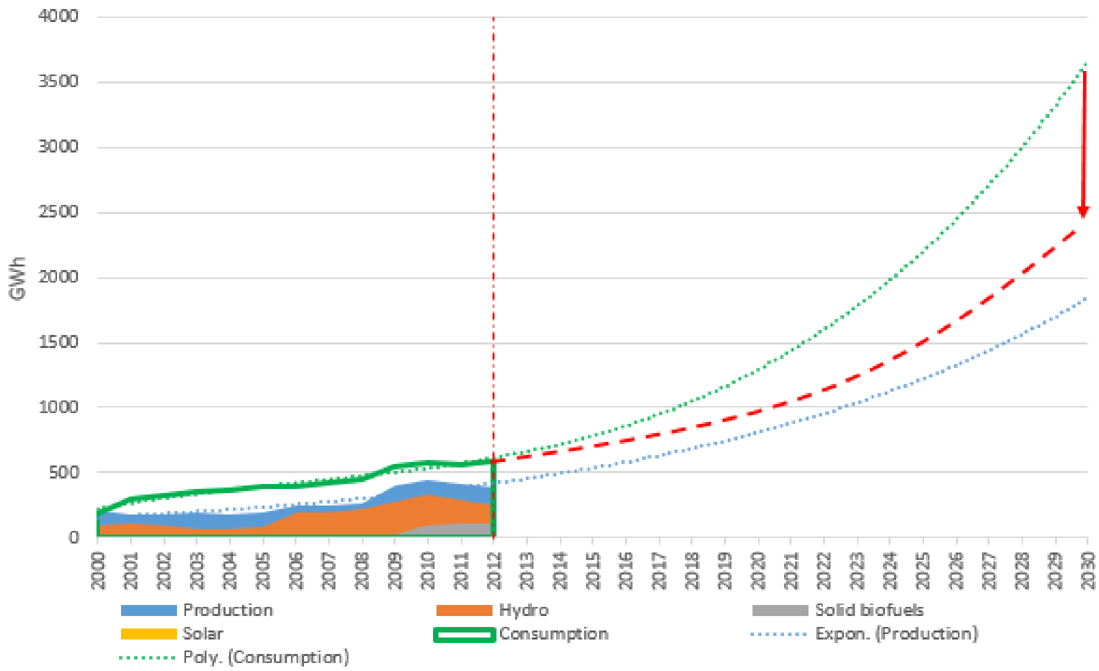

Figure 37. Electricity Consumption, 2000–2012 and Forecast to 2030, Reduced by the Energy Efficiency Targets Expressed in the NEP

5.2.2 Scenario 2: NSES Scenario

The *National Sustainable Energy Strategy (NSES)* is presented in the Belize Sustainable Energy Strategy (2015) and is based on the premise that renewables could represent 89% of electricity supply, electricity consumption could decrease by 24%, and stationary fuel consumption could decrease by 19%, combining to lower greenhouse gas emissions by 2.4 million tons over the period 2014–2033.[206] For each potential power source, the availability of renewable energy resources (in terms of quantity and quality) is explored and the maturity of the technology is assessed. Table 34 summarizes the technologies and their potentials.[207]

Table 34. Technical Screening Summary of Renewable Energy Technologies

Technology	Resource Availability (0-2)	Tech. Maturity (0-2)	Overall Assessment	In or Out	Project size (MW)	Annual Projected Output (GWh)	Scheduled for commissioning
Onshore wind	2	2	Several sites with good wind speeds; mature technology	IN			
Offshore wind	1	1	Sites with good wind speeds are far offshore; technology still maturing	OUT			
Distributed solar PV	1	2	Decent solar resource; relative mature technology; still experiencing	IN			

Technology	Resource Availability (0-2)	Tech. Maturity (0-2)	Overall Assessment	In or Out	Project size (MW)	Annual Projected Output (GWh)	Scheduled for commissioning
			costs decline				
Utility-scale solar PV	1	2	Decent solar resource; relative mature technology; still experiencing costs decline	IN			
CSP	1	1	Marginal resource availability; technology in commercial operation; but significant improvements and costs reductions expected	OUT			
Waste incineration	0	2	Mature technology; insufficient waste quantity	OUT			
Landfill gas	1	2	Small resource, but sufficient for power generation; mature technology	IN	1.7		
Anaerobic digestion				IN	1 (up to 6)		2017 (by 2030)
Biomass power	2	2	Good resource availability; proven technology in Belize	IN	4.3		2018
Small-scale hydro (1-5 MW)	2	2	Good resource availability; proven technology	IN	5		2017
					5		2018
					5		2019
Large-scale hydro (5-25 MW)	1	2	Several sites still undeveloped; proven technology in Belize	IN	5 (additional at Mollejon)		2020
					15 (Mopan River)		2022
					8.4 (Vaca Falls)		2025
Geothermal	0	2	Mature technology, no resource identified	IN			
Ocean Thermal Energy Conversion	1?	0	Resource quality unstudied; immature technology	OUT			
Ocean wave	1?	0	Resource quality unstudied; immature technology	OUT			

Source: See Endnote 207.

5.2.3 Scenario 3: RPEG Scenario

As result of a *Request for Proposals for Electricity Generation (RPEG)* in Belize issued in October 2013, the Public Utilities Commission (PUC) released in March 2015 the results of a competitive selection process for least-cost generation capacity to address projected electricity demands in the short to medium term. All proposals were subjected to a comparative evaluation process (taking into account costs, LCOE, and dispatch capacity) over the review period 2016–2030.[208] (See Table 35.)

Table 35. Recommended Power Generation Projects for Belize for Years 2016–2030

Developer	Power Generation Technology	Project Size (MW)	Annual Projected Electricity Output (GWh)	Scheduled for Commissioning
Blair Athol Power Company Ltd. (BAPCOL)	Thermal (3rd Wartsila HFO Engine)	7.5	0	2015
SS Energy Ltd.	Biomass co-generation (sugar and electricity)	8.0 (Phase 1); 8.0 (Phase 2)	19.58 (Phase 1); 19.58 (Phase 2)	2016 (Phase 1); 2018 (Phase 2)
GSR Energy Ltd.	Biomass co-generation (ethanol and electricity)	17.88	141.00	2018
Southern Renewable Energy Ltd. (SREL)	Hydro (Chalillo 2 on Macal River)	12.8	46.55	2019
Southern Renewable Energy Ltd. (SREL)	Hydro (Upper Swasey)	9.0	41.38	2019
Blair Athol Power Company Ltd. (BAPCOL)	3MW Solar (Ladyville); 5 MW (Placencia); and 7 MW (Corozal)	15.0	34.66	2016
Total		**78.18**	**302.76**	

Source: See Endnote 208.

In this so-called RPEG scenario (see Figure 38), we proposed the integration of a sufficient level of renewable energy in the national grid to satisfy the entire electricity consumption of Belize, including covering the imports from Mexico. The forecast period of 2011–2019 is complemented with the projects included in Table 35 (red lines). In this scenario, the deployment of renewables—mainly solid biomass fuels (34%), solar (24%), and hydro (29%)—can easily satisfy 97% of the country's total electricity consumption.

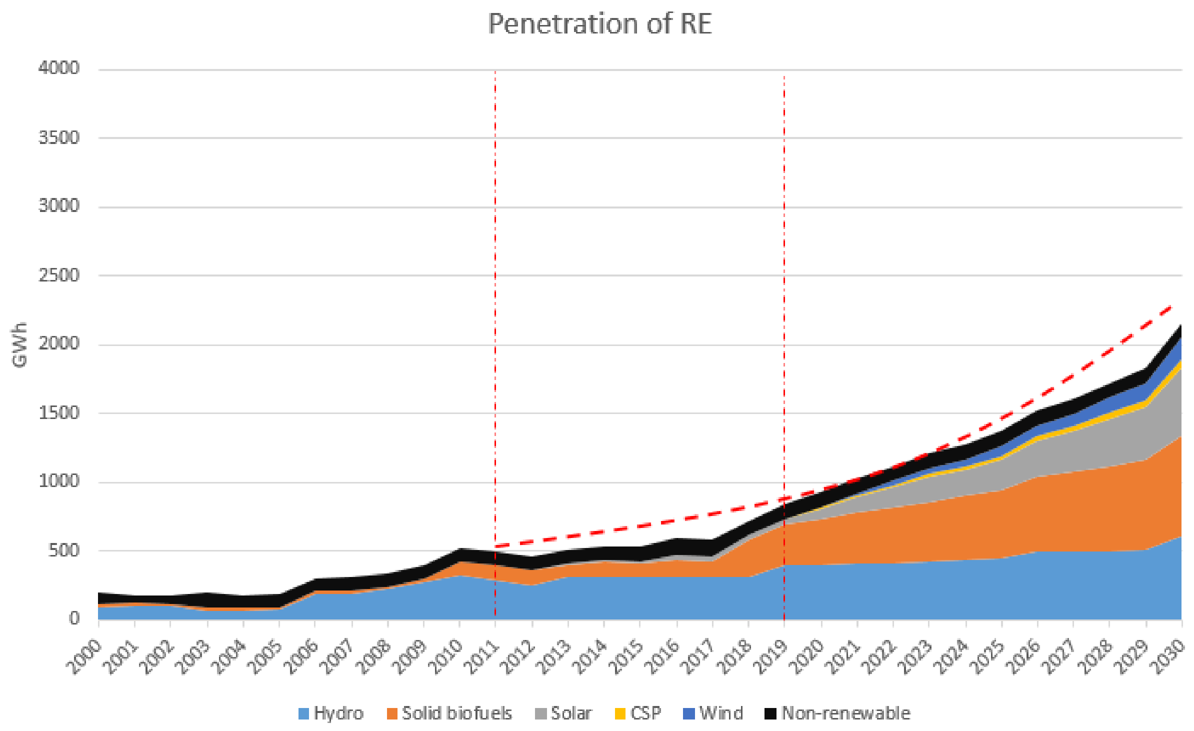

Figure 38. Penetration Scenario for Renewable Energy, 2000–2030

5.3 Future Fuel Demand

5.3.1 Stationary Fuels

This fuels scenario has been adopted from the *Belize Sustainable Energy Strategy Volume 1* report.[209] In the scenario, Belize would reduce the level of stationary fuels consumed by 19% by 2033. (See Figure 39.) This is based on a portfolio of energy efficiency measures contemplated to be applied across the two major end-use sectors, namely the industrial and residential sectors.

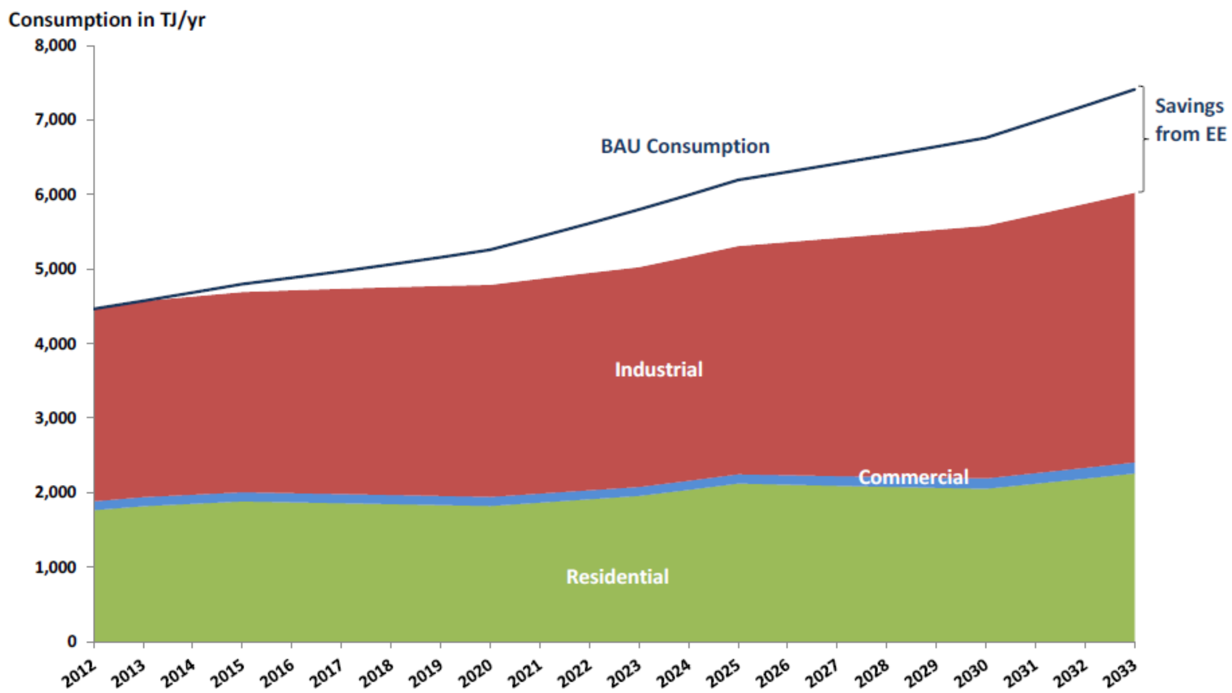

Figure 39. Scenario of Stationary Fuel Use in Belize, Heat Demand Profile, 2012–2033

5.3.2 Transportation Fuels

The biofuel potential of Belize can be the answer for the future fuel supply. According to a study from the OAS, an estimated 46 million gallons of ethanol could be produced annually in the country given the state of the technology in 2009.[210] Belize consumes an average of around 14 million gallons of gasoline per year for transportation. Thus, if one assumes that ethanol is blended with gasoline at 10%, approximately 1.4 million gallons would be required per year. If flex-fuel vehicles replaced the entire vehicle fleet, no more than 14 million gallons of ethanol would be required locally. In that case, Belize has the potential to meet all of its domestic demand and export needs for fuel transportation.

A significant spike is observed in Belize's historical petroleum consumption trend. Between the years 2000 and 2007 the consumption more than doubled to a peak of about 7,300 barrels per day. (See Figure 40.) Then a sharp reduction in consumption is observed. It is not known whether this is influenced by the discovery of petroleum in 2005. Consumption of fuel from others sectors is small compared with transport sector. Therefore, the dependence on imported fuels will be reduced significantly.

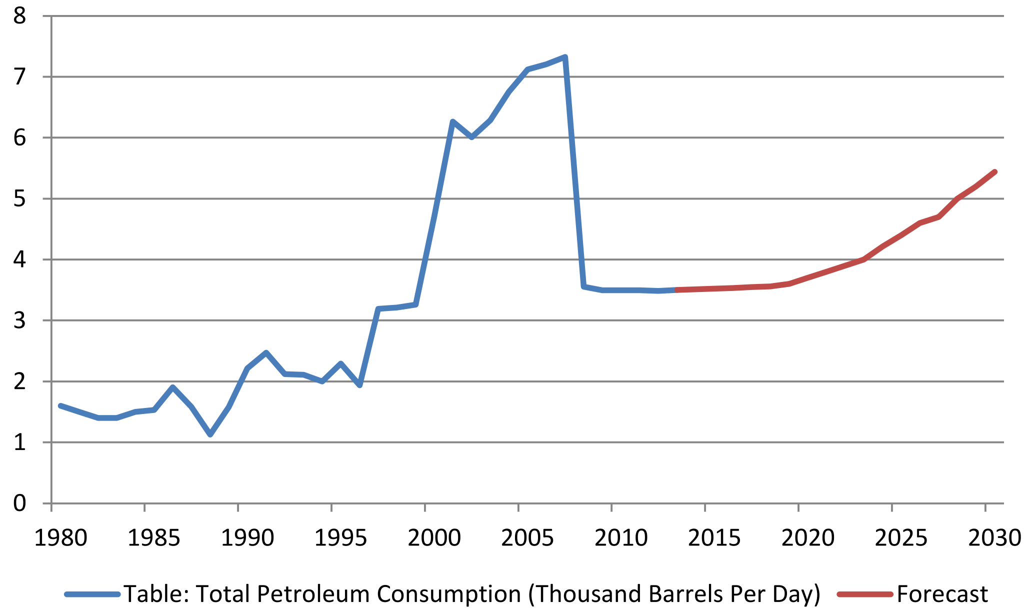

Figure 40. Total Petroleum Consumption in Belize, 1980–2012, and Forecast to 2030

5.4 Key Findings

Forecasting potential energy demand and presenting potential technology deployment pathways and energy supply scenarios is only useful when the primary data and information used as baseline input are correct or complete. There is a tendency to use very sophisticated modeling tools and forecasting software to help visualize and describe the potential for achieving improvements and progress on set targets. But all of these tools are dependent on a proper set of consistent, validated, and comprehensive data.

OLADE is currently working on an Energy Planning Manual to enhance the capabilities and development of new skills in energy planning within the Latin America and Caribbean region. Together with MPSEPU they are assisting in the implementation of an National Energy Information System in Belize. The idea is to have scenarios as an instrument for the representation of hypothetical futures in the analysis of energy prospective, with the purpose of reducing the degree of uncertainty in the decision-making process

6 Energy Conservation Measures for Belize (Phase 1)

This chapter presents a non-exhaustive list of measures and activities that are considered first-order priorities to be tackled within the time frame of 2016–2019, and represent the first phase of the *Belize 2030 Sustainable Energy Roadmap* Action Plan. More detailed interventions will become feasible when data collection management and analysis capacity are improved.

Based on current available data on Belize's energy situation and the identified gaps, a number of targeted strategies could have a significant impact in accelerating the development and deployment of sustainable energy and energy efficiency in the nation.

Here, recommendations have been structured according to five major categories of need:

1) **Information:** improve Belize's energy data collection, analysis and management; and improve the information network by strengthening existing information systems and building awareness of renewable energy;

2) **Finance:** identify innovative financing mechanisms for renewable energy projects;

3) **Legal and Regulatory:** support the implementation of regulatory frameworks that enable renewable energy development;

4) **Education and Capacity Building:** build technical capacity among players in the renewable energy field including project developers, financiers, engineers and technicians, policymakers, and planners; and

5) **Technical:** Assist the national electric utility in preparing for changes in the power sector in increasingly dealing with distributed and intermitted renewable energy technologies.

The projects, policies, and initiatives presented across all categories aim to mitigate some of the most prevalent barriers in Belize. While each individual action is listed and described independently, in practice many rely on the execution of complementary tasks also enumerated here. Overall, completion of the full slate of potential activities described below would allow Belize to meet and likely exceed its set sustainable energy goals.

Table 36. Energy Conservation Measures for Belize

Energy Conservation	Intervention	Description	Strategic Focus Area:
EC1	**Promote a work-from-home culture**	Instead of sitting for hours in traffic to commute from home to work and back, the Internet offers the opportunity for people to work from home and avoid the usage of vehicles, therefore reducing gas consumption and increasing productivity, which in time also saves energy.	Strategic Focus Area 1: Energy Efficiency focusing on the Transport Sector
EC2	**Create incentives to increase access to multi-functional products and devices**	Modern devices such as laptops, tablets, and smart phones offer the opportunity to share data, reports, and other information digitally, instantly, and across the globe, avoiding the need to use paper, printers, copy machines, mailing services, and other types of products that required energy to be produced, or activities that consume energy. Furthermore, these devices serve as all-in-one devices that include digital agendas, cameras, phone, text, data processing, and many other functions that replace traditional stand-alone energy-consuming products, tools, and services, which otherwise would have demanded additional energy.	Strategic Focus Area 1: Energy Efficiency
EC3	**Use social media to transform entire communities' perspective about the use of energy and trigger behavioral change**	Through social media campaigns and other digital media, effective energy-saving measures can be incentivized and public awareness on behavioral changes can effectively be communicated to conserve energy.	Strategic Focus Area 1: Energy Efficiency
EC4	**Explore the opportunities for application of smart metering systems in public buildings**	Through demonstration projects, smart metering can be tested and its benefits and effectiveness assessed. Properly functioning smart metering systems provide instant data and information about energy consumption patterns and trigger behavioral change of the owner or building occupants to conserve	Strategic Focus Area 1: Energy Efficiency focusing on the Residential & Commercial Buildings, and Public Buildings &

Energy Conservation	Intervention	Description	Strategic Focus Area:
		energy.	Lighting
EC5	**Promote and incentivize the use of alternative mobility options**	The objective behind alternative mobility is to trigger people to opt for alternative means of mobility that prevent the need for additional energy consumption. This includes activities as carpooling, biking, walking, or use of mass public transportation options.	Strategic Focus Area 1: Energy Efficiency focusing on the Transport Sector
EC6	**Create or upgrade infrastructure for alternative means of mobility**	During urban planning processes, new bike lanes and other infrastructure can be planned to lead to improvements in bicycle, pedestrian, and transit service alternatives.	Strategic Focus Area 1: Energy Efficiency focusing on the Transport Sector
EC7	**Introduce sustainable design criteria in national building codes and procedures**	The objective of sustainable design of buildings is to reduce, or avoid, depletion of critical resources (energy, water, and raw materials), prevent environmental degradation caused by facilities and infrastructure throughout their life cycle, and create environments that are comfortable, safe, and productive. A variety of internationally accepted building certification programs, such as ASHRAE, LEED, and others, can be applied in Belize.	Strategic Focus Area 1: Energy Efficiency focusing on the Residential & Commercial Buildings, and Public Buildings & Lighting
EC8	**Promote eco-design, innovation, and sustainable production and consumption to conserve energy**	Belize, with its abundance of biomass resources, is well-positioned to explore innovative ways to use organic materials for producing high-end biodegradable products to be exported and sold in niche and premium markets. Investigating eco-design and sustainable manufacturing approaches, and exploring the cost-benefits of incentivizing local start-ups and SMEs in creating new business models, will not only result in the design of a high-quality product, but also enable businesses to become profitable, competitive, and sustainable while creating energy savings.	Strategic Focus Area 3: Clean Production

6.1.1 Energy Savings and Conservation

The Internet can be used as an effective means to avoid energy consumption by replacing traditional energy-consuming activities and by effecting a change in the mindset of entire communities through access to information. The ease of access and the low cost of the Internet make it a very useful tool to address energy savings. This is exemplified by opportunities such as:

6.1.2 Generation and Supply

- **Investigate and assess emerging technological solutions to close material and carbon cycles and generate renewable energy:** CO_2 emissions from industrial processes can be captured and used in bio-reactors to grow algae, which also serves as a feedstock to produce biofuels. In this way, an integrated, closed-loop-cycle carbon sequestering solution is provided to power plants and agro-processing industries in the country. This is an example of mutually beneficial solutions that allow for integration of industrial processes, generate renewable energy, and open up opportunities for new innovative business development in Belize.

- **Execute a heat demand and supply assessment for Belize**: A nationwide heat demand and supply analysis is needed that provides a clear assessment of the recoverable heat potential in the country, which at some point could meet the entire space heating demand of Belize.

- **Explore opportunities to promote the retrofitting of existing vehicles:** An estimation can be made to find out how much retrofitting vehicles to use E10 or higher biofuel mixes will increase demand for national biofuels over several time frames. This effort will help incentivize the domestic production of ethanol or biodiesel to offset imported fossil fuels.

- **Formulate and implement a sustainable transport policy to reduce economy-wide fuel intensity**: This may include biofuels policy within an overarching upgrading of the regulatory and business environment for fuel production, delivery, storage, and end-use.

- **Perform a nationwide waste-to-energy assessment:** A comprehensive assessment is needed to identify and characterize the waste-to-energy potential in Belize. This entails sourcing the organic fraction of MSW, sewage from waste water, agricultural and forestry residues, and other potential waste streams that contain organic matter and can be converted in energy carriers.

- **Design and implement a grid integration policy for Belize:** For improved deployment of grid-connected renewable energy technologies, a grid integration policy is needed. Grid integration is a vital component of Belize's policy and must be based on an integrated power systems study of BEL's grid system with various variable renewable energy penetration scenarios.

- **Introduce net metering for increased deployment of decentralized renewable energy technologies:** Net metering allows consumers with renewable energy systems to supply power to the grid and to receive a credit for their own production, reducing their own electricity bill and providing increased power in utility. Implementing a net metering program for large-scale electricity consumers such as hotels would promote the use of renewable energy technologies and encourage major consumers to connect to the grid if possible. Net metering could provide significant incentive for self-producers while at the same time generating additional power.

Table 37. Strategic Elements and Commitments Included in the Belize Sustainable Energy Action (2014–17)

#	Action Category	Activity	2014	2015	2016	2017
1	Help households, businesses, and government be more efficient	Decentralize government payment for electricity	x	x		
		Adapt and implement a building code			x	
		Develop financial mechanisms to invest in sustainable energy	x	x	x	x
		Provide consumers with more information on energy services and equipment		x	x	
2	Expand access to electricity using renewable energy	Develop a least-cost electrification plan			x	
		Develop an electrification investment program			x	
3	Promote large-scale renewable energy	Retain a transaction advisor for 2013-14 renewable energy tender	x			
		Develop a complete licensing regime		x		
		Streamline and clarify renewable energy permitting process		x	x	
		Accommodate the integration of intermittent renewable energy			x	
		Prepare resource studies for biomass, waste-to-energy, hydro			x	x
4	Build an efficient	Complete a cost-of-service study	x	x		

#	Action Category	Activity	2014	2015	2016	2017
	and enabling utility	Amend the tariff structure	x	x		
		Revise BEL's efficiency incentives	x	x		
		Update BEL's expansion plan		x		
		Study integration with the Central American Electricity Transmission System				x
5	Prepare for distributed generation	Develop a standard offer contract	x	x		
		Adopt a certification system for third-party inspectors			x	
6	Increase awareness and enhance skills	Provide training and capacity building	x	x	x	
		Provide education and public outreach		x	x	

6.1.3 Energy Efficiency

- **Incentivize the purchase and use of more-efficient vehicles:** Enhancements in conventional vehicle technology, such as regenerative braking and automatic "start/stop technology," should be deployed to increase overall fuel efficiency, among other technologies.

- **Incentivize the purchase and use of vehicles running on alternative energy sources:** Belize can explore the possibilities of incentivizing replacing fossil fuel-based transportation technologies with alternatives such as: all-electric vehicles, gas/electric hybrids (including plug-in hybrids), and other technologies that can greatly improve fuel efficiency while offsetting the use of imported fossil fuels.

- **Explore possibilities for implementation of Active Traffic Management (ATM) systems:** Real-time information to provide variable speed limits and dynamic lane control; real-time traffic and multimodal travel information; dynamic routing; smart transit and parking systems; electronic and open-road toll collection, and more. Intelligent Transportation System (ITS) technologies are an integral part of the strategies described above and their successful operation. These all lead to changes in transport patterns and thereby to optimizing the fuel consumption rate.

- **Design and implement a nationwide energy efficiency program:** Within the industrial sector, the largest energy carrier consumed is heat for process and manufacturing. A comprehensive energy efficiency strategy focus on heating and cooling for Belize would benefit multiple sectors and stakeholders in becoming aware of efficiency-improving technologies and solutions.

- **Investigate and assess potentials for creating synergies between the electricity sector and the heating and cooling sector:** In light of the emergence of renewable energy sources, for example, one can look at the potential use of thermal storage during off-peak electricity generation.

Table 38. Additional Suggested Energy Efficiency Measures to Enable Belize to Gather Data and Measure Progress

Sector	Energy Efficiency Measures
Commercial buildings	• Provide a roadmap to help Belize's building sector adapt to the new building standards • Energy certification of new and existing buildings that are sold, rented out, or leased • Require public sector buildings to display the energy certificate to the public • Establish national energy certification procedure(s) • Demand annual energy performance certificates for buildings • Introduce new standards for the energy performance of air conditioners

Sector	Energy Efficiency Measures
	• Issue the energy certificate on the basis of an energy audit, using authorized technicians who have the required training for performing energy audits and certification of buildings • Create financial incentives, such as in the form of a fund that will encourage and stimulate all programs and projects that will foster implementation of efficiency measures in buildings (e.g., reduced taxation for 10 years by “x” percentage, non-import taxes during the first five years to increase the importation of energy-efficient machinery and materials for construction, etc.)
Transportation	• Restrict the use of vehicles older than 20 years • Conduct a national assessment of vehicle efficiency measures, liters of fuel consumed per kilometer, and CO_2 emission standards (e.g., include this in existing car inspection procedures and requirements) • Introduce or lower CO_2 emissions standards and demand high fuel efficiency standards for vehicles imported into Belize • Offer tax reduction or provide economic support to replace old vehicles with new energy-efficient vehicles or alternative fuels vehicles • Offer supportive assets/infrastructure (electric charging stations/parking lots) to incentivize increased use of green vehicles within a period of time (average 3–5 years); • Introduce organizational measures (toll fees, congestion charging, parking space control, parking fees, freight transport control in urban areas, urban traffic infrastructure control) • Implement fuel diversification initiatives to incentivize the increased use of clean fuel vehicles by conducting and enhancing technical capacity to use alternative fuels (laboratories, testing facilities, etc.) • Introduce alternative fuels vehicles (CNG, biogas, biodiesel, ethanol, LPG, hydrogen) as well as propulsion system equipped with batteries and fuel cells
Industry	• Introduce consistent energy efficiency standards for appliances and equipment and a process to enable industry to adjust to increasingly stringent standards over time • Increase awareness and knowledge about the possibilities and economic benefits of investing in energy efficiency • Monitor and analyze energy consumption rates to allow for setting goals for the industry sector • Facilitate/demand energy audits and benchmark studies by industry sector • Initiate pilot projects (implementation of projects, best practices, replicability, and disseminate information about them) • Facilitate capacity building by training and education • Support business and industry with incentives to acquire know-how, skills, and human capacity to implement cost-effective energy efficiency opportunities and therefore meet the challenges of a low-carbon economy
Public sector	• Establish a system for monitoring energy consumption in all government facilities • Implement energy audits in priority facilities • Demand energy certification of public buildings • Introduce series of educational and motivational workshops and seminars for employees of government administration • Compensate governments working to improve the energy efficiency of their own buildings and operations
Residential sector	• Support households to reduce energy use by providing information and advice regarding energy-efficient technologies imported to Belize • Offer financial assistance and incentives to promote the shift from old technology to the new energy-efficient technology and pilot programs at the community level • Introduce higher energy efficiency standards to deliver substantial growth in the number of highly energy-efficient homes and buildings • Introduce new standards for the energy performance of air conditioners

Sector	Energy Efficiency Measures
Cross-cutting sectors	• Create a National Energy Efficiency Program (NEEP) • Establish programs and plans for energy efficiency in local communities, fortified by a general energy efficiency policy and its implementation procedure • Define energy audits, energy services, and contracting of the energy impacts • Improve energy efficiency of electricity generation and distribution (improve technology, equipment, etc.) • Define criteria for educating energy auditors, as well as their rights and obligations • Address potential regulatory impediments to the uptake of innovative demand-side initiatives and smart grid technologies

7 Sustainable Energy Targets for Belize: 2020–2040

This chapter presents the set of targets from the complete EUEI PDF-supported project "Capacity Development in Renewable Energy Policy and Mapping in Belize." The section includes information extracted from Task 2, "Capacity Building – Assessment of Renewable Energy Workforce Training Needs in Belize"; Task 3, "Energy Mapping Review and Future Mapping Strategy"; and Task 4, "Off-grid Rural Electrification Assessment and Strategy," as well as from Section 2.7. Specific information for targets of each task can be found in the original documents submitted to MPSEPU.

It should be noted that Task 3 has only two proposed targets, since the objective of the document is to address the fundamental issue of gathering data. To serve as a legend from where target can be found regarding each of the above mentioned tasks, a set of codes were given to identify each task in Table 39 below: Task 2, "Capacity Building – Assessment of Renewable Energy Workforce Training Needs in Belize" (Code A); Task 3, "Energy Mapping Review and Future Mapping Strategy" (Code B); Task 4, "Off-grid Rural Electrification Assessment and Strategy" (Code C); and Task 5, "Draft 2030 Sustainable Energy Roadmap" (Code D).

The goal of this section in to have an overreaching document that includes the five Strategic Focus Areas extracted from the *Sustainable Energy Programme – Strategy and Work Plan 2015–2020,* which are: 1) *Energy Efficiency* to dramatically lower energy intensities across the key economic sectors of Transport, Agriculture & Industry, Buildings (Commercial & Residential), and Public Lighting; 2) *Renewable Energy* to shift the energy matrix away from fossil fuels (especially oil) and toward alternative renewable energy technologies; 3) *Clean Production* to upgrade production systems in the processing of agriculture and forestry outputs to co-produce biofuels and/or electricity; 4) *Enhancing National Capacity* in clean energy and clean production by developing human, technological, and institutional and governance resources; 5) *Striving to Achieve Universal Access* to affordable, modern energy services, including resilient energy infrastructure.

Table 39. Proposed Targets: 2030 Belize Sustainable Energy Roadmap Strategy

Strategic Focus Area	Code	Targets	Target Year				Comments
			2020	2025	2030	2040	
Renewable Energy (RE)	D	Supply 87% of electricity demand from renewable energy			X		Taking into account Figure 38 (Penetration Scenario for Renewable Energy, 2000–2030), from the graph we can observe the total electricity demand for 2030 is approximately 2,300 GWh, and the fraction of renewable energy for 2030 is approximately 2,000 GWh out of 2,300 GWh of total electricity demand. Therefore, based on this RPEG Scenario 3
RE / Clean Production	D	Establish an ethanol market and use 50% of production to replace 52% of gasoline demand			X		For the transport sector Figure 16 (Forecast for 2012–2030 and Ethanol Supply Scenario) was considered in order to forecast and project the gas demand. From the graph, ethanol 10% by 2030 and motor gasoline were used and considered as the most realistic scenario. Motor gasoline for 2020 is projected to have a demand of 0.6 million gallons of gasoline needed, and for E10, 0.25 million gallons of ethanol needed. For 2030, it is projected that the demand will be 0.9 million gallons of gasoline and 0.48 million gallons of ethanol needed.
RE / Clean Production	D	Set a mandate for E10 production	X				The production of biodiesel in Belize could serve as closed-loop production since a fraction of the biomass produced can be used for blending, another fraction would serve other purposes, and a final fraction goes to powering agricultural equipment, which requires diesel as fuel.
RE / Clean Production	D	Set a mandate for E20 production			X		
RE / Clean Production	D	Heat – Set targets for remaining time frame until 2030	X				Presently no heat reduction or improvement targets are established for 2030 in Belize. Because little to no data are available to determine current heat production, it is not possible at this time to draw a baseline for measuring progress over time. Significant research is warranted to start mapping out how heat is produced and consumed in the country prior to setting any targets that can be measured and monitored in a practical and cost-effective way.
RE / Clean Production	D	Increase the production of biomass to supply 50% of demand with domestic production			X		The approach is more of a political or mission statement not based on real numbers.

Strategic Focus Area	Code	Targets	Target Year				Comments
			2020	2025	2030	2040	
RE / Clean Production	B	Institutionalize an entity in charge of energy collection, energy statistics, and energy management	X				We suggests this approach since the fundamental issue for renewable energy resource mapping is that there is not enough available data. Therefore these targets seem like a realistic starting point and approach to stall filling the gap towards data collection.
Renewable Energy/ Clean Production	B	Establish a statistics analysis development program	X				
National Capacity	A	Increase the number of trained engineers to 4	X				As stated by in the Task 2 report, under the most ambitious scenario, Belize need to increase training of 1) technicians and operators, and 2), associate engineers; by 2030, over 90 people will need to be trained per year in order to cover the National Capacity Targets. As per Figure 6 from Task 2, “Capacity Building – Assessment of Renewable Energy Workforce Training Needs In Belize” and the assumption of the consultants of different RE project coming online in the future, the following targets are recommended
National Capacity	A	Increase the number of trained engineers to 8			X		
National Capacity	A	Increase the number of trained associate engineers to 23	X				
National Capacity	A	Increase the number of trained associate engineers to 39			X		
National Capacity	A	Increase the number of technicians/operators to 60	X				
National Capacity	A	Increase the number of technicians/operators to 85			X		
Infrastructure	C	Phase out kerosene and candle lighting starting from 18% of households in the residential sector		X			These targets are part of the National Energy Policy Framework 2011 and were considered to evaluate rural electrification as part of Task 4
Infrastructure/ RE	C	Shift from electricity to solar lighting: electricity lighting (60%) and solar lighting (40%) in the residential sector				X	
Infrastructure/RE	C	Shift from electricity to solar lighting: electric lighting (75%) and solar lighting (25)% in the				X	

Strategic Focus Area	Code	Targets	Target Year				Comments
			2020	2025	2030	2040	
		commercial and services sector					
Infrastructure/RE	C	Shift to solar and geothermal technologies for cooling: electric cooling (50%), geothermal cooling (25%), and solar cooling (25%)				**X**	
Infrastructure	C	Supply electrification for 98% of households			**X**		
Energy Efficiency	D	Promote a work-from-home culture	X				Instead of sitting for hours in traffic to commute from home to work and back, the Internet offers the opportunity for people to work from home and avoid the usage of vehicles, therefore reducing gas consumption and increasing productivity, which in time also saves energy.
Energy Efficiency	D	Create Incentives to increase access to multifunctional products and devices	**X**				Modern devices such as laptops, tablets, and smart phones offer the opportunity to share data, reports, and other information digitally, instantly, and across the globe, avoiding the need to use paper, printers, copy machines, mailing services, and other types of products that required energy to be produced, or activities that consume energy. Furthermore, these devices serve as all-in-one devices that include digital agendas, cameras, phone, text, data processing, and many other functions that replace traditional stand-alone energy-consuming products, tools, and services, which otherwise would have demanded additional energy.
Energy Efficiency	D	Use social media to transform entire communities' perspective about the use of energy and trigger behavioral change		**X**			Through social media campaigns and other digital media, effective energy-saving measures can be incentivized and public awareness on behavioral changes can effectively be communicated to conserve energy.
Energy Efficiency	D	Explore the opportunities for application of smart metering in public buildings		**X**			Through demonstration projects, smart metering can be tested and its benefits and effectiveness assessed. Properly functioning smart metering systems provide instant data and information about energy consumption patterns and trigger behavioral change of the owner or building occupants to conserve energy.
Energy Efficiency	D	Promote and incentivize the use of alternative	**X**				The objective behind alternative mobility is to trigger people to opt for alternative means of mobility that prevent the need for additional energy

Strategic Focus Area	Code	Targets	Target Year				Comments
			2020	2025	2030	2040	
		mobility options					consumption. This includes activities as carpooling, biking, walking, or use of mass public transportation options.
Energy Efficiency	D	Create or upgrade infrastructure for alternative means of mobility		X			During urban planning processes, new bike lanes and other infrastructure can be planned to lead to improvements in bicycle, pedestrian, and transit service alternatives.
Energy Efficiency	D	Introduce sustainable design criteria in national building codes and procedures	X				The objective of sustainable design of buildings is to reduce, or avoid, depletion of critical resources (energy, water, and raw materials), prevent environmental degradation caused by facilities and infrastructure throughout their life cycle, and create environments that are comfortable, safe, and productive. A variety of internationally accepted building certification programs, such as ASHRAE, LEED, and others, can be applied in Belize.
Clean Production	D	Promote eco-design, innovation and sustainable production and consumption to conserve energy	X				Belize, with its abundance of biomass resources, is well-positioned to explore innovative ways to use organic materials for producing high-end biodegradable products to be exported and sold in niche and premium markets. Investigating eco-design and sustainable manufacturing approaches, and exploring the cost-benefits of incentivizing local start-ups and SMEs in creating new business models, will not only result in the design of a high-quality product, but also enable businesses to become profitable, competitive, and sustainable while creating energy savings.
Energy Efficiency	D	Measure energy demand applying the Vehicle, Kilometer, Rate of Consumption (VKR) method	X				
Energy Efficiency	D	Measure the Consumption of Net Energy (C,m,M) for the transport sector	X				
Infrasstructure/RE	D	Analyze the different electricity industry structures and evaluate the different degrees of government ownership and control	X				

8 Sustainable Energy Action Plan for Belize: 2016–2020

This chapter presents the actions proposed by the consultants for the following elements of the EUEI PDF-supported project "Capacity Development in Renewable Energy Policy and Mapping in Belize": Task 2, "Capacity Building – Assessment of Renewable Energy Workforce Training Needs in Belize"; Task 3, "Energy Mapping Review and Future Mapping Strategy"; Task 4, "Off-grid Rural Electrification Assessment and Strategy"; and Task 5, "Draft 2030 Sustainable Energy Roadmap." The actions are based upon each report's assessment and ensuing recommended fields of action, including a series of associated activities and sub-activities. The activities provided from Task 2, Task 3, and Task 4 provide suggestions with regards to lead agency, supporting agency, estimated cost, level of priority, estimated returns/benefits and a proposed timeline during the time frame of 2016–2020.

The Actions from the Sustainable Energy Strategy (2015) report have been shifted to fit the new set timelines accordingly. Specific information for each of the Actions of each task can be found in the original documents submitted to MPSEPU.

Table 40. Capacity Development in Renewable Energy Policy and Mapping in Belize Actions

No.	Activity	Lead Agency	Strategic Focus Area	Est. Cost (USD 1,000)*	Priority (low-med-high)	2016				2017				2018				2019			
						Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	**Phase 1: Management commitment**	**MPSEPU**	**Energy Efficiency**		**High**																
1.1	**Commitment by MPSEPU to an energy management program**			100-200																	
1.2	**Assign an energy management coordinator**			100-200																	
1.3	**Creation of an Energy Council to manage departments for Residential; Commercial, Services, and Public; Industrial; Transport; and Agriculture**			300-500																	
2	**Phase 2: Audit and Analysis**	**MPSEPU**	**Energy Efficiency**		**High**																
2.1	**Review historical patterns of fuel and energy use**			10-15																	
2.2	**Perform walk-through surveys**			25-50																	
2.3	**Preliminary analysis, review of drawings, data sheets, equipment specifications**			10-15																	
2.4	**Development of energy audit plans**			50-100																	
2.5	**Conduct energy audit**																				
2.5.1	Covering Residential Sector			9-21																	
2.5.2	Covering Commercial, Services, and Public Sector			100-200																	
2.5.3	Covering Industry Sector			200-500																	
2.5.4	Covering Transport Sector			200-300																	
2.5.5	Covering Agriculture Sector			200-500																	
2.6	**Calculation of annual energy use based on audit results**			100-200																	

2.7	**Comparison with historical records**			50-100				
2.8	**Analysis and simulation step (engineering calculation, heat and mass balances, theoretical efficiency calculations, computer analysis and simulation) to evaluate the energy management option**			200-500				
2.9	**Economic analysis of selected energy management options (life cycle costs, rate of return, benefit-cost ratio)**			100-150				
3	**Phase 3: Implementation**	**MPSEPU**	**Energy Efficiency**		**High**			
3.1	**Establish energy efficiency goals per sectors**							
3.2	**Determine capital investment requirements and priorities**			30-50				
3.3	**Establish measurements and reporting procedures, install monitoring and recording instruments and sub meters as required**			50-100				
3.4	**Institute routine reporting procedures ("energy-tracking" charts) for managers and publicize reports**			30-50				
3.5	**Promote continuing awareness and involvement of personnel**			**20-40**				
3.6	**Provide periodic review and evaluation of overall energy management program**			10-15				
4	**Fuels**	**MPSEPU**	**Energy Efficiency/ Clean Production**	200-300	**High**			
4.1	**Assess the available fraction of biomass**							
4.2	**Measure if there is any continuous supply of biomass**							
4.3	**Establish a power purchase agreement for biomass fuels**							
4.4	**Diesel**							
4.4.1	Evaluate the diesel demand							
4.4.2	Assess the market potential of Ethanol production							
4.4.3	Establish a mandate for ethanol blending or							

	mixing				
4.4.4	Evaluate the biomass resource availability for biodiesel production				
5	**Heat**	**MPSEPU**	**Energy Efficiency**		**High**
5.1	**Evaluate stationary fuel component to assess the conversion factor and determine how much heat must be extrapolated**			20-30	
5.2	**Collection of heat data**				
6	**SIEPAC Interconnection**	**MPSEPU , BEL**	**Infrastructure**	100-120	**High**
6.1	**Analyze the different electricity industry structures and evaluate the different degrees of government ownership and control**				
7	**Help householders, business, and government be more energy efficient**	**Ministry of Finance, PUC, MPSEPU**	**Energy Efficiency**		
7.1	**Adapt and Implement a Building Code**			10-15	
7.2	**Decentralize Government Payment for Electricity**			50-60	
7.3	**Develop financial mechanism to invest in Sustainable Energy**	**Ministry of Finance, MPSEPU**			
7.3.1	Develop and Operationalize a Financial Mechanism for the Public Sector			~ 30,000	
7.3.2	Develop and Operationalize a Financial Mechanism for the Private Sector		**e**	~ 10,000	
7.4	**Provide Consumers More Information on Energy Services and Equipment**	**Bureau of Standar ds**			
7.4.1	Adopt Certifications for Energy Services			15-20	
7.4.2	Adopt Labeling for EE Equipment			75-100	
8	**Expand Access to Electricity Using RE**	**MPSEPU**	Renewable Energy		
8.1	**Develop a least cost electrification Plan**			60-80	
8.2	**Develop an electrification investment programs**			~ 1,100	
9	**Promote Large Scale Renewable Energy**		Renewable Energy		
9.1	**Retain Transaction Advisor 2013-2014 RE Tender**	**MPSEPU**		0	

9.2	**Develop a Complete Licensing Regime**	**PUC**		15-20
9.3	**Streamline and Clarify RE Permitting Process**	**MFFESD**		200-300
9.4	**Accommodate the integration of Intermittent RE**			
9.4.1	Complete Grid Integration/Impact and Transmission Strengthening Studies	**BEL**		125-150
9.4.2	Upgrade the Grid Code	**BEL**		15-20
9.5	**Prepare Resource Studies for Biomass, Waste-to-Energy and Hydro**	**MPSEPU**		200-300
10	**Build an Energy and Enabling Utility**		Energy Efficiency	
10.1	**Complete a Cost of Service Study**	**BEL, PUC**		150-170
10.2	**Amend Tariff Structure for EE and Distributed Generation**			
10.2.1	Improve Tariff Structure for EE and Distributed Generation	**PUC**		20-25
10.2.2	Improve the Functioning of BEL's Decoupled Tariff Structure	**PUC**		20-25
10.3	**Revise BEL's Efficiency Incentives**	**PUC**		20-25
10.4	**Update BEL's Expansion Plan**	**BEL**		100-130
10.5	**Study Integration with Central American Electricity Transmission System**	**MPSEPU, BEL**		100-120
11	**Prepare for Distributed Generation**		**Energy Efficiency**	
11.1	**Develop a Standard Offer Contract**	**PUC**		15-20
11.2	**Adopt a Certification System for Third Party Inspections**	**PUC**		10-15
12	**Increase Awareness and Enhance Skills**		National Capacity	
12.1	**Provide Training and Capacity Building**			
12.1.1	Train the PUC in RE and EE Relevant Areas	**MPSEP, PUC, BEL**		50-100
12.1.2	Build Capacity of the MPSEPU	**MPSEP**		50-100
12.1.3	Implement Technical Training Program for EE and RE Technologies	**MEYS**		100-150
12.1.4	Train Financial Institutions on Lending for Sustainable Energy Projects	**MPSEP**		100-150
12.1.5	Train BEL to manage Intermittent RE	**BEL**		50-100
12.2	**Provide Education and Public Outreach**			
12.2.1	Upgrade Curricula and Programs for Tertiary Education	**MEYS, MPSEPU**		120-140

12.2.2	Develop and Conduct a Public Outreach Campaign	**MPSEP**		100-150	
12.2.3	Upgrade Curricula and Programs for Primary and Secondary Education	**MEYS, MPSEPU**		70-90	
13	**Determine scope of data needed to map renewable energy assessment potentials**	**MPSEPU**	**Renewable Energy/Clean Production**	**10 – 15k**	High
13.1	Identify and outline the critical set of renewable energy statistics to perform assessments and map potentials			10 – 15k	
14	**Assess the available data in the country**	**MPSEPU**	**Renewable Energy/Clean Production**	**70 – 100k**	High
14.1	Perform a renewable energy data gap analysis			10 – 15k	
14.2	Perform a detailed literature review to gather renewable energy resource data			10 – 15k	
14.3	Identify and map out the critical stakeholders that serve as primary sources of data			5 – 10k	
14.4	Conduct in-country interviews using pre-designed data collection surveys			5 – 10k	
14.5	Perform data quality assessment			15 – 20k	
14.6	Run a data-quality analysis to determine the statistical quality of the data generated by each identified data source			25 - 30k	
15	**Improve primary data collection**	**MPSEPU**	**Renewable Energy/Clean Production**	**245 – 360k**	**High**
15.1	Complete a detailed mapping of the primary sources for data collection per each renewable energy source			10 – 15k	
15.2	Conduct a survey to understand how the primary data is collected at each of the identified primary sources in Belize			20 – 30k	
15.3	Map out how the primary data is measured, collected or calculated			10 – 15k	
15.4	Identify primary sources that require technical assistance to improve their primary data collection activities			5 – 10k	
15.5	Within the primary sources that require assistance, review the suitability of the applied methodology			15 – 20k	
15.6	Assess and evaluate the used measurement			15 – 20k	

	instruments and recommend appropriate corrective measures																				
15.7	Assess the need for investment in measurement tools and instruments			10 – 15k																	
15.8	Identify financial sources for the purchase of the required tools and instruments			10 – 15k																	
15.9	Identify and select the appropriate primary data resource collection method per renewable energy resource			20 - 30k																	
15.10	Prepare an inventory of primary data collection methods per renewable energy resource			10 – 15k																	
15.11	Select appropriate methodology and tailor to the local conditions			15 – 20k																	
15.12	Train the assigned personnel within each primary source on the primary data collection process			30 – 50k																	
15.13	Design a training program to address the data collection needs or identify existing programs available			25 – 30k																	
15.14	Institutionalize the training at a university or other educational institute to ensure sustainability			50 – 75k																	
16	**Set up data collection and management system**	**MPSEPU**	**Renewable Energy/Clean Production**	**875 – 1,230**																	
16.1	Perform a stakeholder analysis to identify the potential host of the data collection and management system			20 – 25k																	
16.2	Organize a stakeholder meeting to assess the strengths and needs of participating entities			10 – 15k																	
16.3	Preselect potential candidates to host the data management system and assess the in-house capabilities			5 – 10k																	
16.4	Select a suitable data collection and management system software			10 – 15k																	
16.5	Perform an analysis of available data collection and management system software and determine their suitability for the context of Belize			10 – 15k																	
16.6	Purchase licenses			50 – 100k																	
16.7	Tailor the selected software to the specific needs of the country			25 – 30k																	

16.8	Establish the required IT infrastructure to operate the software on the entities that provide the primary data for data sharing with the host entity			400 – 500k
16.9	Train the assigned personnel to optimally manage and use the system			100 – 150k
16.10	Each primary source to assign a focal point to interact with the host entity of the data management system			5 – 10k
16.11	Organize workshop for the focal points of the primary data sources to learn about how to populate and use the system			10 – 15k
16.12	Outreach and communication			100 – 150k
16.13	Create an outreach and communications strategy for the promotion and dissemination of renewable energy statistics of Belize			20 – 30k
16.14	Prepare reporting templates for the organization of statistics and effective presentation of information			10 – 15k
16.15	Create and maintain a publically accessible renewable energy statistics database (via website)			100 – 150k
17	**Convert and analyze primary data into energy statistics and indicators**	**MPSEPU**	**Renewable Energy/Clean Production**	**1,045 – 1,310k**
17.1	Build capacity to analyze primary data and convert into energy statistics			200 – 250k
17.2	Assign one or more energy analyst to the host entity of the data management system			300 – 350k
17.3	Select and purchase appropriate software that includes among other geospatial mapping tools to perform energy analysis			400 – 500k
17.4	Define indicators based on established policy targets and roadmaps objectives			10 – 15k
17.5	Perform a detailed energy policy analysis to identify established targets			15 – 20k
17.6	Identify, select and adapt indicators			20 – 25k
17.7	Perform a monitoring and evaluation of the resource mapping system			100 – 150k
18	**Institutionalize the resource mapping system**	**MPSEPU**	**Renewable Energy/Clean Production**	**355 – 500k**

18.1	Institutionalize the supply of primary data to the data collection and management system			100 – 150k	
18.2	Prepare, negotiate and confirm a multi-actor agreement to secure the formal commitment of primary sources for the continued and periodic supply of primary data			20 – 30k	
18.3	Institute a national renewable energy resource mapping steering committee			25 – 30k	
18.4	Adopt a renewable energy resource management policy to institutionalize the resource mapping system			25 – 30k	
18.5	Draft a renewable energy resource management policy			20 – 25k	
18.6	Socialize, finalize and submit the renewable energy resource management policy to cabinet for review and approval			30 – 35k	
18.7	Institutionalize the integration of the national energy statistics into international databases			50 – 75k	
18.8	Analyze the type and format of renewable energy statistics required by international renewable energy databases and global resource maps			15 – 20k	
18.9	Perform regular assessments and updates to determine any changes in international data base requirements and management			15 – 20k	
18.10	Assign a focal point to each of the respective international renewable energy resources database and platforms			5 – 10k	
18.11	Participate in international seminars, workshops and training programs to gather the latest developments in renewable energy statistics collection and management			50 – 75k	
19	**Create stronger industry demand-orientation including better assessments of workforce data, occupational needs and skill demands, and industry attachments**		**National Capacity**	120	
19.1	**Improve demand-orientation of ITVETs**			40	
19.1.1	Conduct detailed occupational analysis based on local industry needs of Belize's vocational programs in terms of tracks and trades relevant to the RE sector (ITVETs)	MOEYSC			now
19.1.2	Identify priority areas for course curriculum strengthening	MOEYSC			now

19.1.3	Identify areas for improved quality control measures	MOEYSC			now																
19.2	**Improve demand-orientation of University of Belize curriculum**			40																	
19.2.1	Conduct detailed occupational analysis of Belize's core Assoc. Degree training programs at University of Belize	MOEYSC, UB			now																
19.2.2	Identify priority areas for course curriculum strengthening	MOEYSC, UB			now																
19.2.3	Identify areas for improved quality control measures	MOEYSC, IB			now																
19.3	**Establish as system for regularly updating the workforce assessment completed (Task 2 of EUEI PDF supported project)**			-																	
19.3.1	Identify ways to collect workforce data in a coordinated and cost-effective manner (note: this activity to align with Task 3 recommendations - further detail to come)	MoL		-	now																
19.3.2	Implement process for ongoing data collection and communication (e.g. centralized management of data collection, tracking and agency with clear responsibility for communication) (note: this activity to align with Task 3 recommendations)	Statistical Institute of Belize		-	soon																
19.4	**Create systems to monitor and evaluate the successes, failures and the impact of the workforce capacity building initiatives using the data collected on RE workforce capacity and analyzing employment trends and changes in capacity gaps**	MOEYSC		-	now																
19.5	**Establish a public-private dialogue on workforce capacity needs and capacity building to promote exchange of needs and supply, to identify opportunities to collaborate, to identify gaps and to exchange best practices**																				
19.5.1	Develop dialogue structure, mandate and goals and implement a series of conversations/round tables (consultancy, facilitators)	Beltraide		40	soon																
19.5.2	Use the dialogue to identify where corporate skill sets are not being met, exploring whether the model used by BTL and Saint John's (IT sector - see report example) can be applied in the RE sector	Beltraide		-	soon																

20	**Increase the number and competence of skilled graduates for the whole industrial sector and build the foundation for specialized training in RE technologies**		**National Capacity**	145																		
2.1	**Select three institutions for technical education in three regions to champion technical capacity building for RE**																					
20.2	**Develop criteria and clarify investment offers for a call for proposals.**	MPSEPU, MoE			soon																	
20.3	**Establish a public-private jury for the selection process.**	MPSEPU, MoE			soon																	
20.4	**Publish call and identify three institutions (centres of excellence).**	MPSEPU, MoE			soon																	
20.5	**Invest in general knowledge and practical skills in demanded occupations at the Centres of Excellence (students & instructors)**																					
20.5.1	Establish and maintain one platform with all information and courses at all ITVETs	MOEYSC		15	soon																	
20.5.2	Evaluate how the successes of the Orange Walk ITVET tracking system can be improved further to better meet the needs of energy companies	MOEYSC		15	soon																	
20.5.3	Create an ITVET roundtable for knowledge sharing and to create a mechanism to share and support the implementation of successful approaches taken by various ITVET (e.g. deploying the Orange Walk tracking system across other ITVETs)	MOEYSC		15	soon																	
20.5.4	Form partnerships with international IVETs to make it easier for students to get the training required for jobs available in Belize	MOEYSC		-																		
20.6	**Invest in general knowledge and practical skill development within the assoc. degree program at UB (students & instructors)**																					
20.6.1	Conduct a detailed curriculum review of the Associate Degree in Mechanical and Electrical Engineering at UB and identify ways to strengthen it and whether it should be split into two separate degrees	MOEYSC		20	soon																	
20.6.2	Develop an *Introduction to Conventional & Renewable Electricity Generation* course to be delivered to students in the Mechanical and Electrical Engineering program (developed in dialogue with energy sector	MOEYSC		40	soon																	

	companies so that it meets their needs, ensure that relevant equipment and modern teaching methods are employed)																				
20.6.3	Expand the current curriculum review of the Agriculture and Biology Assoc. Degrees to determine whether existing courses can be updates and/or whether a new course covering biomass is feasible	MOEYSC		20	soon																
20.6.4	Create internship partnership program for university-level students with Belize companies, establishing incentives for corporate participating (e.g., financial, talent matching) and a clear feedback mechanism and evaluation process for participating companies (e.g. streamlined process articulating performance evaluation and hiring criteria)	MOEYSC		-	later																
20.6.5	Form UB partnerships with international universities to make it easier for students to get the training required for jobs available in Belize	MOEYSC		-																	
20.7	**Develop train-the-trainer curriculum to strengthen instructor abilities to teach and assess practical skills for UB and ITVETS**																				
20.7.1	Identify and prioritize areas for instructor knowledge and skill development including pedagogy for hands-on skills training	MOEYSC		20	soon																
20.7.2	Identify ways to incentivize instructors to share knowledge and skill expertise to strengthen curriculum delivery e.g. cooperation with companies	MOEYSC		-	soon																
20.7.3	Provide stipends for instructors to travel to and participate in train-the-the trainer courses	MOEYSC		25	soon																
20.7.4	Form partnerships with international universities for train-the-trainer programs			-																	
21	**Support multi-company and public-private partnerships to co-finance or co-provide laboratories, equipment and specialized RE training courses, including mid-career and extension-school courses and in train-the trainers programs**		**National Capacity**	210																	
21.1	**Invest in technical labs and training equipment to improve practical application an hand-on skills at UB and ITVETs**																				

21.1.1	Conduct laboratory and equipment needs assessment (what is needed based upon curriculum and skill set development) teaching laboratories and centres	MOEYSC / MPSEPU		20	soon															
21.1.2	Allocate public funds in budget to purchase basic teaching equipment for all core Assoc. Degree and vocation training programs	MOEYSC / MPSEPU		100	soon															
21.1.3	Form PPPs or sign MOUs with major employers to provide sector specific equipment and/or to co-finance equipment upgrades on a regular 2-5 year cycle	MOEYSC / MPSEPU		-	soon															
21.1.4	Form PPPs or sign MOUs with major employers to finance or co-finance specialized training courses and/or train-the-trainer programs	MOEYSC / MPSEPU		30	soon															
21.1.5	Teach instructors how to use and teach with modern lab and equipment e.g. in cooperation with companies	MOEYSC / MPSEPU		15	soon															
21.2	**Create opportunities for corporate training partnerships**																			
21.2.1	Encourage and if possible provide financial incentives for companies to provide joint trainings across common skill set needs in partnership with ITVETs	MOEYSC / MPSEPU		TBD	soon															
21.2.2	Create opportunities and incentives for company progressions to serve as trainers at ITVETs (or lead train-the-trainer courses) to make courses more practically applicable	MOEYSC / MPSEPU		-	later															
21.2.3	Promote company attachment and investigate options for dual degrees with international consultant	MOE / MPSEPU		40	later															
22	**Make stronger use of regional and international training providers, stipends and scholarships**		**National Capacity**	190																
22.1	**Based upon needs assessment (1.1), identify partners to address priority areas**																			
22.1.1	Explore partnership with UVI on NABCEP training	MOEYSC		-	soon															
22.1.2	Explore partnership with ATEEC on occupational analysis	MOEYSC		-	soon															
22.1.3	Provide travel and accommodation stipend	MPSEPU		90 (10 per year a 3.000)																

22.2	**Create and fund internship programs for Belizean citizens/residents obtaining education in the renewable energy sector to be matched with internship opportunities in Belize and internationally**			100	
22.2.1	Establish the internship fund (budget, mandate, priorities, job/university partnerships, application process)	MOEYSC			later
22.2.2	Identify financing and co-financing sources	MOEYSC		-	later
22.2.3	Implement internship fund	MOEYSC		TBD	later
22.2.4	Improve bonded scholarship program with industry attachment for engineering programs abroad e.g. with internships and job guarantee	MOEYSC		-	later
23	**Promote certification programs for plant operators, electricians, and welders**		**National Capacity**	120	
23.1	**Based upon needs assessment (1.1), determine whether to create Belize-specific certification program or modify international/regional certificates to Belize context**	MOEYSC		20	soon
23.2	**Establish regular continuing education and skill-assessment courses for early- and mid-career operators, electricians and welders**	MOEYSC		60	soon
23.3	**Create scholarships for extension school and evening school programs**	MOEYSC		40	later
24	**Invest in targeted trainings and capacity building in rural communities to enable sustainable operations and use of off-grid installations of solar PV and minigrids**		**National Capacity**	see Activity 4 budget	
24.1	**Create train-the-trainer partnership with leading mini-grid and remote electricity management instruction centers and technology providers**	Rural Develop ment			now
24.2	**Prepare, deliver, and evaluate training curriculum to rural communities on electricity management**				
24.2.1	Develop a practical training course for pico-, micro-solar and minigrid for instruction in regional ITVETs, junior colleges. Prepare videos, games, and practical exercises.	Rural Develop ment, MPSEPU			soon
24.2.2	Start a living stipend program to cover travel and living costs during technical education in Belize City or Centres of Excellence to residents of Toledo.	Rural Develop ment, MPSEPU			soon

24.2.3	Invest in a mobile lab (truck-mountable) with pico-, micro-solar and minigrid technologies that can be used for remote training courses	Rural Development, MPSEPU			soon
24.2.4	Monitor and evaluate maintenance of rural electrification investments and create open dialogue to ensure trainings are effective	Rural Development			soon
25	**Improve public information and matching platforms for vacancies, training and scholarship opportunities, exchange on technical and educational innovations, and promoting the image and attractiveness of STEM and engineering careers and trainings, especially at ITVETs, including for girls and women.**		**National Capacity**	148	
25.1	**Improve public information on RE and engineering sector opportunities**				
25.1.1	Develop brochures and flyers on careers in Engineering and in the RE sector, ensuring gender neutrality and also highlight examples of females in the sectors	Beltraide, BTEC		2	soon
25.1.2	School competition in STEM with a focus on engaging women	MOE		30	later
25.1.3	Develop an interactive online course (MOOC) for secondary school "Introduction to RE in Belize"	MOE		50	later
25.1.4	Create opportunities for secondary students to tour RE and engineering labs, see demonstration technologies and gain hands-on exposure to sector, e.g., through programs for short summer placements	MPSEPU		30	soon
25.2	**Create matching platforms for vacancies, training, scholarships, and exchange opportunities**				
25.2.1	Create a database of local RE enterprises and training providers and collect data on existing RE capacity, skill gaps, and trainings through a biannual survey (refer to RE Sector Labour Stats Excel tab for data collection sheet)	MESTPU / M of Labour/ MOE		6	
25.2.2	Create a Facebook page as a market platform with information sharing	Betraide		-	-
25.3	**Provide targeted trainings on an introduction to RE technologies and capacity building needs and opportunities**		**National Capacity**	20	

	to public officials at the MPSEPU, MOEYS, the Ministry of Economic Development, Beltraide, to the PUC, BEL and private sector companies.				
25.4	**Create partnership with GIZ, 5 C's, Clean Energy Solutions Centre and/or IRENA Lighthouse program for regional/international experts to prepare and deliver course for public officials, including on the relationship of RE on climate mitigation and adaptation.**	MPSEPU		20	
26	**Ensure the quality and coordination of capacity building initiatives by giving the mandate to an inter-ministerial steering committee (i.e., the Energy Council)**		**National Capacity**		
26.1	**Create an online one-stop-shop for RE enterprises, training providers and individual stakeholders to provide information on RE sector capacity, available trainings, and career opportunities**	Beltraide		-	
26.2	**Energy Council develops roadmap with milestones and indicators to manage, monitor and evaluate CDP implementation**	MPSEPU		-	
26.3	**Explore opportunities for combined research in Science, Technology and Innovation (STI) and practical application and capacity building with the Korea Development Institute.**	MPSEPU		long	
27	Prior to Program implementation: Pilot phase	MPSEPU	**Infrastructure**		Soon
28	Project Management	Implementing agency		810	
28.1	Project Management Unit set up	Implementing agency			
28.2	Awareness campaign and publicity	Implementing agency			
28.3	Monitoring and Evaluation	Implementing agency			
29	Pico-solar and Small autonomous PV Kits		**Infrastructure**	1640	
29.1	Definition of criteria and selection of participating Credit Unions	Implementing			

		Agency		
29.2	Signature of Loan Access Agreement (Credit Unions)	Implementing Agency		
29.3	Definition of criteria and selection of participating importers	Implementing Agency		
29.4	Signature of Service Level Agreements (importers)	Implementing Agency		
29.5	Review and update of Loan Access Agreements, Service Level Agreements	Implementing Agency		
29.6	Review and update of Credit Institutions	Implementing Agency		
29.7	Review and update of participating companies	Implementing Agency		
30	**Autonomous PV plants - Businesses**		**Infrastructure**	1808
30.1	Definition of sizing criteria	Implementing Agency		
30.2	Criteria and involvement of Financial Institutions	Implementing Agency		
30.3	Open call for applications involving productive use stakeholders	Implementing Agency		
30.4	1st batch of projects: determine financial profile, set loan structure	Implementing Agency		
30.5	2nd batch of projects: determine financial profile, set loan structure	Implementing Agency		
30.6	3rd batch of projects: determine financial profile, set loan structure	Implementing Agency		
31	**Autonomous PV plants - Public Services**		**Infrastructure**	513
31.1	Definition of sizing criteria	Implementing Agency		
31.2	Criteria and involvement of Financial Institutions	Implementing nting		

		Agency			
31.3	Open call for applications liaising with the relevant stakeholders	Implementing Agency			
31.4	1st batch of projects: determine financial profile, set loan structure	Implementing Agency			
31.5	2nd batch of projects: determine financial profile, set loan structure	Implementing Agency			
32	**RE off-grid Micro-grids**	Implementing Agency	**Infrastructure**	600	
32.1	Review and study of the micro-grid experience in La Gracia: analysis of the social, technical, economic and environmental sustainability elements	Implementing Agency			
32.2	Development of possible operation models and tariff schemes for micro-grids in Belize and IPP contracts	Implementing Agency			
32.3	Coordination with BEL on rural electrification extension of national grid (continuous)	Implementing Agency			
32.4	Roll-out 1: Open Request for Electrification, selection of 1st batch depending on available funds, considering BEL plans	Implementing Agency			
32.5	Feasibility studies at selected batch of locations, considering Energy Council Working Group on Universal Access and productive uses stakeholders' inputs	Implementing Agency			
32.6	Development of tender documents for IPP	Implementing Agency			
32.7	Tender of IPP (batches or individual projects to be defined)	Implementing Agency			
32.8	Construction of Generation and Distribution at selected locations	Implementing Agency			
32.9	Operation of IPP and BEL in roll-out 1	Implementing Agency			
32.10	Lessons learned from roll-out 1 (after 1 year)	Implementing Agency			

32.11	Roll-out 2: Open Request for Electrification, selection of 1st batch depending on available funds, considering BEL plans	Implementing Agency		
32.12	Feasibility studies at selected batch of locations, considering Energy Council Working Group on Universal Access and productive uses stakeholders' inputs	Implementing Agency		
32.13	Development of tender documents for IPP	Implementing Agency		
32.14	Tender of IPP (batches or individual projects to be defined)	Implementing Agency		
32.15	Construction of Generation and Distribution at selected locations	Implementing Agency		
32.16	Operation of IPP and BEL in roll-out 2	Implementing Agency		
33	**Capacity Building**	Implementing Agency	**National Capacity**	587
33.1	Village-cluster level	Implementing Agency		
33.2	Prepare the village-cluster program assigning villages to village-cluster schools, support on train-the-trainers by NAVCO	Implementing Agency		
33.3	Create the curricula	Implementing Agency		
33.4	Invest in infrastructure for training	Implementing Agency		
33.5	Prepare and roll out the scholarship program	Implementing Agency		
33.6	Village level	Implementing Agency		
33.7	Community workshops at primary schools	Implementing Agency		
33.8	Individual level	Implementing		

		Agency																			
33.9	Assistance to applicants (between launch of Call for proposals for Businesses/Productive uses and moment of selection)	Implementing Agency																			

8.1.1 Next Steps

Note that additional steps are required to finalize this *2030 Sustainable Energy Roadmap* Strategy. The next steps are as follows:

1. **Circulate this Draft *2030 Sustainable Energy Roadmap* Strategy with the National Energy Council**

   MPSEPU needs to provide a clear presentation/explanation of the value of this proposed *2030 Sustainable Energy Roadmap* Strategy. Formal buy-in should be secured from the NEC, including a clear official mandate articulating the specific tasks, responsibilities, and authority level of MPSEPU as the designated lead entity for guiding further development of this roadmapping process and eventually guiding implementation of the *2030 Sustainable Energy Roadmap* Action Plan.

   Specific issues to be addressed by the NEC:

   - Confirm the purpose and need for a 2030 Belize Sustainable Energy Roadmap.
   - Establish and describe the Strategic Vision and Statement for Belize's energy development by 2030 (*this should include and clarify the core principles to be adhered to, to determine the guiding framework to select and to develop sustainable energy technologies and solutions*).
   - Determine the scope and boundaries of the roadmapping exercise (*this includes the extent of depth of data and analyses needed, the range and type of stakeholders to be included, and confirming the time frame of the Roadmap—currently set for 15 years up to 2030*).
   - Confirm the current selected approach and focus areas (this refers to the current outline and structure of this report, and to the selected energy carriers—*electricity, fuels, and heat*—and end-use categories—*transport, industry, residential and commercial buildings, and public buildings and lighting*).
   - Verify and confirm the current state of energy generation, supply, and consumption patterns in Belize (*this relates to the present baseline conditions as described in Chapter* 3).
   - Make an initial judgment regarding the scope of technologies and solutions to be considered for further analysis and incorporation in the Strategic Roadmap (*Section 4.5 captures several technologies and solutions deemed appropriate for Belize*).
   - Determine whether and how the NEC will use the first official edition of the 2030 Sustainable Energy Roadmap (*to be finalized in 2016*) for national government decision making and monitoring of progress.
   - Determine the scope of stakeholders to be invited and incorporated in the roadmapping exercise (*this requires identification of the roles and responsibilities of the stakeholders with appropriate level of authority and expertise that can generate value and become supporters of the Strategic Roadmap*).

2. **Engage in dialogue with select stakeholders in key sectors to review and update the Draft *2030 Sustainable Energy Roadmap* Strategy (Technical Workshop #1)**

   MPSEPU should plan and organize multiple expert and select stakeholder workshops during the course of developing the next draft of the *2030 Sustainable Energy Roadmap*. This helps to build consensus among stakeholders to ensure an effective technology roadmapping process. For these workshops, a cross-section of industry leaders, experts in technology, policy, economics, finance, social sciences, and other disciplines should be invited to help formulate the Roadmap's goals and milestones, help address the identified gaps in data and analysis, determine priorities, and start assigning tasks. It is critical to gather local industry leadership and expert judgment to help make informed choices among possible scenarios or technological options that need to be backed up by data and analysis. This also facilitates future public-private partnerships and private sector engagement in implementing the roadmap.

Specific objectives are:

- Create awareness and build consensus among key stakeholders on the strategic vision, goals, objectives, and targets.

- Review and confirm the baseline conditions in the energy sector of Belize (*currently relying solely on limited interview feedback, and existing publicly available data and information*).

- Evaluate and verify assumptions made in technology and solutions assessments. This includes the requirement of screening and selecting technologies and solutions based on cost-benefit analyses, multi-criteria analyses, and other decision-making tools (*presently only electricity and end-use power related technologies and interventions have been screened and selected based on renewable energy resource availability assumptions and technology cost analyses*).

- Review, discuss, and define alternative technology pathways compared to the business-as-usual scenario.

- Confirm the scope of technologies to be considered and incorporated in the Strategic Roadmap.

- Identify and confirm the key specific or crosscutting technical, human capacity, institutional, and market barriers that exist within the respective sectors in the economy among groupings of stakeholders to realize the presented technology pathways and the 2030 vision.

3. **Draft, update, and confirm the following issues set out in the next Draft *2030 Sustainable Energy Roadmap* Strategy (Technical Workshop #2 or more)**

- Establish the goals and objectives of the *2030 Sustainable Energy Roadmap* Strategy (*there is a need to establish a coherent set of measurable short-, medium-, and long-term targets*).

- List the types of data needed to address the objectives and targets established in the Roadmap.

- Determine the final scope of technologies to be considered in the Roadmap and in which sectors and end-use categories the selected technologies will be applied.

- Identify which policies and regulations may help or hinder the application of these selected technologies. This includes measures to bridge institutional, technical, and market barriers.

- Confirm strategies to be pursued (Strategic Elements) (*presently the strategic elements are: 1) energy efficiency, 2) renewable energy, 3) clean production, 4) enhancing national capacity, and 5) achieving universal access*), see Section 2.5.

- Determine specific outcomes to be achieved and confirm recommendations and activities.

- Set a time frame for achievement of results in the short, medium, and long term.

4. Draft and set out the Framework for Monitoring and Evaluation (Technical Workshop #3)

- Determine and define the critical metrics to measure progress and indicate the data sources from which they are extracted.

- Establish a procedure for continuous monitoring and reporting.

- Establish a process for independent evaluation at specified intervals and periodic update of the Roadmap Strategy and Action Plan.

5. Circulate the latest Draft *2030 Sustainable Energy Roadmap* Strategy to external peer-reviewers

- List a number of key local and international experts and specialized organizations within the government and stakeholders' networks to share the latest draft Roadmap Strategy for review, comments, and feedback.

- Assess and incorporate comments to produce a final draft Roadmap, which is reviewed by the NESC to resolve any final outstanding issues.

- Proceed with a final editorial review, graphic design of layout of the Roadmap, and prepare for publication.

6. Official launch of the *2030 Sustainable Energy Roadmap* Strategy and Action Plan

The overall process of finalizing the Belize *2030 Sustainable Energy Roadmap* Strategy and Action Plan is estimated to take between 8 and 10 months. The launch and dissemination of the final Roadmap is critical to inform and trigger action to jump-start the implementation phase.

- Firstly, the stakeholders in Belize involved in the roadmapping process must be made aware that the document has been finalized and is available.

- For the wider public, a press release is needed about the purpose, scope, and objectives of the Roadmap Strategy, including information about where it can be obtained or downloaded.

- A special launch ceremony can be organized where senior public officials and industry leaders are invited to provide public remarks on the value and relevance of the Roadmap Strategy.

- The key is to make sure that awareness is raised among key stakeholders to enable them to become active agents in the process of implementing the Roadmap's action plan.

9 Conclusions

The energy sector diagnosis, technology review, and sustainable energy development pathways presented in chapters 3–5 point to the significant potentials for achieving sustainable energy development in Belize by 2030. Nevertheless, realization of the projected pathways will depend first and foremost on the proper design and preparation of a comprehensive Belize *2030 Sustainable Energy Roadmap* Strategy and Action Plan.

This chapter discusses the main conclusions and recommendations of this report and provides an outline of recommended next steps to guide MPSEPU's efforts in moving forward the roadmapping process in Belize.

9.1 Conclusions and Recommendations

1. There is a need to establish a common strategic vision for how Belize's energy sector should look by 2030. This is a critical starting point for guiding the further development of the scope and content of the *2030 Sustainable Energy Roadmap* Strategy and Action Plan.

2. After careful review of the existing Energy Policy Framework of Belize, it is concluded that an in-depth analysis is required to map out and verify the goals, objectives, targets and time frames used in each respective policy document. An initial inventory is made and the objectives per each respective document is mapped out. This includes international treaties that Belize has signed on to, national policies, laws, regulations, strategies, programs, and action plans that relate or influence the energy sector development in Belize.

3. The purpose of the *2030 Sustainable Energy Roadmap* is to introduce and use a coherent set of short, medium, and long term measurable targets to achieve the strategic vision for Belize's energy sector in 2030. It is very important to perform the necessary additional quantitative background analysis per specific sector or energy carrier, as discussed further below, to set out quantifiable and realistic objectives that will secure and increase the commitment and collaboration of stakeholders for implementing solutions and recommendations contained in the Roadmap's action plan.

4. Recognizing the limited quantity and type of data and energy statistics available to properly describe current energy production, supply, and consumption patterns in Belize, data collection and analysis should be considered as one of the initial roadmap activities and top Roadmap priorities. It also is essential for all stakeholders to be made aware of this reality, in order to have an equal and effective understanding of the current status as a baseline for structuring activities and setting priorities.

5. Alongside the energy production, supply, storage, and consumption data, the baseline description also should include a broader scope of information and factors. This entails data related to demographics, number of residential and commercial buildings, vehicle fleet, state of infrastructure, environmental conditions and impacts as climate change, and any other data or factors that can influence energy production, supply, and consumption patterns in Belize.

   A critical area that demands attention in Belize is the transport sector. This sector consumes, based on 2014 values, about 50% of the country's total primary energy supply, relying mainly on fuels such as kerosene, diesel, gasoline, and jet fuel. No recent quantitative analysis has been performed in the sector to understand fuel supply and consumption patterns and to identify areas for intervention. A critical first step is to perform a specific diagnostic of the transport sector to gather a snapshot of current fuel supply and consumption conditions and related data.

This will help provide a better understanding of the type, volume, and rate of fuel consumption as well as of the vehicle, vessel, and aircraft fleet and the state of related infrastructure.

This transport sector-wide analysis or diagnosis is only a first step to gathering a snapshot and understanding the present baseline conditions of land-based, maritime, and air transportation. More important is the need to lay out the foundations (data collection instruments and system) to systematically and periodically gather primary data and convert these into energy statistics that will make it possible to trace energy consumption volumes and trends over longer time periods specific to transportation sub-sectors or activities. It also will allow for monitoring, evaluation, and reporting on the progress of implementation measures toward achieving the objectives and targets contained in the *Sustainable Energy Roadmap* for the 2030 time frame.

6. Chapter 4 of this study discussed several technologies and solutions, organized according to the Trias Energetica hierarchy to: 1) first explore behavioral changes that could lead to avoidance of energy demand, 2) explore alternative technologies and means to shift to the use of alternative power generated or fuels derived from renewable energy sources or in some cases even shift to completely different sources of energy (as, for instance, the electrification of the transport sector by using electric vehicles), and 3) explore technologies and solutions for optimizing the use of generated power or supplied fuels. For example, fuel mileage in Belize can be improved by upgrading road systems, using newer and more efficient vehicles, demanding regular maintenance and inspection of existing vehicles, and through other means to improve the efficiency of fuel use for transportation. Such an activity would be categorized as an energy conservation and efficiency effort. Thus, the order is: 1) avoid energy need, 2) shift to use of renewable energy sources, and 3) use existing energy as efficiently as possible. The benefit of applying this Trias Energetica hierarchy is that it makes it possible to structure interventions in a way that helps determine priorities and to group similar intervention measures; furthermore, it is applicable to all energy carriers and sectors in Belizean society.

7. There is a critical need to investigate energy-savings opportunities through behavioral changes by using smart metering systems, harnessing the possibilities offered through the effective use of the Internet, considering alternative mobility means beyond the scope of available vehicles and road systems, and designing and manufacturing innovative products and services and new business models that may trigger creative thinking and discussion among decision makers and unconventional stakeholders and partners that may become part of the conversation to address energy development challenges in Belize.

8. The assessment of the technologies and solutions requires further investigation into the current status of the costs, performance, technology maturity and commercial availability, technology development and advancement forecasts, and, more importantly, their applicability, sustainability, and appropriateness for Belize. This requires outlining a clearly described set of principles in the Strategic Roadmap to help determine and select technologies and solutions.

9. It is understood from the *Belize Sustainable Energy Strategy (Volume 1)* report that process heat is by far the most important energy carrier used in the industrial sector in Belize.

10. Within the commercial sector, additional research and analysis is needed to gather a complete picture of energy consumption in commercial facilities (which includes electricity and fuels used to generate the heat demanded). This can be achieved by performing a comprehensive auditing exercise to map out a representative segment of the existing commercial facilities in Belize and to perform site visits and measure electricity, heat, and other types of energy generation and consumption rates and volumes.

11. More importantly, a systematic data collection mechanism needs to be designed, introduced, and established that includes forms and templates that can be distributed among all residential, commercial, and industrial facilities and buildings accompanied by tailored training and capacity-building workshops to systematically start collecting primary data relevant to electricity, heat, and other types of energy use and consumption in each respective building or facility. Only in this manner can a proper understanding of energy production and consumption patterns within a sector be achieved. This will help to identify low-hanging fruit opportunities to optimize energy use, introduce incentives to shift to other energy sources and carriers, and eventually provide information to building and facility owners and operators about their energy consumption levels and patterns that may trigger behavioral changes that could lead to energy savings.

12. Yet for an effective roadmapping process, regardless of the limitations of data and analysis available in Belize, one can still use expert judgment and consensus by drawing from other sources, such as international energy databases, technology roadmaps, or roadmaps from countries or regions with similar characteristics.

13. In Belize's context, heat is a major energy source for industry, where currently all heat generated is from burning crude and heavy fuel oil. This signifies a significant potential to transition to the use of biomass for heat generation.

14. If consumers are not given adequate incentives to address the cost of energy use, they are unlikely to make optimal decisions from an economic and environmental perspective. Plus, there are several key barriers that need to be addressed, including high initial costs, market risks for new technologies, and information uncertainty (technical, regulatory, policy). So it is critical to develop and implement policies that incentivize consumers to opt for highly efficient appliances and products and to help eliminate these barriers.

15. The MPSEPU's technical staff should aim to effectively link and integrate various primary data sources and platforms, models, forecasts, and technology portfolios into a single comprehensive framework to allow for the proper and periodic examination of whether technology choices meet future energy needs and targets set out in the Strategic Roadmap.

16. It also is important to take into account that the Roadmap's implementation success will continue to rely on supportive economic, technology, and environmental policies and measures, and more so on the engagement and actions of a variety of key stakeholders including scientists, academia, technology importers, entrepreneurs, financiers, and community leaders across Belize.

17. Accordingly, the periodic data and analyses updates in the *2030 Sustainable Energy Roadmap* should remain a supporting part of a larger implementation process under the auspices of the National Energy Council composed of influential and informed leaders and decision makers to guarantee the continued political commitment and the critically needed funding support during the Roadmap's development and implementation.

18. Ultimately, access to adequate financing is considered the most critical barrier to the wide-scale transfer, deployment, and use of sustainable energy technologies in Belize.

19. A critical issue to be clarified is that financial resources need to be secured and invested in Belize to 1) address the market conditioning needs for the deployment of commercially available and appropriate sustainable energy technologies in the short to medium term, and 2) address the lack of technology assessment, application, and use capacity in Belize to guarantee the continued innovation, development, deployment, and use of future identified appropriate sustainable energy technologies in the mid to long term.

20. In other words, in order to set up the adequate training programs, build up training staff, and coordinate efforts among educational institutions, funding is needed. In order to address and improve the regulatory framework to facilitate the improved process of transferring of technologies to Belize, funding is needed to involve legal specialists, and other experts to properly justify and guide the changes in regulatory issues. In order to perform general public outreach and improve awareness, significant campaigns have to be set up to be effective; this requires funding. The message here is that none of the recommended solutions, instruments, or activities can be implemented without having access to adequate funding and making sure that the right assistance is provided to Belize through a coordinated approach.

21. The key message is that without an international dedicated financing mechanism in place that is recognized by SIDS, that represents the interest of SIDS around the globe, and that has a coordinating role among SIDS and the international community, all suggested ideas, recommended approaches, instruments, and activities may not be implemented quickly, comprehensively, or effectively enough to safeguard the livelihood of Belizeans. Fortunately Belize is host to the only UN-entity that qualifies for these requirements which is SIDS DOCK.

22. It therefore is highly recommended to finalize as soon as possible and make the *2030 Sustainable Energy Roadmap* a central planning and guiding document to attract and coordinate international financing with complementing specialized technical assistance capacity to facilitate the deployment and transfer of appropriate sustainable energy technologies and solutions in Belize.

Annexes

Annex 1. Proposed Roadmap Outline Template

The following template is proposed for the preparation of Belize's *2030 Sustainable Energy Roadmap* Strategy.* In the case of Belize, several modifications and additional features are included in an attempt to address the multiple challenges at play.

The proposed outline contains critical elements such as the need for a formally established vision statement; description of the objectives to be achieved by implementing the Roadmap; established sustainable energy targets; how the concerted efforts will be organized through the definition of guiding principles and strategic focus areas; and a clear delineation of the scope of the Roadmap. In addition, a diagnostic of the energy sector is required to provide a picture of the latest conditions and developments to determine the existing gaps and areas of intervention.

Thereafter, technologies and solutions deemed suitable and in line with sustainable development principles need to be assessed and presented. These are used as input to the creation of long-term scenarios and projections to determine plausible technology development pathways. Upon the selection of a technology development pathway, particular barriers to the realization of this pathway are identified, and time-based measures and activities are proposed, discussed and presented in an action plan. The implementation of such an action plan will take place in line with priority levels that require a monitoring and evaluation program to assess the progress and success of efforts to facilitate the transition toward achieving the set strategic vision.

* This outline is based on a combination of templates and approaches that Worldwatch has used to prepare past Sustainable Energy Roadmaps.

Belize's *2030 Sustainable Energy Roadmap* Strategy Outline

1. Introduction and Background
    a. Vision Statement
    b. Guiding Principles
    c. Goals and Objectives
    d. 2030 Targets
    e. Scope and Boundaries of the Roadmapping Process
2. Belize's Current Energy Production and Consumption
    a. National Energy Balance
    b. Power Sector
    c. Transportation Sector
    d. Energy Use in Major Economic Sectors
    e. Residential, Commercial, and Government Buildings
    f. Rural and Isolated Regions
3. Technologies and Solutions to Consider
    a. Current and Emerging Technologies
    b. Evaluation and Prioritization of Technologies
    c. Recommended Technologies and Solutions
4. Technology Development Pathways
    a. Electricity
    b. Fuel
    c. Heat
    d. Primary Energy
5. Barriers and Recommendations
    a. Gaps and Barriers
    b. Recommended Actions and Measures
6. Action Plan
    a. Decision Points and Schedule
    b. Plan to Implement Actions and Measures
    c. Budget Summary
7. Monitoring and Evaluation
    a. Periodic Review and Update
    b. Report Adaptations
    c. Securing of Approval
8. Conclusions and Recommended Next Steps
9. Appendices
    a. Description of Roadmapping Process
    b. Participants and Stakeholders

Annex 2. Summary of Smart Meter Benefits

Table 41 summarizes the functionality required of all smart meters, which is the same for both domestic and non-domestic sectors.[211]

Table 41. Smart Metering Functionality

A	Remote provisions of accurate reads/information for defined time periods; delivery information to customers, suppliers, and other market organizations
B	Two-way communications to meter systems; communications between meter and energy supplier; ability to upload and download data to a network' ability to transfer data at defined periods; remote configuration and diagnostics, software and firmware changes.
C	Homes are network-based open standards and protocols providing "real time information to an in-home display; other devices able to link to the meter system
D	Support for range of time of use tariffs; multiple registers within the meter billing purposes
E	Load management capability to deliver demand-side management; ability to remotely control electricity load for more control of devises in building
F	Remote disabling and enabling of supply to support remote switching between credit and prepayment modes.
G	Exported electricity measurement; measure net export
H	Capacity to communicate with a measurement device within micro generator; receive, store and communicate total generation billing

An immediate benefit of smart metering is that accurate meter-readings can be obtained without the need for physical meter readings and access to buildings, and the information it can provide. Smart meters can pave the way for radical changes in the way that buildings use energy for heating and cooling, how much they use, and how much they pay for it. Smart metering allows energy users to understand energy use and to make informed decisions.

Table 42. Smart Metering Benefits[212]

Customers Accurate billing without physical meter-reading Detailed information about energy use (current and multiple time periods) Quicker, easier switching Facilitating energy measures Platform for "smart building" services Support for micro generation Access to innovative, competitive energy services	**Suppliers** Avoided site visits to read meters Delivering energy efficient commitments Debt management
Networks Improved information to help planning and reduce cost, target investment and improvements Support for future smart grids	**Belize** Reduced energy consumption Reduced CO_2 emissions

A structured approach is necessary, in order to obtain raw data and turning it into information that facilitates insights and enhances behavior change. Figure 41 illustrates the structured process for smart metering.[213]

Figure 41. Process of Smart Metering

Annex 3. Belize Energy Policy Framework Analysis

The following documents are reviewed in this Annex:

1. Horizon 2030: National Development Framework for Belize 2010–2030 (2010)
2. Belize National Energy Policy (2012)
3. MESTPU's Strategic Plan 2012–2017 (2012)
4. Belize Sustainable Energy Strategy (2015)
5. Belize Sustainable Energy Action Plan (2014–2017) (2015)
6. Caribbean Sustainable Energy Roadmap and Strategy (C-SERMS), 2015

1. Horizon 2030: National Development Framework for Belize 2010–2030 (2010)

The National Development Framework embodies the vision for Belize in the year 2030 and the core values that are to guide citizen behavior and inform strategies to achieve this common vision for the future. A core value for Belizeans is the care for the Natural Environment as the Source and Basis for Economic and Social Progress. The document identifies as a key priority the need to put in place effective laws and regulations, information and communication systems to protect the environment while promoting sustainable social and economic development. Strategies described include promoting "green" energy and energy efficiency.

Table 43. Strategic Elements and Commitments Made Under Horizon 2030

#	Strategic Focus Area	Goal
1	Improve Institutional Capacity	Create an institutional framework for producing a viable energy policy.
2	Improve Regulatory Framework	Strengthen the regulatory framework to improve the efficiency and quality of energy services, implement international standards for services and waste, and monitor the production and supply of services.
3	Promote Renewable Energy Technologies	Provide incentives to promote energy saving and investment in production and use of renewable energy in the areas of wind, solar, biomass, geothermal, and hydropower, including energy purchase arrangements for those who have excess to sell to the main grid.
4	Improve Energy Policy Framework	Adopt a national transport policy that covers all modes of transport to ensure safety and energy efficiency with the lowest environmental impact.
5	Promote Renewable Energy Technologies	Promote "greening" of the productive sector by providing incentives for private companies to adopt superior environmental performance objectives to achieve strong international market positioning.
6	Education	Educate the public on energy sources, uses, services, safety, and other relevant areas.
7	Promote Renewable Energy Technologies	Provide tax and other incentives for households to more easily adopt "green" technologies and impose penalties for the use of hazardous materials.

2. Belize National Energy Policy (2012)

The National Energy Policy is divided in six main activities which include: 1) Assessing the major factors driving energy policymaking in the 21st Century, 2) Reviewing the main trends and players that currently impact and may continue impacting the global and regional market and an analysis on Belize's energy sector in relationship between supply and demand, cost of energy and related GHG emission in different subsectors, 3) Conducting a comprehensive assessment of the main supply options, both indigenous and external to Belize, available now and in the near future to meet the energy needs, 4) Analyzing various end-use conservation measures that can be put in place to reduce local demand for energy, 5) Developing goals and strategic objectives for Belize's energy sector, and formulating and evaluating various plans for meeting these strategic energy objectives, and which utilize, to varying extents, the supply options and end-use efficiency measures, and 6) Recommending specific policies for ensuring the realization of the optimal energy plan, general policies and a supporting organizational framework for administering and guiding the development of the energy sector.

The purpose of *Belize National Energy Policy (2012)* is to present a draft on how Belize can achieve energy efficiency, sustainability, and resilience over the next 30 years. It is a document that presents policy recommendations but it is not a policy document. In order to be able to make policy decisions, policymakers and planners must model complex inter-relationships between energy and the economy and the environment. It serves as a document that can provide policy recommendations to policymakers and decision makers.

Table 44 summarizes the strategic elements included in the *Belize National Energy Policy 2012* and its goals, and provides some notes describing what is covered in the strategic element. The report provides good information for renewable energy and energy efficiency covering potentials for production cost, environmental benefits and cost, energy demand reductions and cost savings, potential for greenhouse gas emission reduction, and Clean Development Mechanism (CDM) earnings. It also includes a detailed section on the projected increase of energy trends from 2010 to 2040 in Belize.

Table 44. Strategic Elements and Commitments Included in the Belize National Energy Policy (2012)

#	Strategic Focus Area	Goal	Note
1	Improve Energy Efficiency	Analyze various end-use energy efficiency and conservation measures that can be put in place to reduce local demand for energy.	Analyzes the complete context of EE (Energy recoverability, economic vs. technical efficiency, economies of scale, capacity utilization, energy sustainability, link between sustainable energy and climate change, energy resilience, fuel resource diversity, process flexibility, energy independence)
2	Market	Review the main trends and players that currently impact and may continue impacting the global and regional market and an analysis on Belize's energy sector in relationship between supply and demand, cost of energy, and related GHG emission in different subsectors	Electricity supply, energy consumption patterns, GHG emissions.
3	Reduce dependence on imported fossil fuels	Conduct a comprehensive assessment of the main supply options, both indigenous and external to Belize	Costs, carbon pricing, supply potential Indigenous renewable energy source: wind, solar, hydro, geothermal, biomass Non-renewable energy source: Indigenous crude

#	Strategic Focus Area	Goal	Note
			oil, Indigenous Petroleum Gas, Downstream refined oil production, Downstream LPG Industry, Downstream natural gas industry, Electricity imports, Micro-generation, emerging technologies
4	Improve Energy Conservation	Analyze various end-use conservation measures that can be put in place to reduce local demand for energy	Transport (New Vehicle Technologies, Diesel Vehicles, LPG Fuel-Converted Vehicles, Flex Fuel Vehicles, Hybrid/Electric Vehicles) Mass Transport, Carpooling, Walking, Bicycles, Highway Driving behaviors, Urban Driving Behaviors, Vehicle Maintenance, Building Design, EE and Alternative Lighting Technologies, Alternative Heating/Cooling, Retrofitting, Refrigeration, Stand-by electric Usage, Cooking, Agriculture, Energy Audits, Energy Management, Certification Programs
5	Improve Energy Policy Framework	Develop goals and strategic objectives for Belize's energy sector, and formulate and evaluate various plans for meeting these strategic energy objectives, and which utilize, to varying extents, the supply options and end-use efficiency measures	Goals: Sustainable production, reducing energy costs, mitigates external market prices, supply shocks, natural disasters on cost of energy and reliability of energy supply. Strategies: Promote importance of EE planning on all economic sectors, promote indigenous RE resources, develop and manage agriculture for biomass production, diversity of supply mix to maximize resilience in energy sector, energy for export industry for regional and foreign markets, modern elect distribution infrastructure for EE and resilience, maximize production of non-crude oil products from petroleum extract activities, micro generation markets, promote local participation in energy supply (RE initiatives, increase control of local petro industry, generate employment and economic opportunities), cleaner and more versatile energy carriers in rural areas, carbon pricing (Kyoto Protocol).
6	Improve Energy Policy Framework	Recommend specific policies for ensuring the realization of the optimal energy plan, general policies, and a supporting organizational framework for administering and guiding the development of the energy sector	Energy Planning, Screening of energy supply technologies using Life Cycle Unit Cost Analysis, Electric Planning, Energy sector restructuring, Indigenous energy supply, Renewable energy development, Managing impacts of indigenous energy projects on local communities, biofuels, Micro-generation, energy imports/exports, Energy distribution infrastructure & pricing, rural electrification, energy pricing, Fuel industry regulation & pricing, GHG emission cost and other pollutants, Carbon Tax, Credit system, Emission performance standards, EE and conservation, Building, Lighting & Cooling, Education and Information Dissemination, Capacity building, Financing EE and Recoverable Energy Projects

3. MESTPU's Strategic Plan 2012–2017 (2012)

The Strategic Plan of the former Ministry of Energy, Science & Technology, and Public Utilities (MESTPU) covering the period 2012-2017 is composed of two main parts, where Part I is dedicated to articulating the *Belize Sustainable Energy Strategy 2012–2033*, and Part II is dedicated to furthering the *Science, Technology, and Innovation (STI) National Strategy and Action Plan for Sustainable Development 2013–2030*.

The purpose of Part I is to establish a framework that will result in transitioning the energy sector and economy toward low-carbon development through 1) improving energy efficiency and conservation, 2) developing domestic energy resources to facilitate private sector participation and investment in the low-carbon energy sector, 3) empowering rural communities (particularly women and youth) to participate in income-generating activities, and 4) encouraging and advising the public/private sectors and the general public to become more aware of critical energy issues and to take appropriate actions and response measures.

The *Strategic Plan 2012–2017* sets ambitious goals and targets to put Belize on a sustainable energy trajectory to 2033. The strategy builds on work plans formulated under the NEP (2012) and on commitments made under the SIDS DOCK targets established in 2009, the

Table 45 describes five strategic elements that originate from Part I of the *MESTPU's Strategic Plan 2012–2015*. The strategic plan provides direction and planned pursuit of the vision and mission of MESTPU from 2012 to 2017. It provides the Ministry with the ability to channel resources to yield the greatest benefit to Belize, and enables the Ministry to plan and execute organizational improvements and to achieve competitive advantage to generate sufficient revenue to support the projects and programs. As the table shows, institutional capacity is an important factor in Belize, and a well-educated and trained workforce is critical to addressing domestic energy development challenges.

Table 45. Strategic Elements and Commitments Included in the Sustainable Energy Strategy (2012–2033)

#	Strategic Focus Area	Goal	Note
1	Improve Energy Efficiency	Reduce per capita energy intensity by at least 30% by 2033	Using energy use and GDP in 2011 as baseline.
2	Reduce Dependence on Fossil Fuel Imports	Reduce dependence by 50% by 2020, with the goal of converting Belize to a net exporter of biofuels before 2033	To be achieved by combining the production of modern energy carriers from domestic RE sources, coupled with improving EE and conservation.
3	Reduce Dependence on Fossil Fuel Imports	Triple the amount of modern energy carriers derived from agricultural, forestry, and fisheries production and processing, including MSW, by 2020	
4	Generate Income from Energy Exports	Become a net exporter of electricity by 2020	To be achieved by: 1) prioritizing the institutionalization of a country-wide infrastructure to collect data and assess the potential for converting solar, wind, and hydro to electricity, 2) obtaining market access for excess electricity produced, and 3) having the critical pieces in place to build the necessary electricity infrastructure.
5	Improve Institutional Capacity	Build MPSEPU's institutional capacity to accomplish its mandate	Through increased professional staff, training and human resource development, acquisition of office supplies, materials, equipment, and funding to undertake institutional studies and audits, public awareness and education, and travel.

4. Belize Sustainable Energy Strategy (2015)

This report, commissioned by the Inter-American Development Bank (IDB) and prepared by Castalia Consulting, describes a potential national sustainable energy strategy scenario for the period 2014–2033 with a specific focus on energy efficiency and renewable energy measures to assess the cost-comparison between the proposed scenario and business as usual, targeting electricity and stationary fuel production and use in Belize. The report title creates unnecessary confusion, since it does not capture all energy aspects or carriers, e.g., fuel and heat.

Table 46. Strategic Elements and Commitments Included in the Belize Sustainable Energy Strategy (2015)

#	Strategic Focus Area	Goal	Notes
1	Improve Energy Planning	Present a scenario for a NSES that could show what Belize's energy matrix could look like in 2030 in comparison to today	Business-as-usual scenario (BAU) with net cost of electricity; National sustainable energy strategy scenario (NSES) with stationary fuels Electricity consumption, stationary fuel consumption, electricity for EE, cumulative GHG emissions, Capex for EE, electricity + stationary fuels (NPV from 2-13-2033), All-in-cost of electricity supply (NPV from 2-13-2033), Value of stationary fuel use (NPV from 2-13-2033), Electricity exports (NPV from 2-13-2033)
2	Improve Energy Efficiency	Show the potential for EE	Recommended EE measure for electricity, EE measure for stationary fuels; Baseline energy consumption, screening EE measures, long-term uptake of EE
3	Promote Renewable Energy Technologies	Show the potential for RE	Recommended RE technologies for Belize Baseline RE generation in Belize, screening RE technologies, long-term uptake of RE, evaluating Belize's RE export potential, Off-grid RE
4	Address Barriers to Sustainable Energy	Present barriers that prevent good EE and RE projects from being developed	Types of Barriers to EE (agency, information, regulation, market, financial, skills), barriers to distribute RE, barriers to utility scale RE development (information, regulatory, financial, technical/skills)
5	Address Barriers to Sustainable Energy	Present preliminary recommendations on how to overcome the barriers	Overcoming barriers to EE, distributed RE, and to utility scale RE

From Table 46, Strategic Focus Area 2, Belize's Energy Efficiency Potential, the data and information for projections and potential for energy efficiency is based on the auditing of 26 homes, businesses, and government buildings. Energy efficiency measures were applied in order to observe the end-uses of energy to determine the maximum energy saving by sector. Strategic Focus Area 3 was estimated assessing the available renewable energy resources in Belize, selecting a commercially proven technology that would use those resources that reliably generate at a cost below the relevant cost of power in Belize, and building a scenario to match the demand. The report has recommendations on renewable energy and energy efficiency and also on how to overcome barriers to implementation. The report concludes with the importance of technical trained personnel in order to integrate renewable energy and energy efficiency technologies into the current distribution system in Belize.

5. Belize Sustainable Energy Action Plan (2014–2017) (2015)

In June 2015 a National Sustainable Energy Action Plan was released that covers the period 2014–2017, prepared by Castalia Consulting and commissioned by the Inter-American Development Bank. This Action Plan captures a limited scope of action measures that are related mainly to short- and medium-term interventions regarding electricity generation, distribution, and use in several sectors in Belize. It is a tool to achieve Belize's RE and EE potential while meeting the government's economic, social, and environmental goals. The analysis shows that with the use of RE and EE, Belize could generate millions in savings over a period from 2014 to 2033. The report also identifies the barriers that can prevent the actions from being taken.

Table 47 summarizes the framework of actions and tasks to overcome the barriers to sustainable energy in Belize. It is structured in six actions that work together to unlock Belize's renewable energy and energy efficiency potential, dividing the tasks into groups based on the goal of the task. All of the actions are interdependent, so actions complement one another.

Table 47. Strategic Elements and Commitments Included in the Belize Sustainable Energy Action (2014–2017)

#	Action Category	Activity	2014	2015	2016	2017
1	Help households, businesses and government be more efficient	Decentralize government payment for electricity	x	x		
		Adapt and Implement a building code			x	
		Develop financial mechanisms to invest in sustainable energy	x	x	x	x
		Provide consumers more information on energy services and equipment		x	x	
2	Expand access to electricity using renewable energy	Develop a least-cost electrification plan			x	
		Develop an electrification investment program			x	
3	Promote large scale renewable energy	Retain a transaction advisor for 2013-2014 RE tender	x			
		Develop a complete licensing regime		x		
		Streamline and clarify renewable energy permitting process		x	x	
		Accommodate the integration of intermittent renewable energy			x	
		Prepare resources studies for biomass, waste-to-energy, and hydro			x	x
4	Build an efficient and enabling utility	Complete a cost of service study	x	x		
		Amend the tariff structure	x	x		
		Revise BEL's efficiency incentives	x	x		
		Update BEL's expansion plan		x		
		Study integration with the Central American Electricity Transmission System				x
5	Prepare for distributed generation	Develop a standard offer contract	x	x		
		Adopt a certification system for third party inspectors			x	
6	Increase awareness and enhance skills	Provide training and capacity building	x	x	x	
		Provide education and public outreach		x	x	

Additional Reports that influence Energy Sector Planning and Development in Belize

6. Growth and Sustainable Development Strategy for Belize (2015)

This report aims to rise to the challenges of guiding overall development in Belize from 2015 to 2018. It adopts and integrates a systemic approach based on principles of sustainable development and on three notable drivers that are common to successful developing countries: 1) a proactive role of the state, 2) tapping into global markets, and 3) innovative social policy.

This report encompasses both poverty reduction and longer-term sustainable development issues. This strategy document is Belize's primary planning document that provides detailed guidance on priorities and on specific actions to be taken during the planning period.

Table 48. Strategic Elements and Commitments Included in the Growth and Sustainable Development Strategy for Belize (2015)

#	Strategic Focus Area	Goal	Note
1	Address Barriers to Sustainable Energy	Achieve real output growth of 5% annually over a prolonged period. Assuming population growth remains at about 2%, the targeted output growth will lead to sustained improvement in per capita income of approximately 33% over a 10-year period. Over the short to medium term, Belize may not be able to reach the 5% growth target, but efforts will commence during the medium-term planning period (2015–2018) to raise growth to that level.	Penetrating expert markets; Attracting foreign investments; More efficient markets; Adequate infrastructure (roads, ports, energy, water, telecommunications, and transport); Adequate skills and capacity to support economic growth, sustainable development, and resilience
2	Enhance Social Cohesion and Resilience	Create a society that is *socially cohesive*, a term that refers to the forces that bond individuals at both the community and national level. Belize will be a socially cohesive society, one in which individuals feel a sense of belonging, one that is inclusive and that provides opportunity for social mobility. The aim of this Critical Success Factor is to build trust, goodwill, fellowship and mutual sympathy among all Belizean citizens, resulting in reduced social unrest, lower crime, and enhanced quality of life	Belize will seek to eradicate poverty by 2030 and to achieve more equitable income distribution through: Adequate access to healthcare; Adequate access to education and lifelong learning for all; Optimal social security/insurance; Better social assistance; Effective livelihood programs; Decent wages and work conditions; Strong national identity and future vision; and Social inclusion and equitable growth.
3	Sustained or Improved Health of Natural, Environmental, Historical, and Cultural Assets	Maintain the health of Belize's natural, environmental, historical, and cultural assets	Sustainable environmental management; Urban and rural planning; and Waste management and pollution control.
4	Enhance Governance	Reduce wastage, abuse of government resources, and inappropriate procurement while generally improving public sector management including budgeting and hiring practices, and accountability mechanisms	Better technical and political governance systems; Amelioration of social issues that fuel crime; Effective policing; Better administration of justice; and Maintaining the integrity of national borders.

7. Caribbean Sustainable Energy Roadmap and Strategy (C-SERMS) (2015)

This report, prepared for CARICOM through a collaboration between Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ) GmBH, the Worldwatch Institute (WWI), and the Inter-American Development Bank (IDB), is designed to build on existing efforts in the region among CARICOM member states with a coherent strategy for transitioning to sustainable energy. The report recommends a series of national and regional-level priority projects, policies, and initiatives that should be undertaken by CARICOM and its member states to achieve these

Table 49. Strategic Elements and Commitments Included in the C-SERMS (2015)

#	Strategic Focus Areas	Goal	Note
1	Promote Renewable Energy Technologies	Assess the region's current energy situation, potential. Includes input/ output, production/ consumption, petroleum imports/ exports, natural gas use, energy use by sector, electricity and transport sectors, CO_2 emissions, identifies data gaps	Belize's total primary energy consumption (power plant and refineries, transportation, industry and construction, residential, commercial and public, losses and self-consumption); Belize share of population with access to electricity (approx. 90%); Belize electrification rate (100%); Belize installed power capacity and share of RE: Installed Power Capacity (141.8 MW), Installed RE Power Capacity (82.5 MW), RE Share of Installed Power Capacity (58.5 MW); Installed RE capacity: Hydro (54.5 MW), Wind (0), Solar (0.48 MW), Biomass (27.5)
2	Promote Renewable Energy Technologies	Assess current potential and initiatives, review long-term socio-economic impacts of renewables	Belize RE potential: Hydro (70 MW), Geothermal (0), Solar (42 MW), Wind & Biomass (N/A); Global Power Generation Cost Biomass (USD 0.21/kWh); Regional interconnection: 34.5 kV cable links mainland, San Pedro
3	Improve Energy Policy Framework	Assess CARICOM's existing regulatory policy environment, and existing policies for renewable energy, energy efficiency, and emission reduction policies and goals	Belize Policy Document: Draft National Energy Policy Framework; MPSEPU Strategic Plan 2012–2017; Belize RE target: 50% reduction in fossil fuel dependence by 2020; Belize electricity target: 89% by 2033; Belize EE target: 30% improvement EE and conservation by 2033; Belize sustainable transport target: Participation in SIDS DOCK Diesel Fuel Replacement program; Belize emission reduction target: none; Belize RE regulatory policies: Feed-in tariffs (suggested), Net Metering/Billing (suggested), Renewable Portfolio Standard/Quota (suggested), IPPs Permitted (none); Belize RE fiscal incentives and public financing: Tax Credits (suggested), Tax Reduction/Exemption (none), Public Loans/Grants (none), Green Grant Procurement (none); Belize EE support policies: National EE Standards (none), Tax Credits (none), Tax reduction/exemption (suggested), Prohibition of use/Import of Incandescent Bulbs (none), Appliance Labeling Standards (none); Belize Transport policies: Blend Mandate (none), Import Tax Exemption/Reduction (none), Fuel Efficiency Standards (none)
4	Establish Coherent Targets	Set a common vision for regional targets for 2017, 2022, and 2027	Regional targets for RE capacity: 20% by 2017, 28% by 2022, 47% by 2027; Proposed CARICOM RE Targets: 20% by 2017, 20% by 2022, 47% by 2027; Belize Existing and Proposed National RE Targets: Existing RE targets (none), Capacity to meet regional target of 48% by 2027 (76%), Meet regional target of 48% capacity by 2027 (85%); Proposed Power Sector CO_2 Emission Reduction Targets: CARICOM: 18% by 2017, 32% by 2022, 46% by 2027; Belize: 62% reduction vs. 2012 BAU
5	Roadmap for the Caribbean	Recommend national and regional level priority projects, initiatives, policies, and activities	Information and data gathering; Finance; Policy priority initiatives, polices, projects, and activities for CARICOM. Belize Concrete Policies and Mechanisms: IPP Reform (no action taken), Generation Incentives (no action), Incentives for rural renewable (no action), Maximizing EE (no action), RE in transportation (no action).

INTERNATIONAL COMMITMENTS		Horizon 2030: National Development Framework for Belize 2010-2030 (2010)	2011 Belize National Energy Policy (Jul, 2012)	MESTPU's Strategic Plan 2012-2017 (Sept, 2012)	Growth and Sustainable Development Strategy for Belize (Feb, 2015)	Belize Sustainable Energy Strategy (June, 2015)	Belize Sustainable Energy Action Plan (2014-2017) (June, 2015)	2030 Sustainable Energy Roadmap Strategy and Action Plan (expected 2016)
United Nations 2030 Agenda for Sustainable Development (Sept. 2015) **Goal:** • End poverty, fight inequality and injustice, and tackle climate change by 2030	**Objective 1.** End poverty in all its forms everywhere.	●	●	–	●	●	●	●
	Objective 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.	●	●	–	●	●	●	●
	Objective 3. Ensure healthy lives and promote well-being for all.	●	●	–	●	●	●	●
	Objective 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.	●	●	–	●	●	●	●
United Nations Sustainable Energy for All (SE4All) (May, 2012) **Goal:** • An initiative with multi-stakeholder partnership between governments, the private sector, and civil society with three interlinked objectives to be achieved by 2030	**Objective 1.** Ensure universal access to modern energy services.	●	●	●	●	●	●	●
	Objective 2. Double the global rate of improvement in energy efficiency.	●	●	●	●	●	●	●
	Objective 3. Double the share of renewable energy in the global energy mix.	●	●	●	●	●	●	●
United Nations Framework Convention on Climate Change (UNFCCC) (March 1994) **Goal:**	**Objective 1.** To ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.	–	–	●	–	–	–	●

• Stabilize GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system								
United Nations Sustainable Development Goals (UN SDGs) **Goal:** • Universal set of goals, targets and indicators that UN member states will be expected to use covering sustainable development issue though framing their agendas and political policies over the next 15 years	**Objective 1.** End poverty and hunger by 2030.	●	●	–	●	–	–	–
	Objective 2. Improve health and education by 2030.	●	●	–	●	–	–	●
	Objective 3. Make cities more sustainable by 2030.	●	●	–	●	–	–	●
	Objective 4. Combat climate change by 2030.	●	●	–	●	–	●	●
	Objective 5. Protect oceans and forests by 2030.	●	–	–	–	–	–	●
CARICOM Energy Policy (2013) **Goal:** • Establish a Task Force, comprising of Barbados, Grenada, Guyana, Jamaica, Suriname and Trinidad and Tobago to develop recommendations for Regional Energy Policy	**Objective 1.** Address issues such as: 1) security of energy supplies; 2) Energy pricing policy and impact on relative competitiveness in the CARICOM Single Market and Economy (CSME); 3) Purchasing and transportation agreements.	●	●	●	●	●	●	●
NATIONAL COMMITMENTS								
Horizon 2010-2030 National Development Framework for Belize (2010) **Goals:** • Democratic governance for effective public administration and sustainable development • Education for Development • Economic resilience: Generating resources for long term development • The Bricks and the Mortar - Healthy Citizens and a Healthy Environment	**Objective 1.** Create an institutional framework for producing a viable energy policy.	–	–	●	–	–	●	●
	Objective 2. Strengthen the regulatory framework to improve the efficiency and quality of energy services, implement international standards for services and waste, and monitor the production and supply of services.	–	–	●	–	–	●	●
	Objective 3. Provide incentives to promote energy saving and investment in production and use of renewable energy in the areas of wind, solar, biomass, geothermal, and hydroelectricity, including energy purchase arrangements for those	–	–	●	–	–	●	●

	who have excess to sell to the main grid.	–	–	●	–	–	–	●
	Objective 4. Adopt a national transport policy that covers all modes of transport to ensure safety and energy efficiency with the lowest environmental impact.	–	–	●	–	–	–	●
	Objective 5. Promote the "greening" of the productive sector by providing incentives for private companies to adopt superior environmental performance objectives to achieve strong international market positioning.	–	–	●	–	–	–	●
	Objective 6. Educate the public on energy sources, uses, services, safety, and other relevant areas.	–	–	●	–	–	●	●
	Objective 7. Provide tax and other incentives for households to more easily adopt "green" technologies and impose penalties for the use of hazardous materials.							
2011 Belize National Energy Policy (July 2012) **Goals:** • To foster the sustainable production, distribution and use of energy as a critical resource needed to achieve the overarching national goals of economic growth and long-term prosperity, security, poverty reduction and social equity. • To minimize the cost of energy in the local economy. • To mitigate the impacts of uncontrollable events such as external market price and supply shocks and natural disasters on the cost of energy and on the reliability of energy supply. • To create a national energy-efficiency-focused culture that is fully aware of how its actions (or inactions) affect energy use and that is pro-active about the conservation and efficient use of energy.	**Objective 1.** In the residential sector, phase out use of kerosene and candle lighting. By 2025, phase out all kerosene and candle lighting, starting from 18% of households in 2010.	●	–	●	–	●	●	●
	Objective 2. In the residential sector, shift away from electric to solar lighting. By 2040: electric lighting (60%) and solar lighting (40%).	●	–	●	–	●	●	●
	Objective 3. In the commercial and services sector, shift away from electric to solar lighting. By 2040: electric lighting (75%) and solar lighting (25%).	●	–	●	–	●	●	●
	Objective 4. Shift toward using solar and geothermal technologies for cooling. By 2040: electric cooling (50%), geothermal cooling (25%) and solar cooling (25%).	●	–	●	–	●	–	●

National Solid Waste Management Policy (NSWMP) **Goal:** • Reduce, recover, and recycle electrical and electronic equipment, and used batteries and accumulators (both dry cell and lead-acid)		●	–	–	–	–	–	–
LAW OR ACT								
Belize Environment Protection Act		–	–	–	–	–	–	–
REGULATION								
–		–	–	–	–	–	–	–
STRATEGIES, PLANS, PROGRAMS, AND INITIATIVES								
National Poverty Elimination Strategy and Action Plan 2009-13 (NPESAP) **Goals:** • Improve access, coverage, efficiency, and equity in health and education and continued expansion and improvement in potable water supply systems. • Improve education facilities through expanded and upgraded infrastructure.	**Objective 1.** Rehabilitate and expand rural primary and secondary schools and health facilities based on poverty, school statistics, and population.	●	–	●	–	–	●	●
National Climate Resilience Investment Plan (NCRIP) **Goals:** • Achieve an efficient, productive and strategic approach to economic and social resilience and to fostering development • Achieve greater climate resilience and improve disaster risk management capacities across all sectors		–	–	–	–	–	–	●
National Integrated Waste Management Programme (NIWMP) **Goal:** • Reduce, reuse, recover, and recycle solid waste and		●	–	●	–	–	–	●

reduce greenhouse gas emissions into the atmosphere								
Intended Nationally Determined Contribution (INDC) **Goal:** • Promote and support universal access to affordable modern energy services including energy infrastructure		–	●	–	–	–	●	●
Growth and Sustainable Development Strategy **Goals:** • Optimize national income and investment • Enhance social cohesion and resilience • Sustain or improve health of natural, environmental, historical, and cultural Assets	**Objective 1.** Build institutional capacity to encourage technological adaptation and innovation while also taking into account climate change resilience considerations.	–	–	●	●	–	–	●
	Objective 2. Secure investments in expanding electricity generation capacity, with special emphasis on renewable energy, and develop a low-carbon development strategy.	–	–	–	●	–	–	●
		–	–	–	●	–	–	–
	Objective 3. Completely eradicate poverty by 2030.	–	–	–	●	–	–	–
	Objective 4. Provide universal access to basic and early childhood education, provide universal access to health care.	–	–	–	●	–	–	–
	Objective 5. Improve irrigation and drainage (improved agriculture water management) to help lift agricultural productivity and hence farm incomes.	–	–	–	●	–	–	●
	Objective 6. Encourage technological adaptation and innovation (Including Green Technology).	–	–	–	●	–	–	●
	Objective 7. Strategically prioritize sectors for development: agriculture (increasing farm productivity), agro-processing, energy, ICT, marine fisheries and aquaculture, tourism.	●	–	●	●	–	●	●
		●	–	–	●	–	–	–
	Objective 8. Develop adequate infrastructure (roads, ports, energy, water,	●	–	–	●	–	–	–

	telecom, and transport). **Objective 9.** Complete the Solid Waste Management Plan: Policy and Plan to include strong incentives and robust systems for recycling and for returning waste streams to the production cycle. **Objective 10.** Develop a legal framework for the disposal of chemical, electronic, medical, and other types of hazardous waste.							
MESTPU's Strategic Plan 2012-2017 **(Sept. 2012)** **Goals:** • Analyze various end-use energy efficiency and conservation measures that can be put in place to reduce local demand for energy. • Review the main trends and players that currently impact and may continue impacting the global and regional market and analyze Belize's energy sector in relationship between supply and demand, cost of energy and related GHG emission in different subsectors • Conduct a comprehensive assessment of the main supply options, both indigenous and external to Belize • Analyze various end-use conservation measures that can be put in place to reduce local demand for energy • Develop goals and strategic objectives for Belize's energy sector, and formulating and evaluating various plans for meeting these strategic energy objectives, and which utilize, to varying extents, the supply options and end-use efficiency measures • Recommend specific policies for ensuring the realization of the optimal energy plan, general policies and a supporting organizational framework for administering and guiding the development of the energy sector		● ● ● ● ● ●	● ● ● ● ● ●	● ● ● ● ● ●	● ● ● ● ● ●	● – ● ● ● –	● ● ● ● ● ●	● ● ● ● ● ●

Belize Sustainable Energy Strategy (2015) **Goals:** • Describe a potential national sustainable energy strategy scenario for the period 2014-2033 with specific focus on energy efficiency and renewable energy measures to assess the costs comparison between the proposed scenario and the business-as-usual, targeting electricity and stationary fuel production and use in Belize	**Objective 1.** Present a scenario for a NSES that could show what Belize's energy matrix could look like in 2030 in comparison to today.	●	●	●	–	●	●	●
	Objective 2. Show the potential for EE.	●	●	●	–	●	●	●
	Objective 3. Show the potential for RE.	●	●	●	–	●	●	●
	Objective 4. Present barriers that prevent good EE and RE projects from being developed.	●	●	●	–	●	●	●
	Objective 5. Present preliminary recommendations on how to overcome the barriers.	●	●	●	–	●	●	●
Belize Sustainable Energy Action Plan (2014–2017) (June 2015) **Goals:** • Capture a limited scope of action measures that are mainly related to short and medium term interventions regarding electricity generation, distribution and use in several sectors in Belize.	**Objective 1.** Help households, businesses, and government be more efficient.	●	●	●	–	●	●	●
	Objective 2. Expand access to electricity using renewable energy.	●	●	●	–	●	●	●
	Objective 3. Promote large-scale renewable energy.	●	●	●	–	●	●	●
	Objective 4. Build an efficient and enabling utility.	●	●	●	–	●	●	●
	Objective 5. Increase awareness and enhance skills.	●	–	●	–	–	●	●
Belize 2030 Sustainable Energy Roadmap Strategy and Action Plan	**Objective 1.** Improve EE and conservation across all sectors.	●	●	●	●	●	●	●
	Objective 2. Reduce dependence on imported fossil fuels.	●	●	●	●	●	●	●
	Objective 3. Triple the amount of modern energy carriers.	●	●	●	●	●	●	●
	Objective 4. Become a net exporter of electricity.	●	●	●	●	●	●	●
	Objective 5. Build MPSEPU's institutional capacity.	●	●	●	●	●	●	●

Annex 4. Belize Energy Balance, 2013 and 2014

Supply and consumption		Gross electricity production (total)	Gross heat production (total)	Geothermal Energy	Solar thermal energy	Renewable municipal waste	Woodfuel	Energy crops	Wood waste	Black liquor	Straw	Bagasse	Rice husks	Other vegetal and agricultural waste	Other primary solid biofuels (animal waste)	Biomass pellets and briquettes	Charcoal	Landfill gas	Sewage sludge gas	Other biogases from anaerobic fermentation	Biogases from thermal processes	Conventional biogasoline	Advanced biogasoline	Conventional biodiesel	Advanced biodiesel	Bio jet kerosene	Other liquid biofuels	Other renewable energy (e.g. heat pumps)
2013		GWh	TJ	TJ	TJ	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	TJ (NCV)	TJ (NCV)	TJ (NCV)	TJ (NCV)	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	TJ
Production	(+)	354					94,500					364,238					750											
Imports	(+)	234															3											
Exports	(-)																21											
Stock changes	(+)																											
International Bunkers	(-)																											
Domestic supply	(=)	**588**					**94,500**					**364,238**					**732**											
Transfers																												
Statistical Differences		**0**																										
Power plants																												
CHP plants												97,600																
Commercial heat plants																												
Charcoal production							3,375																					
Biomass pellet and briquette production																												
Other transformation																												
Energy sector and own use		10																										
Distribution losses		67																										
Total final consumption		**511**					**91,125**					**266,637**					**732**											
Industry sector		176										266,637																
Transport sector																												
of which road transport																												
Commercial and public services		175																										
Residential		159					91,125										732											
of which traditional uses																												
Other		1																										
Net calorific value (MJ/t)						4,320	15,120	15,120	15,120	12,240	15,120	7,720	12,300	12,500	15,120	16,920	30,800					26,800	26,800	30,800	30,800	42,800	27,400	

Supply and consumption		Gross electricity production (total)	Gross heat production (total)	Geothermal Energy	Solar thermal energy	Renewable municipal waste	Woodfuel	Energy crops	Wood waste	Black liquor	Straw	Bagasse	Rice husks	Other vegetal and agricultural waste	Other primary solid biofuels (animal waste)	Biomass pellets and briquettes	Charcoal	Landfill gas	Sewage sludge gas	Other biogases from anaerobic fermentation	Biogases from thermal processes	Conventional biogasoline	Advanced biogasoline	Conventional biodiesel	Advanced biodiesel	Bio jet kerosene	Other liquid biofuels	Other renewable energy (e.g. heat pumps)
2014		GWh	TJ	TJ	TJ	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	TJ (NCV)	TJ (NCV)	TJ (NCV)	TJ (NCV)	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	TJ
Production	(+)	374					94,500					364,238					759											
Imports	(+)	233															3											
Exports	(-)																17											
Stock changes	(+)																											
International Bunkers	(-)																											
Domestic supply	(=)	**607**					**94,500**					**364,238**					**745**											
Transfers																												
Statistical Differences		**0**																										
Power plants																												
CHP plants												97,600																
Commercial heat plants																												
Charcoal production							3,416																					
Biomass pellet and briquette production																												
Other transformation																												
Energy sector and own use		10																										
Distribution losses		71																										
Total final consumption		**526**					**91,085**					**266,637**					**745**											
Industry sector		183										266,637																
Transport sector																												
of which road transport																												
Commercial and public services		178																										
Residential		165					91,085										745											
of which traditional uses																												
Other		1																										
Net calorific value (MJ/t)						4,320	15,120	15,120	15,120	12,240	15,120	7,720	12,300	12,500	15,120	16,920	30,800					26,800	26,800	30,800	30,800	42,800	27,400	

Annex 5. Current Scope of Programs and Initiatives Relevant to Belize

Program/Initiative	Objective and Brief Description	Program Scope	Status/Comments
Energy Integration			
PetroCaribe: Venezuela - Caribbean States Alliance on Oil	Under PetroCaribe, Venezuela offers oil agreements to member countries, which must pay 60% of the bill within 90 days. The remaining 40% can be financed over 25 years at 1% interest, should oil prices stay above USD 80 per barrel. Financing takes into account the current cost of oil, allowing for more favorable terms when the cost of oil is higher.	The PetroCaribe Initiative provides energy security and favorable financing terms for imports of distillate fuels, energy services and energy infrastructure.	Venezuela has been supplying Belize with its quota of 4,000 barrels a day since September 2012, all diesel, gasoline, and kerosene has been sourced under the PetroCaribe initiative.
	Based on the agreement, each country receives a quota of barrels per day (bpd). Countries may also offer goods and services to pay off oil shipments, ranging from food such as beans and sugar to human capital such as doctors.		Expanding the agreement to put into effect the PetroCaribe Economic Zone (PEZ), would mean that Belize could barter goods such as rice and sugar (unrefined and refined), and services such as tourism and the teaching of English.
	At the II Technical Meeting of PetroCaribe, member states strengthened and expanded cooperation within the framework of the PetroCaribe Agreement on Energy Cooperation, based on existing potentials in the PetroCaribe Economic Zone		Venezuela, through PDVSA Industrial, offered to supply PV modules, small-scale wind turbines, and energy-saving bulbs to PetroCaribe member states.
Mexico–Belize Cooperation on Energy	CFE currently supplies electricity to Belize via a 115 kV transmission line that originates in its substation in Quintana Roo. Commercial arrangements for the supply and purchase of this electricity are governed by three contracts between CFE and BEL: 1) a Framework Agreement, 2) an Economic Energy Purchase Agreement, and 3) an Emergency Assistance Agreement.	The CFE-BEL Interconnection provides security of electricity supply and a potential market for the export of surplus electricity.	Mexico has been supplying Belize with up to 50 MW of electricity from its interconnection point at Xul Ha. Mexico agreed to modify the Economic Energy Agreement in 2014; that contract change is now being executed.
			Mexico has implemented historic reforms to its Energy Sector commencing in 2013; there may be opportunities for deepening trade in electricity going forward under the new Law.
Clean Energy and Clean Production			
Inter-American Development Bank Technical Cooperation (IDB-TC)	The IDB provided support for preparation of the Energy Efficiency strategy; 1) determine a baseline of consumption patterns and areas of opportunity for EE measures in buildings (residential, commercial, public) and Industry; 2) explore feasible renewable energy options for Belize in addition to what other donors are already exploring; 3) formulate an Action Plan to achieve market transformation goals, and 4) training and dissemination of findings	This is technical cooperation by the IDB to the GoB	The consultants finalized a draft of the National Sustainable Energy Strategy & Action Plan (NSES) that will be submitted for endorsement by the GoB.
Energy for Sustainable Development in Caribbean Buildings	**Component 1:** Establish an assessment and monitoring system for energy efficiency and renewable energy in buildings	A sub-Regional Project managed by the Caribbean Community Climate Change Centre (5 Cs) with Antigua & Barbuda; Belize; Grenada; St. Lucia;	The 2nd Annual Operational Plan (AOP 2015-16) has been prepared. Including TOR for a consultant to "Train the Trainers" in energy management and audit. Two technical staff were

Program/Initiative	Objective and Brief Description	Program Scope	Status/Comments
(ESD-Caraibes)		and St. Vincent & The Grenadines.	recruited in May 2015.
	Component 2: Strengthen the national capacity for energy efficiency and renewable energy	A USD 12.5 million initiative, with GEF co-financing contributing just under USD 5 million	Institution to implement training and certification for professionals and practitioners has been selected. Contract negotiations pending.
	Component 3: Develop appropriate financial and market-based mechanisms that support sustainable energy use in buildings	The main objective is sustainability through energy efficiency and renewable energy intervention within the project territories	Belize's specific responsibility under this project is to create the legal and institutional arrangements for Energy Services Companies (ESCOs) that will be shared with other project members.
	Component 4: Demonstration: selection and implement demonstration projects	Project activities—a mix of policy actions and demonstrations—intended to reduce energy intensity for electricity by 20% from BAU	Project is slated for completion in March 2017.
	Component 5: Regulatory framework to promote energy-efficient buildings, appliances and equipment		
	Component 6. Regional public awareness, knowledge management, and sharing, replication strategy and reporting		
National Transportation Master Plan	Transportation consumes half of total primary energy supplied. The scope of the project is planning for growth in intra-node transit in Belize while considering regional influences on transportation and logistics.	Technical cooperation by the Government of South Korea to the GoB	The Final Report has been disseminated since end-2014.
Renewable Energy and Energy Efficiency Technical Assistance (REETA) Project	**Component 1:** Regional Integration • Providing support in regional capacity needs assessment • Supporting the work of the C-SERMS platform • Institutional and organizational strengthening of the CARICOM Energy Programme	German Government has committed EUR 5.02 million for the REETA project to build on the work of CREDP	A three-year project [2014-16] that builds on the work of CREDP
	Component 2: Capacity building • Strengthening of selected regional institutions that work in EE and RE • Capacity building of local providers of EE and RE products and services • Supporting universities and technical schools in delivering relevant training and certification in the field of RE and EE	The political counterpart of the new project is the Energy Unit of the CARICOM Secretariat (CCS)	The 5C's applied for a Mobile Biogas Lab to be hosted by Belize. An MOU with the UB system is pending.
	Component 3: Upgrade the enabling environment for private sector participation • Promotion of private sector cooperation (e.g., ESCOs, PPPs) • Support of specific projects in the field of EE/RE technology transfer • Documentation and exchange of best practices		
OAS Sustainable Energy Capacity-building Initiative (SECBI)	**Outcome 1:** An enabling legal and institutional framework for utilities, ESCOs, and end-users in Belize has been developed and is reinforcing the transformation of the energy sector.	BEL and the PUC are supporting this activity to enhance the policy environment for EE and RE.	BEL is conducting a CoS Study and a Generation Expansion Plan
	Outcome 2: Investment in Sustainable Energy is being guided by financial	ECPA Fellows has attached an expert	David Williams had successful first mission the

Program/Initiative	Objective and Brief Description	Program Scope	Status/Comments
	mechanisms developed via the ESD project.	to support Belize in this outcome	week of April 6-10.
	Outcome 3: End-users are making more informed decisions based on EE equipment and the competency of potential service providers.	Consultant McGeown selected to carry out Outcomes 3 and 4	First Mission scheduled for June 29-July 3
	Outcome 4: MEPS for equipment and buildings were developed and are under consideration by parliament.		
Request for Proposals for New Electricity Generation – RFPEG2013	The PUC has requested proposals to establish electricity generation and/or supply facilities that will satisfy public demand for electricity in Belize for the next 15 years. Through this process the PUC, BEL, and MESTPU are working to select up to 60 MW of firm capacity, and 15 MW of variable renewables to the National Electricity System, by the end of this decade.	The Energy Unit was a key participant in developing the bid documents and assisted the PUC and BEL in evaluating the request for proposals.	The PUC selected 4 developers, proposing 6 projects for negotiations with BEL.
			Technologies: Diesel for backup and emergency power, 2 sugarcane co-generation facilities, 2 hydroelectric facilities and a utility-scale PV
10 Island Challenge – Carbon War Room (CWR)	Seeks to achieve carbon neutrality within an accelerated time frame. Areas of cooperation are: 1) Strengthening the human and organizational capacity for EE, with special emphasis on hospitals and public buildings; 2) Enhancing the capability of the grid to integrate variable renewables; 3) Piloting micro-grid solutions with the utility; 4) Supporting policy dialogue and planning to transition electricity and transport away from fossil fuels		Next Step: MESTPU and CWR to jointly develop a work program
Japan - Caribbean Climate Change Partnership	**Outcome 1:** NAMAs and NAPs to promote alternative low-emission and climate-resilient technologies that can support energy transformation and adaptation in economic sectors are formulated and institutionalized	A 3-year (2015-2018), USD 15 million regional project managed by UNDP Barbados PMU and governed using a Project Board	
	Outcome 2: Selected mitigation and adaptation technologies transferred and adopted for low-emission and climate-resilient development in the Caribbean. Countries will select at least two of the following areas to implement activities based on national strategic priorities: Water resources management, Sustainable agriculture, Community-based climate-smart resilient infrastructure, Renewable energy and energy	Target countries are: Dominica, Grenada, Saint Lucia, Saint Vincent & the Grenadines, Guyana, Jamaica, Belize, and Suriname	
	Outcome 3: Knowledge networks strengthened in Caribbean to foster South-South and North-South cooperation through sharing of experiences surrounding climate change, natural hazard risk, and resilience	Demonstration component (Outcome 2) is sharing USD 8.1 million across the beneficiary countries	
Projects In the Pipeline			
Energy Resilience and Climate Adaptation Project (ERCAP)	**Component 1:** Mechanisms for adaptation planning and capacity building	SCCF: USD 2.5 million; GoB: USD 1.5 million	World Bank acts as the Implementation Agency for the Special Climate Change Fund (SCCF). Aide Memoire has been signed by the Parties.
	Component 2: Development and implementation of a comprehensive set of measures to demonstrate increase in the resilience of the energy sector	SCCF: USD 5 million; GoB: USD 3 million	A year project (2015-20) that builds on the work initiated by the NCC and the 2Cs along the

Program/Initiative	Objective and Brief Description	Program Scope	Status/Comments
	• Planning & Policy for implementation of energy resilient action • Determination of design/engineering techniques and investment to strengthen resilience of the energy system and reduce vulnerability in future climate change impacts • Strengthening implementation capacity for response and recovery		following themes: Reducing Vulnerability, Increasing Adaptive Capacity, and Adaptation Technology Transfer within the Energy Sector.
	Component 3: Project implementation support and dissemination for knowledge sharing	SCCF: USD 0.5 million; GoB: USD 0.3 million	A key Project Output is the mobilization of private capital of at least USD 30 million utilizing modern biomass conversion technologies.
EDF National Indicative Programme	Three focal areas for the EDF-11: 1) Expanding energy access for rural communities, to achieve universal service; 2) Upgrading energy governance and capacity; 3) Encouraging investment in EE, RE, and clean production	Funded under the 11th European Development Fund. EUR 13.5 million earmarked for Sustainable Energy.	Action Plan is to be developed
		EUR 16 million earmarked for MEPS	NAO's Office is working with line ministries to success bridge financing that was available in 2014; ahead of EDF funding expected to be available in late 2015
EDF Regional Indicative Programme	Belize has submitted to CARICOM/Cariforum a program for implementing Minimum Energy Performance Standards (MEPS) for Lighting, Cooling, Refrigeration, and Appliances across the Caribbean sub-region.	Regional Programmes being funded under the 11th European Development Fund	CARIFORUM has committed 16 million euros. Proposals to be developed in consultation with project member states.
Public Benefit Fund	Fund is be used for overcoming financial barriers that impede the timely uptake of appropriate EE and RE technologies, in particular to support: 1) EE improvements in public lighting and public buildings to reduce the fiscal burden of electricity bills; and in general, for the GoB to take a leadership role in Clean Energy; 2) National capacity development that supports economy-wide EE efforts, beginning with measures identified in the IDB-TC; 3) R&D, including pilot projects in EE, RE, and clean production.	This will be a national program designed to drive market transformation in EE and RE funded by increasing the license fee for suppliers in the electricity sub-sector from 0.5% to 1.0%.	This program and its funding has been under consultation with both the PUC and the BEL since late last year. The PUC has implemented the adjustment in the license fee effective July 1, 2015. This legal instrument authorizing use of the PBF is awaiting formal approval by the Minister in accordance with s. 8-(3) of the Electricity Act.
MesoAmerica En.Lighten Programme	En.Lighten recommendations constitute the most effective way to achieve a global transition to EE lighting, and include: 1) Minimum energy performance standards (MEPS) to ensure the efficiency and quality of energy-saving lighting products; 2) Supporting policies and mechanisms to restrict the supply of inefficient lighting and promote the demand for energy-saving products; 3) Monitoring, verification, and enforcement (MVE) programs to discourage distribution of non-compliant products; 4) Environmental sustainability actions including establishing maximum mercury content limits and setting up collection, sound disposal, and/or recycling programs for spent lamps	Regional Programmes supported by Mexico and Columbia, and being implemented at the regional level by the Meso-America Project.	Project Preparation Document is complete

Annex 6. Sample Forms

Example of Energy Efficiency Building Energy Form[214]

Building description

- Name:______________ Age: ___years heating degree days ____
- Location: ____
- No. of floors____Gross floor area___ m^2 (ft.^{2}) Net floor area___m^2(ft.^{2})
- Percentage of surface area which is glazed ___% cooling degree days _____
- Type of air conditioning system; heating only ____ evaporative _____
  dual duct ____ other (describe) ______________________________________
- Percentage breakdown of lighting equipment: Incandescent ______%

Building mission

- What is facility used for:
- Full time occupancy (employees) ____ persons
- Transient occupancy (visitors or public) ____ persons
- Hours of operations per year ______
- Unit of production per year ____ Unit is _______

Installed capacity

- Total installed capacity for lighting ____kW
- Total installed capacity of electric drives greater than 7.5 kW (10hp)
  (motors, pumps, fans, elevators, chillers, etc.)____hp × 0.746=____kW
- Total steam requirements _____lbs/day or ____kg/day
- Total gas requirements ___ft.^{3}/day or BTU/hr or ____m^3/day
- Total other fuel requirements ____

Annual energy end use

Energy form × conversion				kBTU/yr metric units			Conversion MJ/yr	
• Electricity	__kWh/yr	× 3.41	= _____	_____ kWh/yr	×	3.6	=	_______
• Steam	__lb/yr	× 1.00	= _____	_____ kg/yr	×	2.32	=	_______
• Natural gas	__cf/yr	× 1.03	= _____	_____ m^3/yr	×	38.4	=	_______
• Oil	__gls/yr	× {#2 139, #6 150}	= _____	_____ l/yr	×	{#2 38.9, #6 41.8}	=	_______
• Coal	__tons/yr	× 24,000	= _____	_____ kg/yr	×	28.0	=	_______
• Other	__	×	= _____	_____	×		=	_______
	Totals		_____					_______

Energy use performance factors (EUPF's) for building

- EUPF 1 = MJ/yr (kBTU/yr) ÷ Net floor area = _______ MJ/m^2yr (kBTU/ft.^{2}yr)
- EUPF 2 = MJ/yr (kBTU/yr) ÷ Average annual occupancy = _______ MJ/person ·yr) (kBTU/person ·yr)
- EUPF 3 = MJ/yr (kBTU/yr) ÷ Annual units of production = _______ MJ/unit ·yr) (kBTU/unit ·yr)

Example of Energy Audit Form[215]

Facility name ______________

Location ________________

Symbol: $K = 10^3$ $M = 10^3$

Date ______________ By _________ Sheet ___ of ___

Period of survey: 1 day 1wk 1mo 1yr

Notes ____

Conversion factors		
Multiply	by	to get
kWh	306	MJ
BTU/hr	0.000293	kW
hp	0.746	kW

Item no.	Equipment description	Power			Est. hrs use per period	kWh	Conv. factor	Total energy use per period (MJ)
		Name plate rating (BTU/hr, kW, hp, etc.)	Conv. factor to kW	Est.% load (100%, 50%, etc.)				

Example of Energy Audit Form Completed[216]

XYZ corporation

Lighting energy savings summary				Prepare by:	
Existing annual kWh:	181,828 kWh	Existing kW draw:	36.37 kW	Annual energy $$ saved:	$12,094
Proposed annual kWh:	95,234 kWh	Proposed kW draw:	18.52 kW	Estimated PRE-REBATE cost.	$13,592
Annual kWh savings:	86,594 kWh	KW savings:	17.85 kW		
% kWh savings:	47.6 %	% kW savings:	49.1 %		

Lighting inventory, recommendations, and savings

		Existing				Recommended			Savings			Estimated	
Item #	Location	Weekly hours	Qty	Fixtures	Watts/fix	Qty	Fixtures	Watts/fix	kW	Annual kWh	Annual Energy S	Unit cost	Total cost
1	Presidents office	60	8	75 Watt INC Spotlight	75	8	18 Watt CFL/SI/Ref.	18	0	1368	$219	$22	$176
2	Presidents office	60	6	2-F40T12(40W)/STD	96	6	2-F32T8(32W)/ELEC	61	0	630	$101	$48	$288
3	V.P. office	60	8	75 WATT INC Spotlight	75	8	18 Watt CFL/SI/Ref.	18	0	1,368	$219	$22	$176
4	V.P. office	60	4	2-F40T12(40W)/STD	96	4	2-F32T8(32W)/ELEC	61	0	420	$67	$48	192
5	Nightlighting	168	4	2-F40T12(40W)/STD	96	4	2-F32T8(32W)/ELEC	61	0	1176	$145	$48	$192
6	Women's restroom mirror	60	12	25 Watt INC	25		None						
7	Women's restroom	60	6	2-F40T12(34W)/U/STD	94	6	2-F40T12(34W)/U/ELEC	60	0	612	$98	$48	$288
8	Men's restroom	60	6	2-F40T12(34W)/U/STD	94	6	2-F40T12(34W)/U/ELEC	60	0	612	$98	$48	$288
9	Main office area	60	56	3-F40T12(40W)/2-Class 111	136	56	3-F32T8(32W)/1-ELEC	90	2	7728	$1,240	$48	$2,688
10	Storage room	25	1	100 Watt INC	100	1	28 Watt PL CFL/SI	30	0	88	$19	$32	$32
11	Parking garage	168	26	100 Watt Quartz	350	26	175 Watt MH	205	3	3,166	$3,906	$200	$5,200
12	Parking garage	168	8	2-F96T12(75W)/STD	173	8	20F96T8(50W)/ELEC	104	0	4637	$572	$60	$480
13	Physical plant	80	28	2-F96T12(215W)/WHO/STD	450	28	2-F96T12(95W)/HO/ELEC	166	8	3,180	$4,741	$110	$3,080
14	Physical plant	80	162	100 Watt INC	100	16	28 Watt PL CFL/SI	30	1	4480	$668	$32	$512
	Total								1	8,659	$12,094	N/A	$13,592

Endnotes

[1] Ministry of Public Services, Energy, and Public Utilities (MPSEPU), presentation provided during country visit on 29 September 2015.
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