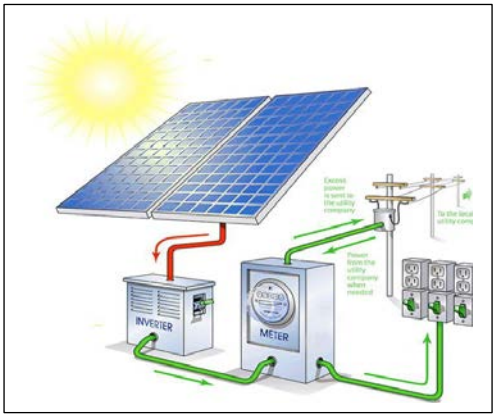

BELIZE TECHNOLOGY

NEEDS ASSESSMENT

BARRIER ANALYSIS AND ENABLING FRAMEWORK MITIGATION

Identification of Barriers and Enabling Framework for Mitigation Technologies in Belize

May 2018

Technology Needs Assessment

Barrier Analysis and Enabling Framework

Mitigation

National Climate Change Office

Ministry of Agriculture, Fisheries, Forestry, the Environment and Sustainable Development

Market Square

Belmopan, Belize

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DISCLAIMER

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Abbreviations

AC	Alternating current
APEB	Association of Professional Engineers of Belize
BBS	Belize Bureau of Standards
BCCI	Belize Chamber of Commerce and Industry
BEL	Belize Electricity Limited
BELTRAIDE	Belize Trade and Investment Development Service
BZ$	Belizean dollars
CARICOM	Caribbean Community
CCCCC	Caribbean Community Climate Change Centre
CFE	Federal Commission of Electricity (acronym in Spanish)
CPI	Consumer Price Index
CTO	Chief Transport Officer
DC	Direct current
DFC	Development Finance Corporation
DOE	Department of Environment
DOT	Department of Transportation
ED	Excise Duty
E.T.	Environmental Tax
FAO	Food and Agriculture Organization
FCD	Friends for Conservation and Development
FD	Forest Department
GEF	Global Environment Facility
GEF SPG	Global Environmental Facility Small Grants Programme
GHG	Greenhouse gas
GIZ	German Cooperation for Sustainable Development Agency
GOB	Government of Belize
GSDS	Growth and Sustainable Development Strategy
GST	General Sales Tax

HS	Harmonised System
ID	Import duty
IPP	Independent Power Producers
ITVET	Institute for Technical and Vocational Education and Training
KBA	Key Biodiversity Areas
LPG	Liquefied Petroleum Gas
Ltd.	Limited
MCA	Multi-criteria analysis
NEMO	National Emergency Management Organisation
NGO	Non-Governmental Organisation
PACT	Protected Areas Conservation Trust
PUC	Public Utilities Commission
PV	Photovoltaic
SIB	Statistical Institute of Belize
SOP	Standard operating procedures
SUV	Sports utility vehicle
TNA	Technology Needs Assessment
UB	University of Belize
US$	American dollars
VED	Vehicle Emission Duty
VFR	Vaca Forest Reserve
WTO	World Trade Organisation

Chemical Species

CO	Carbon monoxide
CO_2	Carbon dioxide
CH_4	Methane
H_2	Hydrogen gas

Units of Measurement

cc	cubic centimetres
ft	feet
g	grams
gal	gallon
Gg	giga grams
km^2	square kilometre
kW	kilowatt
kWh	kilowatt-hour
lbs	pounds
m^2	square metre
MW	mega watt

Glossary

Barrier: Obstruction or impediment that impedes technology transfer; a reason why a target is adversely affected, including any failed or missing countermeasures that could or should have prevented the undesired effect(s).

Biomass: The total mass of living organism in a given area or of a given species usually expressed as dry weight. Organic matter consisting of, or recently derived from, living organisms (especially regarded as fuel) excluding peat. Biomass includes products, by-products, and waste derived from such material. Cellulosic biomass is biomass from cellulose, primary structural component of plants and trees.

Capital goods: Machinery and equipment used in the production of other goods, e.g. consumer goods such as boilers, motors, steel, or pumps. May also mean 'producer goods'.

Carbon dioxide (CO_2): CO_2 is a naturally occurring greenhouse gas, and a by-product of burning fossil fuels or biomass, of land-use changes and of industrial processes. It is the principal anthropogenic greenhouse gas that affects Earth's radiative balance. It is the reference gas against which other greenhouse gases are measured and therefore it has a Global Warming Potential of 1.

Climate Change: Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and /or variability of its properties, and that persist for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

Consumer goods: Good and products specifically intended for the mass market and purchased by (private) consumers.

Diffusion: The process by which a technology is spread or disseminated through various channels over time in a society, where the technology is gradually adopted by more and more members of the society (people, institutions, companies, etc.).

Enabling Environment/Framework: The set of resources and conditions within which the technology and the target beneficiaries operate. The resources and conditions that are generated by structures and institutions that are beyond the immediate control of the beneficiaries should support and improve the quality and efficiency of the transfer and diffusion of technologies.

Energy: The amount of work or heat delivered. Energy is classified in a variety of types and becomes useful to human ends when it flows from one place to another or is converted from one type to another.

Primary energy or energy sources is the energy embodied in natural resources (e.g. coal, crude oil, natural gas, uranium) that has not undergone any anthropogenic conversion. Primary energy is transformed into secondary energy by cleaning (natural gas), refining (oil into oil products) or by conversion into electricity or heat. Final energy is secondary energy delivered at the end-use facilities (e.g., electricity at the wall outlet), where it becomes usable energy (e.g., light).

Land-use: The total of arrangements, activities and inputs undertaken in a certain land-cover type (a set of human actions). The social and economic purposes for which land is managed (e.g., grazing, timber extraction, and conservation). Land-use change occurs when, e.g., forest is converted to agricultural land or to urban areas.

Market/value chain: The chain of economic actors that own and transact a particular product as it moves from primary producer to final consumer.

Market mapping: An analytical framework for understanding market systems and an approach to market development that is both systematic and participatory.

Measures: Measures are technologies, processes, and practices that reduce GHG emissions or effects below anticipated future levels. Examples of measures are renewable energy technologies, waste minimization processes and public transport commuting practices etc. Measures can also be factors (financial or non-financial) that enable or motivate a particular course of action or behavioural change or is a reason for preferring one choice over the alternate. Often the word 'incentive' is used synonymously, sometime with a slightly different interpretation.

Mitigation: Mitigation is short for 'climate change mitigation', meaning an action to decrease the concentration of greenhouse gasses, either by reducing their sources or by increasing their sinks.

Non-market goods: Goods not traded in a market.

Publicly provided goods: A category of technologies characterized by large investments, general public ownership, and production of good and services available for the public or a large group of persons.

Reforestation: Direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was previously forested but converted to non-forested land.

Renewable Energy: Renewable energy is energy that is collected from renewable resources, which are naturally replenished on a human timescale, such as sunlight, biomass, wind, rain, tides, waves and geothermal heat.

Stakeholder: A person, group, organization or system that affects or can be affected by an organization's actions.

Sustainability: The ability to meet the current needs while considering the carrying capacity of the Earth's supporting eco-systems without compromising the ability of future generations to meet their own needs.

Technology: Technology is a piece of equipment, technique, practical knowledge or skills for performing a particular activity. It is common to distinguish between three different elements of technology: the tangible aspect such as equipment and products (hardware); the know-how, experience and practices (software) associated with the production and use of the hardware; and the institutional framework, or organization, involved in the transfer and diffusion of a new piece of equipment or product (orgware).

Technology transfer: Technology transfer involves vertical technology transfer, which is understood as the movement of technologies from the R&D stage to the commercialization, and horizontal transfer, which involves the spatial relocation or diffusion of technologies across space.

Xaté: A species of wild, tropical palm, whose leaves are sought after, harvested and exported as a decorative base for bouquets in the floral industry.

Executive Summary

The report focuses on identifying barriers and suggesting measures, with the consultation of stakeholders, to ensure the successful diffusion of the prioritised technologies for climate change mitigation. Three vulnerable sectors were selected for the technology needs assessment process, namely: Energy; Transportation; and Land Use, Land Use Change and Agroforestry.

The Energy Sector have prioritised three technologies, these are: "Off-grid PV Systems", "Gasification" and "On-grid PV Systems". Among the key stakeholders identified were the Ministry of Energy, the Public Utilities Commission, Ministry of Finance, the private sector, and financial institutions. Stakeholders were gathered in focus groups and interviewed to determine the challenges in the transfer and diffusion of these technologies, and to suggest measures to overcome these barriers.

The Off-grid PV System, will be targeting isolated communities, hospitals and eco-hotels – users that are not connected to the national electrical grid. Table 1 below, compiles the barriers that were identified and measures suggested by key stakeholders for off-grid PV systems.

Table 1: Off-grid Solar PV Barriers and Measures.

Barrier	Measure
- High cost of PV Systems due to taxes and duties being charged for individual components	- Reducing or eliminating taxes to reduce cost of PV Systems
- Lack of knowledge of available financial support	- Create awareness of financial support through campaigns
- Cultural barriers	- Eliminate cultural barriers through communication
- Low awareness of the technology	- Create awareness of the technology through communication campaigns
- Limited access to technical support	- Increase the number of service providers staffed with certified technicians

The gasification technology targets facilities and communities that are not connected to the national grid and are not dispersed over a large area, and have access to feedstock. Table 2 compiles the identified barriers and suggested measures made by stakeholders for gasification systems.

Table 2: Gasification Barriers and Measures.

Barrier	Measure
- High capital cost	- Identifying non-traditional suppliers for gasifiers and shredders
- High operating costs	- Reduce operating costs
- Limited access to financial support	- Provide access to financial support through DFC and other financial institutions
- Limited accessibility to adequate spare parts	- Provide access to adequate spare parts by standardising
- Lack of public awareness of the technology	- Develop and implement public awareness campaigns
- Lack of skilled labour force to service equipment	- Train local electro-mechanical technicians in maintenance of gasifiers

The On-grid PV system targets residential, commercial and industrial buildings that are connected to the grid. Table 3 compiles the barriers identified and measures suggested by stakeholders for on-grid PV systems.

Table 3: On-grid Solar PV Barriers and Measures.

Barrier	Measures
- High cost of PV Systems due to taxes and duties being charged for individual components	- Reducing capital cost by reviewing taxing scheme and increasing offer for services
- Lack of regulations on the tariffs and market schemes	- Pass regulations on tariffs and market schemes
- Lack of awareness of available financial support	- Create awareness campaigns of available financial support
- Low awareness of the technology	- Create awareness campaigns on the technology

The Energy Sector requires the leadership of the Ministry of Energy to coordinate with other institutions to create an enabling framework and ensure the successful diffusion of these technologies. The labour force will need training in these technologies and a certification programme established by the Public Utilities Commission. Competition laws will need to be passed to ensure fairness in the market place. The Ministry of Energy should also develop a communication plan to create awareness of technologies and availability of financial support.

The Transport Sector has prioritised two technologies: “Production of performance based (CO_2 emission) import duties on motor vehicles [VED – Vehicle Emission Duty]”, and “Reducing carbon emissions and vehicle operating cost by retrofitting existing vehicles with Liquefied Petroleum Gas (LPG) Systems”. Key stakeholders, like the Department of Transport and Customs Department, were interviewed and participated in Working Groups to prioritize barriers and determine measures.

The Production of performance based (CO_2 emission) import duties on motor vehicles [VED – Vehicle Emission Duty] originally targets all future vehicles that are imported after the technology has been fully implemented in Belize. However, during the consultation phase for this report, stakeholders voiced that the main barriers are established international trade agreements. To counteract these barriers, it is suggested to take a local approach and applying the concept of the technology on licensing fees instead, thus broadening the scope to vehicles circulating in Belize. Barriers were identified and suggested measures to overcome them are summarised in Table 4 below.

Table 4: Production of performance based (CO2 emission) import duties on motor vehicles [VED – Vehicle Emission Duty] Barriers and Measures.

Barrier	Measure
- Duty based on agreement with WTO	- Modify the focus of the technology application to licensing of vehicles
- Lack of incentives to reduce emissions	- Provide tariff incentives based on vehicle carbon emissions
- Poor quality of fuel	- Enforce fuel quality standards
- Lack of vehicle inspection upon re/registration and licensing	- Enforce vehicle inspections
- Lack of stringent regulations for vehicle importation/licensing	- Draft and adopt vehicle regulations dealing with carbon emission
- Lack of emissions testing equipment in Belize	- Acquire and utilize emissions testing equipment
- Lack of certified persons to perform tests	- Training programme for DOT and municipalities inspectors
- Lack of skilled mechanics in new technology	- Train local mechanics in new technology

The technology of "Reducing carbon emissions and vehicle operating costs by retrofitting existing vehicles with Liquefied Petroleum Gas" targets light-duty gasoline vehicles circulating in Belize. Stakeholders identified barriers and suggested measures to overcome them. These are presented in Table 5 below.

Table 5: Reduce carbon emissions and vehicle operating cost by retrofitting existing vehicles with LPG Systems Barriers and Measures.

Barrier	Measures
- Unregulated market	- Regulate market by establishing regulations for LPG Kits
- Lack of enforcement of LPG standards	- Enforce LPG standards
- Lack of public awareness of the technology	- Have public awareness campaigns on technology
- Lack of skilled labour force	- Provide training for mechanics on technology

An enabling framework for the diffusion of these two technologies will require, among other things, the strengthening of the Department of Transport, which will need to operate with autonomy and in accordance with standard operating procedures. Awareness campaigns and strict tariff structures can be used to change human behaviour. Gaps in legislations and standards will need to be bridged and enforcement units trained, empowered and equipped to enforce laws. The local labour force needs to be empowered with know-how and know-why. The LPG retrofitting needs market standards and regulations to ensure safety and free market conditions.

The Land Use, Land-use Change and Forestry Sector has prioritised: "Integrated Landscape Forest Management". This technology targets forest reserves where there are farming activities. The key stakeholders identified are the Forest Department and the Agriculture Department, others were also interviewed for this sector. Barriers were identified and suggested measures to overcome them are summarised in Table 6 below.

Table 6: Integrated Landscape Forest Management Barriers and Measures.

Barrier	Measures
- Limited access to funding - Weak legislations - Weak institution - Lack of road infrastructure - Difficulty with marketing of farm products - Technical expertise in agriculture is lacking - Challenges in changing farming practices	- Ensure access to funding - Amend legislation - Strengthen the Forest Department - - Form cooperatives or associations to market goods - Partner with national university to provide technical expertise - Change farming culture

The enabling framework for the diffusion of an Integrated Landscape Forest Management requires that the Forest Department maintains its leadership role in the management of forest reserves and in co-management with stakeholders. It is imperative therefore, that capacity building activities be provided for the staff. A legal review needs to be conducted to ensure long-term sustainability of forest reserves. Building alliances with stakeholders for the conservation of forest reserves should be fostered. Funds can be secured through the Protected Areas Conservation Trust for developing and executing a Management Plan.

General conclusions and recommendations were drawn for each technology:

- The success of these technologies relies on the coordination and teamwork of key institutions (Ministry of Energy, Public Utilities Commission, Forest Department, Agriculture Department and Department of Transport) with the National Climate Change Office.

- The Off-grid Solar PV system could be made feasible for rural communities as proven by another project with similar characteristics.
- Gasification is not feasible for isolated communities without a power distribution network, however hospitals or hotels will find it feasible once they have access to adequate quantities of feedstock.
- The On-Grid Solar PV system is only awaiting regulations to be passed, however this technology may only be accessible to middle-class Belizeans, businesses and industries.
- The implementation of performance-based (CO_2 emission) import duties on motor vehicles technology may need to be refocused to licensing or registration of vehicles since Belize has signed international conventions that determine how import duties are charged.
- Awareness campaigns and market regulations are important measures for the diffusion of reducing carbon emissions and vehicle operating costs by retrofitting existing vehicles with LPG systems.
- The Forest Department must strengthen its institution framework to adopt the Integrated Landscape Forest Management technology and ensure its sustainability.

Introduction

This report aims at identifying the barriers that are crucial to the implementation of climate change mitigation technologies, and determining practical and effective measures that should be implemented to eliminate or reduce the effects of these barriers, thereby ensuring sustainability of the technology. Enabling frameworks for each sector that should facilitate the introduction and use of these technologies to create the appropriate environment for change within Belize are presented.

Table 7: Categorisation of selected technologies (Adapted from Boldt, et al., 2012)

Category		Description	Market characteristics	Sector	Prioritized technology
Market Goods	**Consumer Goods**	Goods targeting the mass market; households, businesses and institutions.	- a high number of potential consumers - interaction with existing markets and requiring distribution, maintenance and installer networks in the supply chain - extended and complicated supply chains with many actors, including producers, assemblers, importers, wholesalers, retailers and end consumers - barriers may exist in all steps in the supply chain - demand depends on consumer awareness and preferences and on commercial marketing and promotional efforts	Energy	- Off-grid PV system - Gasification - On-grid PV system
				Transport	- Reduce carbon emissions and vehicle operating cost by retrofitting existing vehicles with LPG Systems Barriers
Non-market Goods	**Other Non-market Goods**	Non-tradable technologies transferred and diffused under non-market conditions, whether by governments, public or non-profit institutions, international donors or non-	- technologies are not transferred as part of a market but within a public non-commercial domain. - serves overall political objectives, such as energy saving and poverty alleviation	Transport	- Production of performance based (CO_2 emission) import duties on motor vehicles. [VED – Vehicle Emission Duty]

		governmental organisations (NGOs)	- donor or government funding	Land Use, Land Use Change and Agro-forestry	- Integrated Landscape Forest Management

The climate change mitigation technologies that this report focuses on were selected through a Multi Criteria Analysis (MCA) in the first phase of the Technology Needs Assessment (TNA) process. These technologies have been categorised according to their intended markets and further sub-categorised for the type of goods as are shown in Table 7. The methodology used to prepare this barrier analysis and enabling framework was through a literature review of the technologies, sectoral small group meetings and stakeholder interviews.

Most barriers were identified during the first phase in preparing the TNA Report consultation with stakeholders. These barriers have been reviewed through a study of the market chain for marketable goods and problem tree for non-marketable goods. The validation exercise was done during a focus group session with all sectors, at which the barriers were presented to relevant stakeholders and were prioritised. A second focus group event was done additionally for the land-use and forestry sector. Interviews were also conducted with key persons in all three sectors. Past governmental and non-governmental reports and legislation were reviewed to get a better understanding of the country's situation in each sector.

Based on knowledge of the country's resources and roles of different governmental agencies, measures were proposed and assigned to different entities for execution. An important consideration kept in mind while proposing measures is the government's need to collect revenues. Thus, measures were then presented to relevant stakeholders (governmental agencies) for verification.

First, the document focuses on the Energy sector, giving a description of each technology identified for the sector. Prioritised barriers for each technology are then listed and categorised as financial and non-financial barriers, giving a breakdown of these. Measures for each barrier are proposed detailing who should be made responsible for the success of its implementation. An enabling framework is then suggested for the sector by first identifying links among technologies and suggesting options for more effective and efficient diffusion of the technologies. The same methodology was employed for the Transport Sector and the Land Use and Land-use Change and Forestry sector.

Chapter 1. Energy Sector

In 2015, the Ministry of Public Service, Energy and Public Utilities reported that 27.0% of the primary energy used by Belize was for electricity and that 33.5% came from renewable sources. Renewable energy sources are made up of biomass, hydro, wind and solar (Ministry of Public Service, Energy and Public Utilities, 2015). The electricity sector in Belize is made up of producers, distributors, consumers, and government institutions (such as, Public Utilities Commission (PUC) and Ministry of Energy).

In 2016, 92% of the population was supplied with electricity by Belize Electricity Limited (BEL) through the national grid (BEL, 2016). Independent Power Producers (IPP) generated their own electricity and have a standby arrangement with BEL. In 2015, the peak demand reported was 96 MW which is buffered by Mexico's Federal Commission of Electricity (Comisión Federal de Electricidad) (CFE). Remote communities generate their own electricity using a mix of generators, small-scale photovoltaic systems or small-scale wind turbines. (Ministry of Public Service, Energy and Public Utilities, 2015)

In 2015, Belize's electricity came from the following sources: 39% from hydro, 14% from biomass, 5% from fossil fuels and 42% was imported from Mexico through CFE (BEL, 2015) Solar energy also contributes to the grid in small amounts; the University of Belize (UB) has a 480 kW solar PV plant meant as a pilot for the on-grid solar PV system (Ministry of Public Service, Energy and Public Utilities, 2015).

Prioritising this sector goes in line with the country's Sustainable Energy Strategy and Action Plan which indicates that by 2030, Belize will depend on 85% of renewable energy sources (GOB, 2016). It also assists the Government of Belize (GOB) with poverty alleviation objectives by providing remote communities off the grid with more sustainable energy options.

Data taken from the 2015 Statistical Institute of Belize (SIB) report indicated that the main sources of lighting for rural Toledo District with a total of 5,842 households were as follows: 44.4% were connected to the national grid, 35.4% used gas lamps, 17.4% either use another type or were unreported, 2.6% used public generators, and 0.3% used none (SIB, 2015 p. 20). A report in 2010, showed that the average size of households in rural Toledo were made of 4.9 persons (SIB, 2013). The reason for most of these communities not being connected to the national grid is because it costs BEL about BZ$ 150,000 per mile of power distribution lines, and the population density is too small to justify this investment.

The first phase of the Technology Needs Assessment (TNA) through a Multi Criteria Analysis, selected the following three technologies for the Energy Sector:

- Off-grid Solar PV
- Gasification
- On-grid Solar PV

1.1. Key Stakeholders for Energy Sector

The Public Utilities Commission (PUC), established by the PUC Act (GOB, 2000a), is the regulatory body for utilities (namely, electricity, water and telecommunications) in Belize. The Electricity Sector under the PUC is mandated to ensure fair competition in power generation. Private entities/households are allowed to generate up to 75 kilowatts (kW) for their own use, after which a licence is required.

The Ministry of Energy, Science & Technology, and Public Utilities formulates policies for the energy sector and serves as an advisory body for Government of Belize (GOB), on issues relating to this sector, making plans for the long-term and for attracting investors. The policies formulated by the ministry are then made into regulations and implemented by the PUC. The Ministry has created a Sustainable Energy Strategy to guide its planned renewable energy expansion.

Belize Electricity Limited (BEL) is the primary power distributor in Belize and is licensed under the Electricity Act (GOB, 2000b) to generate, transmit and distribute electricity. The company is owned by GOB with 32.6% directly and 31.2% indirectly through the Social Security Board. Fortis Cayman Inc. owns 33.3% and the remaining 2.9% is owned by more than 1,500 small shareholders. BEL owns the national electricity grid that consists of approximately 1,875 miles of transmission and distribution lines that connect most of the major municipalities of the country (BEL).

About 65% of the land in Belize, especially the central and northern districts, receives medium to high solar intensity (5–5.5 kWh/m^2/day) that can sustain a reasonably good power generation throughout most of the year (Tillett, et al., 2012 p. 41).

The Ministry of Finance is the body responsible for the collection of revenues for the Government of Belize. GOB's sources of revenue that would be made available to implement the proposed technologies include: General Sales Tax (GST), Duty Fees, and Environmental Tax (E.T.). GST is a tax imposed on consumers upon importation and for business transactions or services provided (Department of General Sales Tax, 2015 p. 1), the tax is currently 12.5% of the mark-up price. The E.T. is currently a 3% tax imposed on imported goods with few exemptions, the proceeds go to the Department of Environment, towards solid waste disposal, and preservation and enhancement of the environment as stated in the Environmental Tax Act (GOB, 2003a). Duty Fees will vary from item to item.

The Development Finance Corporation's (DFC) mandate according to the DFC Act (GOB, 2009) states that "The purposes of the Corporation shall be to expand and strengthen the economy of Belize by providing funding on an economically sustainable and environmentally acceptable basis to those individuals or groups of individuals seeking financing for specifically approved purposes, and who would otherwise be unable to fund their requirements from other sources on reasonable terms and conditions…". In 2016, DFC introduced their Renewable Energy and Energy Efficiency Financing Programme for businesses, which in 2017 was extended to households. (DFC, 2017).

The Institute for Technical and Vocational Education and Training (ITVET) is a vocational institution for Belizeans to learn skills that make them employable. ITVET offers courses in automotive and electrical technology, among others.

1.2. Preliminary targets for technology transfer and diffusion

The Ministry of Energy will be the governmental executing agency targeted to diffuse these technologies for the energy sector.

Off-grid Solar PV systems and the gasification technology will be targeting isolated communities, hospitals and eco-hotels that are not connected to the national grid because the connection costs are prohibitive and, in the case of the gasification technology, users have accessibility to feedstock.

On-grid Solar PV systems shall be installed on residential, commercial and small industrial buildings that are structurally sound to support the load of the solar panels or have expanses of land available.

1.3. Barrier analysis and possible enabling measures for Off-grid Solar PV

Barriers were analysed by conducting a study of the market chain for the off-grid solar PV system and the interactions among the different players (see Figure I-1 in Appendix I). This tool assisted in giving perspective to propose possible enabling measures. The market map and barriers were presented at a workshop with stakeholders to verify and prioritise them. The proposed measures were presented to targeted implementers to verify applicability.

Table 8 shows the results of this analysis: the prioritised barriers to be overcome and the proposed measures to ensure the successful implementation and diffusion of this technology.

Table 8: Off-grid Solar PV Barriers and Proposed Measures (own elaboration).

Type	Barrier	Proposed Measures
Economic	High cost of PV Systems due to taxes and duties being charged for individual components Lack of awareness of available financial support	Reduce or eliminate taxes to lower cost of PV Systems Create awareness of financial support through campaigns
Regulatory		
Institutional		
Resources		
External Factors		
Social	Cultural barriers Low awareness of the technology	Eliminate cultural barriers through communication Create awareness of the technology through communication campaigns
Capacity	Limited access to technical support	Increase service offering of certified technicians

1.3.1. General description of Off-grid Solar PV

An off-grid solar PV system is a decentralized system that uses photovoltaics (PV) technology to produce reliable and cost-effective power (Solar Mango, 2015). Photovoltaics technologies generate electricity from sunlight using solar cells which are semiconductor materials. (Solar Energy Industries Association)

The main components of an off-grid solar PV system are: the photovoltaic array, charge controller, battery bank, and inverter. The solar panels which form the photovoltaic array are placed on mounts tilted to optimise the solar energy production throughout the year, or on adjustable mounts to account for the different seasons. The charge controller protects the battery by monitoring the voltage and avoiding it from overcharging (Weis, 2013). The inverter converts the direct current (DC) to alternating current (AC) and helps to regulate the voltage (Civic Solar, 2017).

These systems tend to be more economic than establishing transmission lines in isolated areas or with low population densities (Solar Mango, 2015). Thus, investing in a backup energy storage becomes essential for times of high energy demand or low solar energy production (Weis, 2013).

The off-grid systems require a larger initial investment than the on-grid systems due to the charge controller and batteries that the former requires (Civic Solar, 2017).

The cost of a 60W system is approximately BZ$ 1,500.00, with an additional cost for installation of approximately BZ$ 500.00 per system.

Figure 1: Solar panel installed in Santa Teresa, Toledo District.

The diffusion of this technology hopes to improve the lives of rural communities by providing additional sources of income, building the capacity of the population to adopt this technology, thereby improving their chances of improved living conditions and opportunities for educational growth.

The village of Santa Teresa in the Toledo District (see Figure 1) is a real example that this technology can be implemented and be made sustainable. Off-grid solar PV systems have been

installed in homes throughout Santa Teresa with the assistance of Plenty Belize through The Global Environmental Facility Small Grants Programme (GEF SGP) in collaboration with Barefoot College in India. Santa Teresa sent a representative to learn about solar PV systems and how to install and maintain them. The person then returned to the community and installed off-grid solar PV systems, teaching the community how to maintain their equipment to ensure a longer life. Complete solar systems were donated by GEF SGP to the community, for which no taxes were levied since it was United Nations project; however, a monthly fee is charged depending on the size of the panel. The purpose of the fee is to make the technology sustainable for this community, for when replacements are required they have money saved to purchase them. The representative was also trained to do repairs, for which a fee is charged for labour, although bartering for services is also possible. The programme has since extended to Santa Elena in the Toledo District, through which two residents of the village have been sent to Barefoot College to master this technology. Thus, this concept/model can be replicated to other communities throughout Belize to diffuse this technology.

In 2018, the Ministry of Energy received grant funding from the United Arab Emirates Countries through the Abu Dhabi Fund, to finance rural communities in the Toledo District with renewable energy solutions.

1.3.2. Identification of barriers for Off-grid Solar PV

Barriers for off-grid PV systems were identified through stakeholder consultation during the first phase of the TNA and listed on the corresponding factsheet. Based on the consultant's research and knowledge, other barriers were identified and included. A small sector-based technology working group (STWG) comprising of multisector stakeholders was consulted on the barriers and asked to prioritise them. Individual experts were consulted to expand on details for the barriers.

1.3.2.1. Economic and financial barriers

a. High cost of PV Systems due to taxes and duties being charged for individual components

Solar PV systems are exempt from paying custom duties but still pay 12.5% GST and 3% E.T. upon importation. This increases the cost of the equipment by at least 15.5%. The cost can further increase if components of the system, such as the batteries and inverters, are purchased or arrive separately, as some of these components can be utilized for other purposes. According to Customs Department the total taxes levied on batteries are 55.25% (including 35% Import Duty, 3% E.T., and 12.5% GST) and for inverters and battery controllers, 21.5% tax is charged (including 5% Import Duty, 3% E.T., and 12.5% GST). Also, since the authorities cannot differentiate for every component of the system, they do not discriminate on what is exempt. Unless the person knows how to apply for the exemption, a broker needs to be hired to process the exemption which may cost more than paying the taxes.

Importers sometimes are unable to source all the components for the same shipment and end up paying these extra taxes.

The cost of operation will also see an increase whenever parts need replacement as these individual components are not exempt from paying import duties, environmental tax (E.T.) and GST.

b. Lack of awareness of available financial support

There is a lack of awareness of financial support available from institutions like: DFC and credit unions. DFC in 2016 started a programme "Renewable Energy and Energy Efficiency Financing" to help businesses that wanted to cut back on their electricity bill by using renewable energy or energy efficient technologies. They now extended this service to home owners as a viable option at an interest rate of 6%.

However, the communities targeted for this technology are located in remote rural areas where the community does not have easy access to the financial services available. This is partly due to poor transportation infrastructure, consisting of dirt roads and transportation by public bus that have limited schedules, and poor radio signal coverage. Although DFC offers their services countrywide, in the Toledo District their offices in Punta Gorda are open only for two days per month, hence communities have traditionally been relying mostly on credit unions for their banking needs.

A specific example is the Toledo Teacher's Credit Union Limited, which is the only credit union in the Toledo District and is located in Punta Gorda town. They work closely with communities, earning their trust as most members are fearful of taking out loans and not being able to repay. The credit union offer loans at interest rates ranging from 10 to 12% on the unpaid balance.

1.3.2.2. Non-financial barriers

a. Cultural barriers

The targeted communities for this technology are poor isolated communities where there is little access to information. They may be reluctant to invest in this solar off-grid technology. The reasons vary with ethnic groups, religious groups, varying cultures and language barriers. There is also the reluctance to borrow money that is not theirs and do not know if they will be able to pay back and prefer not to get themselves indebted.

The Mayan communities have a view of a sense of fairness. Plenty Belize, an international NGO supporting community groups, encountered this when they were investigating the installation of solar panels in Santa Teresa; the community needed convincing in how fees would be charged based on the capacity of each system. They wanted to pay the same regardless of the size of the panels, for example.

b. Low awareness of the technology

People are not aware of the benefits to be gained by investing and how they can get to acquire this technology. Some of these benefits are: independence from energy distributors, and

relatively low operating costs compared to other energy generating options. Awareness campaigns are lacking in promoting renewable energy technologies since these communities are in remote areas with poor road infrastructure and poor communication systems.

c. Limited access to technical support

In order to ensure an extended life, the components for this technology require regular cleaning and inspection. Properly trained and equipped personnel or an installation company should be hired to perform this maintenance which will come at a cost, keeping in mind that the recommended frequency of servicing is on a monthly basis for cleaning (Tetra Tech Inc., 2013) and quarterly for in-depth maintenance. According to one service provider, maintenance costs can range from BZ$ 300 (US$ 150) per visit with minor repairs to BZ$ 3,995 (US$ 1,997.50) for 3 visits per annum giving an in-depth service (Pro Solar Engineering). This cost is not affordable for members of rural communities. This price may also vary for remote communities due to the difficulty in accessing them.

Most of these targeted rural communities are in very remote areas of Belize and very probably lack a good road system. Technical support also comes at a price and these communities may not have the income to finance these expenses.

1.3.3. Identified measures

Measures were developed to respond to each prioritised barrier with consideration to the mandates assigned to the respective government agencies and national resources available. These measures were then presented to targeted stakeholders (Ministry of Energy and PUC) for verification.

1.3.3.1. Economic and financial measures

a. Reducing or eliminating taxes to reduce cost of PV Systems

Capital costs can be reduced by reducing or eliminating taxes and custom duties on PV components by submitting a request via Cabinet Papers prepared by the Ministry of Energy. The Ministry may seek the assistance from the Ministry of Investment and Trade to prepare these papers in a manner that will make the proposal most favourable for approval. These Papers will need to present the social benefits that can be gained, and the losses that will be incurred by GOB with the removal of this potential revenue generator. Santa Teresa can be used as a case study to document the benefits brought about by introducing of this technology since this rural community has seen improvements in education with more students going on to secondary level education and improvement in grades. The Cabinet Papers will then need to be presented to the Cabinet for their approval. The Ministry of Energy will need to be persistent once the proposal is submitted in order to reduce approval time.

The reduction or elimination of taxes will create a more competitive market that will force retailers to find suppliers for the different components at lower prices than buying systems from

a sole supplier. The purchase of generic components may also lower capital and maintenance cost when spares need to be purchased.

Antitrust laws will need to be put in place to mitigate effects of oligopoly; one such measure could be price control mechanism for these articles. This is currently being addressed as competition policies and legislation, which have been drafted and presented to the Office of the Solicitor General for review. The next step will be for it to be presented before the Cabinet for approval. Belize is one of the few CARICOM (Caribbean Community) members that do not have approved competition laws.

b. Create awareness of financial support through campaigns

Awareness of the availability of financial support can be brought about through communication campaigns. The Ministry of Energy could partner with financial institutions to develop these campaigns. However, to ensure the success of this endeavour, a study of the audience is suggested to determine effective ways of communicating with the targeted communities of this technology and thus assisting the communities in accessing funds.

1.3.3.2. Non-financial measures

a. Eliminate cultural barriers through communication

The Ministry of Energy needs a communication plan to target communities and inform them what benefits this technology will provide for their households and communities. This plan will require a study of the targeted communities, learning the most effective ways of communicating with them, which will vary for each community. The study should include surveys of target audience. The plan should then indicate how the information will be disseminated, who will do so, when it will happen, and how the plan will be evaluated for its effectiveness.

The Ministry can partner with DFC to bring awareness of the technology and of available financial assistance for renewable energy sources. This campaign should be the first activity in the diffusion of this technology.

Using the success and experience of Santa Teresa as a case study would be very convincing for these other communities, with similar demographics. This alternative would be effective as there would be no suspicion of ulterior motives on the part of

Figure 2: Solar PV System installed in a household in Santa Teresa, Toledo.

promotors. Figures 2 show the equipment that has been installed in Santa Teresa.

b. Create awareness of the technology through communication campaigns

The Ministry of Energy can create awareness through communication campaigns. It is recommended that first a study be conducted to determine the most effective communications strategy. This strategy should then be translated into a plan/campaign which will determine how the message should be delivered and by whom. The plan should also be evaluated by the executing team to determine the effectiveness of the campaign and to make adjustments from time to time to ensure effectiveness. The SIB, the Ministry of Education and the Department of the Environment can be invited to participate in the public awareness campaign on the positive attributes of solar PV technology.

c. Increase service offering of certified technicians

The PUC could provide certification for technicians trained to install and maintain this equipment. They would work with vocational training organisations like ITVET to develop programmes that include the installation and maintenance of solar PV systems as part of their training for electricians at the assistant technician level. This will develop a larger pool of technicians in the country, increasing the competition among suppliers and ensuring the safety and quality of the service; thus, making the technology more affordable for communities. There can be cooperation from the Association of Professional Engineers of Belize (APEB), or other training institutions coordinated by the PUC.

As an example of this application, in Santa Teresa village, a representative of the community was trained to do installation and maintenance on basic solar PV systems, thereby providing this service to the village at an affordable price. The representative has also trained other villagers to provide these services. Each household pays a monthly fee of BZ$ 6 to 8 depending on the output of the panels, to ensure that funds are available in the village for sustainability of the project.

1.4. Barrier analysis and possible enabling measures for Gasification

Barriers were analysed by conducting a study of the market chain for gasifiers and the system's interactions among the different players (see Figure I-2 in Appendix I). This tool assisted in giving perspective to propose possible enabling measures. The market map and barriers were presented at a workshop with stakeholders to verify and prioritise them. The proposed measures were presented to targeted implementers to verify applicability.

Table 9: Gasification Barriers (own elaboration).

Type	Barrier	Proposed Measures
Economic	High capital cost	Identifying non-traditional suppliers for gasifiers and shredders
	High operating costs	Reduce operating costs

Regulatory		
Institutional	Limited access to financial support	Provide access to financial support through DFC
Resources	Limited accessibility to adequate spare parts	Provide access to adequate spare parts by standardising
External Factors		
Social	Lack of public awareness of the technology	Develop and implement public awareness campaigns
Capacity	Lack of skilled labour to service equipment	Train local electro-mechanical technicians in maintenance of gasifiers

Table 9 shows the results of this analysis: the prioritised barriers to be overcome and the proposed measures to ensure the successful implementation and diffusion of this technology.

1.4.1. General description of Gasification

Gasification is a thermo-chemical process of partially oxidising a carbon-based feedstock, such as: coal, agricultural or forest residues; to produce synthetic gas, also known as syngas, and charcoal. These are produced within a gasifier that allows a controlled environment: high temperatures and pressures and reduced oxygen conditions. The syngas is primarily composed of carbon monoxide (CO) and hydrogen gas (H_2); other gaseous compounds may also be present such as carbon dioxide (CO_2) and methane (CH_4) which will depend on the type of feedstock. This technology allows for flexibility in the type of feedstock that can be used to produce syngas, the limitations will be on the gasifier's manufacturer and the availability of the required feedstock. (US Office of Fossil Energy)

The feedstock is fed into a gasifier and during pyrolysis it is heated releasing volatile compounds and producing charcoal. The process and composition of the charcoal is dependent of the properties of the feedstock. The charcoal is then burnt with a limited supply of air to produce carbon dioxide (CO_2) and carbon monoxide (CO), to provide heat for the subsequent gasification process. The stream of carbon dioxide and water vapour are made to pass through the hot charcoal to produce hydrogen gas (H_2) and carbon monoxide (CO). (ALL Power Labs, 2017)

The technology being proposed is composed of small modular gasifiers that incorporate an internal combustion engine to generate electricity using the produced syngas. The syngas will be produced from agricultural and forestry waste materials that can be readily sourced very near the point of generation. The residues (charcoal) could then be used for soil augmentation by local farmers or in agroforestry initiatives. The purpose of this technology is to reduce the country's dependency of fossil fuels, and to find alternative ways of generating electricity from material that is more readily available.

Feedstock needs to be pre-treated to meet the required size which is between 0.5 inches (in.) to 1.5 in. These shredders vary in cost from US$ 300 to 20,000, depending on the input size of the trees from 3 in. to 12 in. diameter. (National Climate Change Office, 2017).

Most households (61.6%) within the Toledo District use wood/charcoal for cooking (SIB, 2015), for which it can be concluded that the necessary feedstock is available for these communities.

1.4.2. Identification of barriers for Gasification

Barriers for gasification were identified through stakeholder consultation during the first phase of the TNA and listed on the corresponding factsheet. Based on the consultant's research and knowledge, other barriers were identified and included. A working group comprised of multisector stakeholders was consulted on the barriers and asked to prioritise the list of barriers. They considered that financial support, lack of public awareness of the technology and lack of regulations for the cutting of trees were the main barriers that needed to be prioritised for this technology. Interviews were also conducted with a Customs Officer regarding the importation of this technology and with an engineer in the energy sector to obtain more insight on the flexibility and cost of the technology.

1.4.2.1. Economic and financial barriers

a. High capital cost

This barrier is critical to the implementation of this technology. The capital cost includes the purchase of the gasifier, the installation of distribution lines and cost to pre-treat the feedstock.

The cost to distribute electricity to the households within a community is very high. The cost per foot of the simplest cable is BZ$ 1.11 per foot (ft); this wire will need to be placed on posts that costs BZ$ 800 per post. Posts are spaced out about every 150 to 200 ft. An estimation of the cost to run overhead lines will cost at least BZ$ 27,460.80 per mile. This estimate does not include transformers that are needed at least every 1,000 ft.

Although the cost of the equipment could be shared among a community, most rural communities in Belize live below the poverty line and earn a median monthly salary of BZ$ 978, having then limited resources for other more urgent priorities.

If this technology is used to power one building, the distribution cost will not be an issue. But if the technology would be used to provide energy for a large number of buildings (which may be scattered on location), investment in infrastructure (power distribution lines and other components) will be required.

b. High operating costs

Unavoidable operating costs for this technology are: fuel, labour, preventative maintenance, and equipment replacement costs.

Operating costs will also be determined by the quality of the feedstock. The feedstock needs to meet a maximum size and minimum moisture content in order to be introduced into the gasifier to ensure optimum working conditions. Requiring the feedstock to be pre-treated may require the purchase of an additional equipment and to employ someone to perform the daily task. The equipment consumes 1.2 kg/kWh; for the small villages, a running time of four hours a day will require 86.4 kg of pre-treated feedstock per day. If this was used for a small polyclinic that consumes 10,000 kWh per month, the equipment will need to be running all day at full capacity requiring at least 518.4 kg of feedstock per day. This last case will require the hiring of one person or more and purchasing a wood shredder.

A mechanic will also need to be sought within the area to give maintenance to the gasifier periodically to ensure the life of the equipment. As this technology does not yet exist in Belize, it may not be possible to find a qualified mechanic with the knowledge to do maintenance near rural communities. The poor road infrastructure of rural communities may cause an increase to the fees for mechanics to visit the sites.

If the technology is applied to communities with buildings scattered throughout an area, infrastructure (power distribution lines) will be required and these need maintenance and repairs that increases the operation costs.

c. Limited access to financial support

The targeted communities for this technology have limited access to financial support, as they are located in very remote areas of Belize with poor road and transportation systems. Technical support also comes at a price and these farming communities do not have the income to finance and justify these expenses. Some of these institutions also do not have a presence in the communities, for example: DFC has an office in Punta Gorda and does not offer extension services.

1.4.2.2. Non-financial barriers

a. Limited accessibility to adequate spare parts

This technology is currently not available in Belize, therefore spare parts are not available with local retailers, and will need to be sourced abroad by the user. After introducing the technology, accessibility to spare parts will be a constraint considering Belize's small market, which is further reduced to persons that cannot connect to the national grid. Thus, users of this technology may still have a hard time in finding spare parts available locally and/or may need to shop around; as retailers would not want to keep in their inventory spares for each type of gasifier since turnover may not be as often as desired. Low availability will also increase the cost of spare parts.

These communities will have an added challenge that they are located in remote areas with poor road infrastructure.

b. Lack of public awareness of the technology

Gasification is not known in Belize; however, biomass is used for the generation of electricity. Currently, most isolated communities and remote eco-hotels that cannot connect to the national grid use diesel generators or kerosene lamps for lighting. The diesel and gasoline generators are what are more traditionally known to Belizeans. This in part is due to their more accessible capital cost. On the other hand, there have never been awareness campaigns promoting other power generation options. However, in rural Toledo District kerosene lamps are more popular than generators.

c. Lack of skilled labour to service equipment

This technology has variations from the gasoline engines, which some generators use, for which mechanics are not familiar with. The gasifier is also made of other components which mechanics service using intuition and trial and error, thus there is a learning curve that can lead to damage to engines. Although this would be a new technology in Belize and the gasifier would be prefabricated, maintenance and the occasional repair still needs to be done, requiring technical skills and experience.

1.4.3. Identified measures

Measures were developed to respond to each prioritised barrier with consideration to the mandates assigned to the respective government agencies and national resources available. These measures were then presented to relevant stakeholders (governmental agencies) for verification and acceptance.

1.4.3.1. Economic and financial measures

a. Identifying non-traditional suppliers for gasifiers and shredders

This technology is not suited for communities that are dispersed within an area since the installation of distribution lines will be required. However, if the technology would be focused on hospitals or even resorts or hotels this technology could be considered.

To lower cost for equipment, end users may want to look at non-traditional suppliers for gasifiers and shredders, such as Indian or Brazilian companies, or parts can be purchased to be assembled locally in-country. The Agriculture Department or local engineers could be approached to design a shredder suited for the needs of the gasifier.

b. Reduce operating costs

Operating costs could be reduced by training people within the community to provide the servicing of the gasifier. The PUC could provide certification for these technicians. The Ministry of Energy could request assistance from the UB or APEB in developing a training programme for mechanics. Training could be provided by vocational training institutions, such as ITVET and Trade4Life. Having people trained in the maintenance of gasifiers will allow for

proper preventative maintenance, which will help in reducing cost of corrective maintenance once the technician knows what is being done and how to do it properly.

Users of this technology could reduce their operating costs by making some profit in selling the charcoal, a by-product of gasification. This material has the potential to be a marketable good since it can be used for soil augmentation or by organic farmers to produce bokashi.

c. Provide access to financial support through DFC

DFC provides financial assistance through their Renewable Energy and Energy Efficiency Financing Programme which includes alternative green technologies. Interest rates for this type of loan is 6%. In order to access funds, the communities will need to approach DFC, either as individuals or as a community under the village council. DFC will then require an assessment to determine if there are any socio-economic benefits and sustainability of the project.

1.4.3.2. Non-financial measures

a. Provide access to adequate spare parts by standardising

Through a cooperative of owners of gasifiers, spare parts can be purchased from official supplier and kept in inventory, readily available when needed and replenished the stock when they reach a minimum level. This may also be a more economic option for users with the limitation that the equipment should be standardised, but with the benefit that maintenance cost will decrease as mechanics become familiar with the maintenance of the same equipment.

b. Develop and implement public awareness campaigns

The Ministry of Energy will need to develop and implement public awareness campaigns on this new technology. A proper study should be carried out by this Ministry to identify effective communication mechanisms specific to the different groups of end users, to ensure the proper diffusion of this technology. The Ministry will partner with the Caribbean Community Climate Change Centre (CCCCC) to prepare and disseminate information packages to targeted group like hospitals and eco-resorts or other targeted users. In the case of hospitals, liaising with the Ministry of Health will be required for identification of the most appropriate locations to implement this technology.

c. Train local electro-mechanical technicians in maintenance of gasifiers

The PUC could certify electro-mechanical technicians upon successful completion of a training programme in repair and maintenance of gasifiers. Electrical technicians and electro-mechanical technicians will need to be trained to demonstrate how the new technology works, because it is a variation from the gasoline engines. The PUC will need to work with ITVET to develop and implement a training programme for these technicians. PUC can then certify this level of technicians.

1.5. Barrier analysis and possible enabling measures for On-grid Solar PV

Barriers were analysed by conducting a study of the market chain for on-grid solar PV systems and the system's interactions among the different players (see Figure I-3 in Appendix I). This tool assisted in giving perspective to propose possible enabling measures. The market map and barriers were presented at a workshop with stakeholders to verify and prioritise them. The proposed measures were presented to targeted implementers to verify applicability.

Table 10 shows the results of this analysis: the prioritised barriers to be overcome and the proposed measures to ensure the successful implementation and diffusion of this technology.

Table 10: On-grid Solar PV Barriers and Proposed Measures (own elaboration).

Type	Barrier	Proposed Measures
Economic	High cost of PV Systems due to taxes and duties being charged for individual components	Reducing capital cost by reviewing taxing scheme and increasing offer for services
Regulatory	Lack of regulations on the tariffs and market schemes	Pass regulations on tariffs and market schemes
Institutional		
Resources		
External Factors		
Social	Lack of awareness of available financial support	Create awareness campaigns of available financial support
Capacity	Low awareness of the technology	Create awareness campaigns on the technology

1.5.1. General description of On-grid Solar PV

This technology also uses solar cells to generate electricity from the sun. An inverter converts the current from DC to AC to be used instantaneously by most appliances. Grid connected PV systems have two types of applications: distributed and centralized. Distributed systems are installed on residential, commercial or public buildings and generate electricity which is consumed by the customer and the excess is sold to the grid at an established retail rate. This type of systems can range between 1-5 kW in power generation (National Climate Change Office, 2017). A bi-directional meter is used to measure the power entering and leaving the system, i.e., the power purchased from the grid and the surplus sold to the grid (Solar Direct). The centralized systems are usually larger and not necessarily on building rooftops but can be designed as solar 'farms', ranging from 10 kW up to a few MW in generating capacity (National Climate Change Office, 2017). An example of the latter is the solar farm at the University of Belize.

The PUC is currently finalising the consultation phase to allow for net-metering. Regulations are expected to be approved by first quarter 2018 and the market scheme by the end of 2018.

Based on rates from the two major Solar PV companies in Belize, the price for on-grid Solar PV, including installation range from BZ$ 4.50 to 7.00 per watt and the annual maintenance costs is approximately 2 to 5% of the system cost.

1.5.2. Identification of barriers for On-grid Solar PV

Barriers for on-grid solar PV systems were identified through stakeholder consultation during the first phase of the TNA and listed on the corresponding factsheet. Based on the consultant's research and knowledge, other barriers were identified and included. These barriers were presented at a focus group with stakeholders to verify and prioritise them. Individual experts were consulted to expand on details relating to the barriers.

1.5.2.1. Economic and financial barriers

a. High cost of PV Systems due to taxes and duties being charged for individual components

The cost of this system ranges between BZ$ 4.50 to 7.00 per watt. An average household that consumes 350 kWh monthly, will require at least 3 kW system to meet its energy demand without producing surplus of energy. A conservative, estimated cost for this generated power is BZ$ 13,500. The median monthly salary is BZ$ 1,041.00 and 41% of Belizeans live below the poverty line. Thus, this technology is not readily available to at least 41% of the population.

The cost of PV system is composed of the following costs: equipment, taxes, shipping and installation cost. The duties are a barrier, especially when duties are charged for individual components (this is mentioned further in the following point) but this limits local retailers on purchases.

Solar PV systems are exempt from paying duties, although they still pay 12.5% GST and 3% E.T. upon importation, which brings up the cost by 15.5%. However, it is sometimes difficult for importers to find suppliers to ship a complete system by a determined time thus an additional cost of 21.5% is added in taxes which includes 5% Import Duty, 3% E.T. and 12.5% GST (Data provided by Customs Department). They are also limited to purchasing systems from one supplier to get duty exemption, contrary to getting components from various suppliers to build a system. Thus, bringing up the capital cost of the system as well as of the maintenance cost whenever replacements are required. Importers are challenged to keep prices attractive for customers and still make a profit.

b. Lack of awareness of available financial support

In 2016, DFC started a programme, Renewable Energy and Energy Efficiency Financing, to help businesses that wanted to cut back on their electricity bill by using renewable energy or energy efficient technologies. They have now extended this offer to home owners as a viable

option. However, DFC's awareness campaigns have not been effective in attracting clients to request loans for this purpose. The nominal interest rate for this type of loan is 6%.

1.5.2.2. Non-financial barriers

a. Lack of regulations on the tariffs and market schemes

At present there is no tariff structure nor market scheme for net-metering in Belize. The tariff structure will determine what fees will be charged and how much. The tariffs will need to be reasonable to attract Belizeans to want to invest. On the other hand, the market scheme will determine how the energy will be bought and sold on the grid. Thresholds may be set for residential sectors. BEL may need to set a fixed price to compensate for peak demand and drop in supply that will occur when the on-grid solar PV systems go offline. The PUC needs to define the tariff structure, and how it will be broken down. Regulations are currently being drafted by the PUC, the time this process will take to reach culmination is unknown. A market scheme will need to be proposed once the regulations are approved.

b. Low awareness of the technology

This option of on-grid Solar PV is relatively new to Belize. The PUC does not have regulations for this type of technology. The financial benefits to be gained by investing in this technology are still not known because of the unknown tariff structure.

Since there is no legislation for this technology, there has not been a need to make people aware of this option for Belize.

1.5.3. Identified measures

Measures were developed to respond to each prioritised barrier with consideration to the mandates assigned to the respective government agencies and national resources available. These measures were then presented to targeted stakeholders (Ministry of Energy and PUC) for verification and acceptance.

1.5.3.1. Economic and financial measures

a. Reducing capital cost by reviewing taxing scheme and increasing offer for services

Capital costs can be reduced by reducing or eliminating taxes and custom duties. The Ministry of Energy is working on having GOB remove these taxes during a pilot period with the argument that the government is presently not obtaining revenues from this technology in any case. This would need to be proposed via Cabinet Papers prepared by the Ministry of Energy. These Papers will need to present the social benefits that can be gained, and the losses that will be incurred by GOB with the removal of this potential revenue generator. The Cabinet Papers will then need to be presented before Cabinet for their approval. The Ministry of Energy will need to be persistent once the proposal is submitted in order to reduce approval time.

The passing of this Cabinet Paper will create a more competitive market that will force retailers to find suppliers for the different components at lower prices than buying systems from a sole supplier. The purchase of generic components may also lower capital and maintenance cost when spares need to be purchased. Antitrust laws will need to be put in place to mitigate effects of oligopoly, one such measure could be a price control mechanism for these articles. This is currently being addressed as competition policies and legislation, which have been drafted and presented to the Office of the Solicitor General for review. The next step will be for it to be presented before the Cabinet for approval.

An additional measure that can be taken is to reduce installation costs by increasing the pool of technicians that offer the service. The PUC could work with vocational training institutions, like ITVET or Trades 4 Life to provide training on solar technology. These institutions already provide training for electricians, it would not take much to add this technology to their programme. The PUC could then certify these electricians trained to install and maintain this equipment. This measure will increase competition among suppliers/service provider and ensure the safety and quality of the service, making the technology financially viable and more readily available.

b. Create awareness campaigns of available financial support

The Ministry of Energy will be working with DFC in creating awareness of the financial assistance available through their Renewable Energy and Energy Efficiency Financing programme. They will need to determine the target audience, the message they want to send and how they will reach their audience effectively. The message should emphasise the long-term economic savings this technology offers.

1.5.3.2. Non-financial measures

a. Pass regulations on tariffs and market schemes

The Ministry of Energy is working on market schemes to get Cabinet to pass the regulations for this technology. The public sector also needs to continue in their efforts to push GOB, in this particular case, to pass regulations faster if they will benefit the country and its citizens.

b. Create awareness campaigns on the technology

The Ministry of Energy will need to have awareness campaigns to inform the public of this technology emphasising the technical aspects; how the market will work, what the tariffs will be, and the economic benefits to be gained by investing. The Ministry will also have to determine a communication strategy. They will need to determine how the message will be delivered, what will be the message. Key to these campaigns will be evaluating their effectiveness in diffusion.

1.6. Linkages of the barriers identified

Table 11 shows a matrix of linkages among the technologies in the energy sector identifying common mitigation measures to overcome barriers.

Table 11: Common Mitigation Measures in the Energy Sector (own elaboration).

		Gasification						**On-grid**			
		Identifying non-traditional suppliers for gasifiers and shredders	Reduce operating costs	Provide access to financial support through DFC	Provide access to adequate spare parts by standardising	Develop and implement public awareness campaigns	Train local electro-mechanics in maintenance of gasifiers	Reducing capital cost by reviewing taxing scheme and increasing offer for services	Pass regulations on tariffs and market schemes	Create awareness campaigns of available financial support	Create awareness campaigns on technology
Off-grid	Reducing or eliminating taxes to reduce cost of PV Systems	X						X			
	Create awareness of financial support through campaigns			X						X	
	Eliminate cultural barriers through communication										
	Create awareness of the technology through communication campaigns					X					X
	Increase service offering of certified technicians		X				X	X			
On-grid	Reducing capital cost by reviewing taxing scheme and increasing offer for services						X				
	Pass regulations on tariffs and market schemes										
	Create awareness campaigns of available financial support			X							
	Create awareness campaigns on technology					X					

A review of the barriers shows a concern for costs, whether capital or operational costs, and a need for measures that will alleviate some of these costs. Financial support is available, but its existence is unknown to many. DFC offers loans at 6% interest rates, which is better than what commercial banks have to offer. These costs are also incurred in taxes and duties that do not appear to have a consistent enforcing scheme.

These technologies lack public awareness of their potential to provide economic savings in the long-term and social benefits in terms of improved living conditions. The Ministry of Energy should conduct an economic study on different energy options and costs focused on Belize. The study then needs to be communicated to all levels of Belizean Society, in a language they can understand.

Lack of skilled labour force is also a common barrier that if overcome they can alleviate some of the other barriers like operating costs. By increasing the pool of certified technicians, the costs of these technologies will not be as high as there will be more supply of services and better qualified service providers.

1.7. Enabling framework for overcoming the barriers in the Energy Sector

To overcome most of the barriers prioritised in this section, it will require the collaboration of various governmental and non-governmental entities. This collaboration needs to be led by the Ministry of Energy to ensure a synergistic approach among the different groups.

The Ministry of Energy should conduct an assessment of the savings these technologies could bring to its users. The assessment should be followed by a communication plan to bring awareness of these technologies, the financial assistance available and the savings and benefits to be gained on implementation. Awareness campaigns can be conducted by in collaboration with financial institutions, like DFC.

In the case of the on-grid PV system, the Ministry needs draft regulations and develop market strategies for approval by the Legislature (Government).

Financial support can be provided by DFC and credit unions through their financing programmes. However, the public needs to be made aware of these programmes. Financial institutions need to work closer with Government, in particular the Ministry of Energy to reduce duplication of efforts.

To build the capacity of the local labour force the PUC will need to coordinate with vocational institutions or APEB and UB. A curriculum for technicians will need to be developed in collaboration with these organisations. The PUC should create a certification programme for technicians to ensure quality of the service being offered to the public.

To create an enabling environment in the market place for these technologies, the Government of Belize needs to legislate policies relating to competition. This enabling environment would give Belizeans access to these technologies at affordable costs for equipment and spares.

Chapter 2. Transportation Sector

In 2010, the main energy consumer was the transport sector with a 46.8% of the total secondary energy consumption and generating 49% of total net greenhouse gas (GHG) emissions. Tillett et al (2012), estimated that about 3% of gasoline vehicles had been retrofitted to use LPG. The fuel consumed by this sector is distributed as follows: 47% of the gasoline, 37 % of diesel, and the remaining 16% were kerosene, crude oil, and LPG. However, these figures do not quantify the fuel used to generate electricity to charge electric golf carts which are prolific in San Pedro and Caye Caulker, and other areas of Belize like Placencia that use them to a lesser extent (Tillett, et al., 2012 pp. 26-27)

The Transportation Sector in Belize is divided into the following subsectors: roads, aviation, maritime ports, and waterways.

Air transport is overseen by the Department of Civil Aviation under the Ministry of Tourism and Civil Aviation. This sector allows international and domestic air travel consisting of an international airport, the Philip Goldson International Airport in Ladyville, municipal airstrips and private airstrips. (McNish, et al., 2013)

Water transport is overseen by the Belize Port Authority under the Ministry of Transport and NEMO (National Emergency Management Organisation). Belize has many coral and mangrove islands or Cayes, which are sources of attraction for the tourism industry, and which are mostly accessed by sea, although there are commercial flights to the two main Cayes.

The Ministry of Transport and NEMO also oversee the different aspects of land transportation, such as the public transportation, motor vehicles, traffic, among others.

Roads infrastructure are under the mandate of the Ministry of Works, which is responsible for the construction and maintenance of these infrastructures.

The Department of Transportation (DOT) is mandated in section 3(1) in the Motor Vehicles and Road Traffic Act (GOB, 2000c) to register, license and control all vehicles in Belize. In 2008, responsibilities for licensing and registration was shared with the Municipalities as a way for these local administrative bodies to collect revenues. The Transport Units within municipalities still cooperate with DOT.

The Belize Bureau of Standards (BBS) is the body responsible for preparation, promotion and implementation of standards for goods, services, and processes. (Belize Bureau of Standards, 2013). They inspect and verify the fuel pumps throughout the country ensuring that the metering is accurate. They have drafted national standards for LPG, diesel and gasoline, which are still pending approval by GOB. Early 2017, they inaugurated their new building where their Metrology laboratory and administrative office are located. A consultant has been hired to study and report on its sustainability as an autonomous institution, do a conformance assessment for Belize and determine its sustainability. This consultancy should also produce a

business plan for the BBS. Certificates of quality are being requested from importers of LPG and fuels upon importation of these goods. Unfortunately, the BBS does not have the capacity to verify these certificates, much less what is actually being sold to the final consumers. Whenever public concern for the quality of these products arise, testing is sent abroad at a high cost.

Carbon dioxide emissions for this sector were: 263.58, 275.94 and 330.55 giga grams (Gg) of CO_2 in 1994, 1997 and 2000 respectively, which shows an increasing trend (GOB, 2015). By 2030, Belize is aiming to reverse this trend by reducing the amount of conventional fuel used by at least 20%. With this goal in mind, GOB has hired a consulting firm to draft a Transport Master Plan. (GOB, 2016)

In the first phase of the TNA through a Multi Criteria Analysis, the two highest scoring technologies for the Transport Sector are:

- Production of performance based (CO_2 emission) import duties on motor vehicles. [VED – Vehicle Emission Duty]
- Reduce carbon emissions and vehicle operating cost by retrofitting existing vehicles with LPG Systems.

2.1. Preliminary targets for technology transfer and diffusion

The Department of Transport is the primary targeted governmental agency to diffuse the proposed technologies for this sector.

The introduction of a Vehicle Emission Duty (VED), based on carbon dioxide emissions by motor vehicles upon importation, will be targeted to all vehicles imported after the consultation and vetting phases are finalised. The desired results from this technology are: to institute more equitable vehicle import duties, encourage Belizeans to drive more fuel-efficient motor vehicles, and reduce emissions in the transport sector.

The technology for reducing carbon emissions and vehicle operating cost through retrofitting gasoline vehicles with LPG Systems will be target gasoline light-duty vehicles. The goal is to encourage the spread of retrofitted vehicles with LPG systems in order to reduce greenhouse gas emissions.

2.2. Barrier analysis and possible enabling measures for Production of performance based (CO_2 emission) import duties on motor vehicles. [VED – Vehicle Emission Duty]

A problem tree was developed with the assistance of stakeholders in identifying the causes for high vehicle emissions in the transport sector (see figure I-4 in Annex I). A Solution Tree (see figure I-5 in Annex I) was created to determine the measures required to lower vehicle emission. These tools assisted in giving perspective to propose possible enabling measures. The causes were presented for verification and prioritisation at a workshop with stakeholders

. The proposed measures were presented to targeted implementers to verify applicability.

Table 12 shows the results of this analysis: the prioritised barriers to be overcome and the proposed measures to ensure the successful implementation and diffusion of this technology.

Table 12: Production of performance based (CO_2 emission) import duties on motor vehicles [VED – Vehicle Emission Duty] Barriers and Proposed Measures (own elaboration).

Type	Barrier	Proposed Measures
Economic		
Regulatory		
Institutional	Lack of incentives to reduce emissions Poor quality of fuel Lack of vehicle inspection upon re/registration and licensing Lack of stringent regulations for vehicle importation/licensing	Provide tariff incentives based on vehicle carbon emissions Enforce fuel quality standards Enforce vehicle inspections Draft and adopt vehicle regulations dealing with carbon emission
Resources	Lack of emissions testing equipment in Belize	Acquiring emissions testing equipment
External Factors	Duty based on agreement with WTO	Modify the focus of the technology application to licensing of vehicles
Social		
Capacity	Lack of certified persons to perform tests Few skilled mechanics knowledgeable of the new technology	Training programme for DOT and municipalities inspectors Acquire or draft training material for new technology and develop a training programme for local mechanics

2.2.1. General description of Production of performance based (CO_2 emission) import duties on motor vehicles. [VED – Vehicle Emission Duty]

Currently duties in Belize are charged based on the engine capacity for motor cars/sport utility vehicles (SUV), the weight of the vehicle for trucks, and the seating capacity for vans and buses. This technology intervention aims to change this scheme to one based on the amount of carbon dioxide emitted per unit of distance travelled (g CO_2/mile).

Table 13 below shows the duty schedule for the importation of vehicles. The import duty (ID) depends on the type of vehicle and the Excise Duty (ED) is applied to luxury items which in the case of vehicles is associated with the number of cylinders. GST is a tax imposed on consumers upon importation and for business transactions or services provided (Department of General Sales Tax, 2015 p. 1); the tax is currently 12.5% of the mark-up price. The E.T. is imposed on imported goods with few exemptions, the proceeds go to the Department of Environment, towards solid waste disposal, and preservation and enhancement of the environment as stated in the Environmental Tax Act (GOB, 2003a).

Table 13: Rate of Duties and Taxed On Motor Vehicles. (Adapted from Belize Customs and Excise Department, 2009).

Type of Vehicle	Cylinder	Litres	Import Duty (ID)	Excise Duty (ED)	Environmental Tax (E.T.)	General Sales Tax (GST)
Pickups Cargo Van	4 6 & 8	up to 3.0	10% 10%	- 15%	3%? 5%	12.5% 12.5%
Cars, SUVs & minivans	4 6 & 8	up to 3.0	45% 45%	- 5%	2% 5%	12.5% 12.5%
Motor cycle	less than 50cc[1] Above 50cc		- 20%	- -	2% 2%	12.5% 12.5%
Vans & Buses	4 6 & 8	10 to 20 passengers 20 passengers	10% 10%	 5%	2% 5%	12.5% 12.5%
Buses		21 passengers +	10%	-	5%	12.5%
Trucks	5 tonnes+		10%	10%	5%	12.5%
Tractor trucks			5%	10%	5%	12.5%

This technology will require emissions testing equipment; therefore, a reliable and consistent vehicle emission testing protocol will need to be developed. The TNA proposed two different systems that can be used (National Climate Change Office, 2017):

- A laboratory emission testing facility: is a major infrastructure and institutional investment that requires planning and institutional capacity.
- Portable emissions measurement system (PEMS): a lightweight 'laboratory' that is used to test and/or assess mobile source emissions (i.e. cars, trucks, buses, construction equipment, generators, cranes, etc.) for the purposes of compliance, regulation, or decision-making.

2.2.2. Identification of barriers for Production of performance based (CO_2 emission) import duties on motor vehicles. [VED – Vehicle Emission Duty]

Barriers were identified through stakeholder consultation during the first phase of the TNA and listed on the corresponding factsheet. Additionally, individual experts were interviewed and a legislation review was conducted to identify more barriers. These were presented at a focus group with stakeholders for verification and prioritisation.

2.2.2.1. Economic and financial barriers

[1] cc: cubic centimetres

a. Duty based on agreement with WTO

Belize is a signatory to the World Trade Organisation (WTO) agreements since 1995 (WTO, 2017). This organisation uses Harmonised System (HS) codes to ensure that all member countries are comparing similar items to negotiate tariffs. The motor vehicles are categorised by this system based on the size of the engine and the weight of the vehicle. To change the manner of how duties are applied with this HS coding system, it will be required that Belize present the proposal to WTO and member countries will need to agree to the change. This barrier makes it difficult to implement the technology as it may take a long time for Belize to lobby for this change and convince other signatory countries to buy into the technology as well. Belize has agreed to tariff binding and cannot charge more than 45% of the cost (WTO). As can be observed in table 12 above, Belize has almost reached its ceiling (the WTO has sets 45% as the upper threshold) in the import duties the country should charge, and if Belize would like to increase these tariffs they will need to renegotiate the *Ad valorem* duty with the WTO.

b. Lack of incentives to reduce emissions

The Environmental Protection Act (GOB, 2003b) regulates the permissible emissions concentrations of gases into the environment by motor vehicles and penalizes for its violation. Unfortunately, at the moment, these regulations are not being enforced by DOT nor the Department of the Environment (DOE); neither are emissions being measured by them. There is no subsidy that disincentives or incentives vehicle owners to lower vehicle emissions. As has been mentioned before, vehicles are taxed based on the size of the engine. The government offers a reduced import duty only for work vehicles such as pickups and cargo vans. GOB needs to be able to generate revenues and any incentive will need to be carefully considered, so that revenues are not significantly reduced because otherwise the government will look at another source to compensate the loss.

2.2.2.2. Non-financial barriers

a. Poor quality of fuel

There is no standard for fuel quality. Over the last 4 years, the BBS formed a technical committee to bring forth recommendations on the standards for fuel quality; the draft standard has been finalized and is awaiting action by GOB. Two standards have been drafted: one for diesel and the second for premium and regular gasoline. The standards give threshold levels - for different parameters - that are acceptable for these fuels. The standards also suggest the method to test for each parameter. New vehicles operate on technologies that require that the fuel meet certain high standards for emission control devices to work properly. The quality of fuel then becomes a major factor in ensuring the success in reducing fuel emissions, and unfortunately the BBS does not have the installed capacity to perform these tests due to lack of equipment and trained personnel to perform tests.

b. Lack of vehicle inspection upon re/registration and licensing

When a vehicle enters the country, it is mandated by the Motor Vehicle and Road Traffic Act for the owner to register the vehicle, or if modifications are made to the vehicle it should be re-registered. Upon registration (as well as re-registration) the registering authority should do an inspection of the vehicle, which is not currently being performed at the municipalities because they overlook the importance of inspection but still charge the fee. Not verifying the performance of the vehicle becomes a barrier to the main objective of the technology, which is to decrease carbon dioxide emissions. Without inspections, the motor can be replaced or modified and the carbon dioxide emissions may be more than is expected. The cost of emission testing equipment will need to be considered for municipalities and DOT.

c. Lack of stringent regulations for vehicle importation/licensing

Many times, vehicles that entering the country are vehicles that have been in accidents or subjected to extreme weather events. These conditions cause a drop in the value of the vehicle in the country of origin, making it more affordable for Belizeans to purchase. Nevertheless, these vehicles are not in their optimum conditions, especially since the electrical system may have been impaired by flood events.

d. Lack of emissions testing equipment in Belize

Upon importation of vehicles, emission testing is not performed and hence the emission of vehicles is not recorded by Customs and Excise Department since they do not have the equipment to do so. This equipment is neither available to the DOT nor the municipalities that do yearly inspections on vehicles, limiting inspections to visual observations, if carried out. This will incur a cost to GOB to setup these systems at designated locations.

e. Lack of certified persons to perform tests

This technology requires the testing of vehicle emissions for monitoring and controlling emissions; this testing will need to be carried out by technicians certified to perform the tests. The Customs and Excise Department, DOT and the municipalities, currently do not have persons with these qualifications employed. DOT and municipalities require that their inspectors have experience as mechanics, however this is not always possible as hiring policies are not strictly followed. These departments do not have detailed terms of reference, job descriptions and a system to evaluate their performance and, as a consequence, operate on an ad hoc basis. Furthermore, the need for training is not considered and hence there is no budget to train new recruits.

f. Lack of skilled mechanics in new technology

Vehicle maintenance is essential in ensuring that the vehicles are working at optimal conditions and less emissions are produced. Mechanics can make adjustments to the vehicle in order to reduce emissions. However, they need to know what they are doing and need to update themselves to cope with modern vehicle and equipment technology. In Belize, mechanics do

not receive a formal training; their knowledge comes from experience and trial and error. They may also lack the proper tools since newer vehicles have computers and sensors to troubleshoot and program.

2.2.3. Identified measures

Measures were developed to respond to each prioritised barrier with consideration to the mandates assigned to the respective government agencies and national resources available. These measures were then presented to relevant stakeholders (DOT) for verification.

2.2.3.1. Economic and financial measures

a. Modify the focus of the technology application to licensing of vehicles

The Import Duty scheme will require Belize to enter negotiations and agreement with various countries due to international agreements, the Excise Duty can be modified to allow the introduction of this technology. The scheme for the Excise Duty can be reviewed and increased proportionally to a proposed emission-based tariff.

An alternative is to change the focus on licensing fees: instead of reducing duty fees, the municipalities and DOT could have vehicle licensing fees based on the vehicle emissions. DOT would be the agency responsible to get this initiative to pass. The Enforcement Unit would work on preparing a detailed proposal of the change to licensing fees. This would be presented to the Chief Transport Officer of DOT, who then would present it to the Minister to present before Cabinet for their approval. By linking this technology to licensing fees it will guarantee yearly general inspection of vehicles and especially emission control testing.

b. Provide tariff incentives based on vehicle carbon emissions

DOT could have a tariff schedule for licensing fees based on the amount of carbon emission the vehicle produces. The schedule should reward vehicle owners possessing hybrids, electric vehicles and other vehicles that generate less carbon dioxide emissions per unit of distance travelled. This should be included in the proposal to test emissions as part of the registration and licensing process.

2.2.3.2. Non-financial measures

a. Enforce fuel quality standards

The Private Sector needs to get involved and push GOB to implement already drafted fuel quality standards. The next step will be in getting the BBS equipped and trained in expanding their services to include testing of fuel quality. They are currently working on expanding their services and are planning that in a couple of years to provide fuel testing.

At the moment, samples are sent out of the country when required.

b. Enforce vehicle inspections

The inspection process, conducted by municipalities and DOT, needs to be properly defined and institutionalised by DOT with standard procedures and checklists to ensure transparency and compliance with the law. These records should be audited regularly.

c. Draft and adopt vehicle regulations dealing with carbon emission

DOT would need to draft regulations for vehicles allowed to be registered and licensed under the Motor Vehicle and Road Traffic Act. These regulations would then be presented to the Minister for review and submission to Cabinet for approval.

The proposed Transport Master Plan under final review, suggests an age restriction for buses permitted to operate, this should be considered in these regulations.

d. Acquiring emissions testing equipment

Funds to purchase equipment to test vehicle emissions should be sourced by the DOT and DOE through grants or project funding if it is not available locally.

DOT could provide small municipalities that do not have the financial resources with the service of testing emission or vice versa, the municipalities can provide the service to DOT; thus, having a testing equipment for every district. Whoever does the testing, whether DOT or the municipalities will need to be agreed to by these agencies. Currently a BZ$ 10.00 fee is charged for vehicle inspection, this may need to be reviewed since the cost of the equipment and operation costs need to factor into how much will be charged.

e. Training programme for DOT and municipalities inspectors

DOT and municipalities will need to have standard operating procedures and clear expectation on what is expected from the recruitment process, with proper metrics to verify the effectiveness and efficiency of the process. Detailed job descriptions based on positions and not individuals are needed to ensure that there are no gaps in the process. Entry requirements should include a minimum standard of education so that new recruits are trainable and can ascend to the highest level in government. Adequate job descriptions should be made available for all positions within the department so that the staff can aspire for ascension within the department and there is built-in continuity. Department managers should monitor departmental activities and conduct periodic audits.

Additionally, DOT and municipalities should develop in-house capacity to train their staff, guided by a Training Manual, which will include refresher courses and evaluations of performance. Trainings can include: an inspection check list, customer service, and basic automotive mechanics. Initially, this requires input from an external agency, such as a technical cooperation programme with an international organisation. There may also be a need to revise legislation to give more autonomy to these governmental institutions, thus ensuring they operate in a systematic manner rather than ad hoc.

f. Train local mechanics in new technology

DOT could partner with various organisations like APEB, UB, or ITVET to develop or source training programmes for local mechanics to increase the pool of technicians available to provide the service of maintaining newer technology vehicles.

2.3. Barrier analysis and possible enabling measures for "Reduce carbon emissions and vehicle operating cost by retrofitting existing vehicles with LPG Systems"

Barriers were analysed by conducting a study of the market chain for reducing carbon emissions and vehicle operating cost, by retrofitting existing vehicles with LPG Systems; and learning the system's interactions from different stakeholders (see Figure I-4 in Appendix I). This tool assisted in giving perspective to propose possible enabling measures. The market map and barriers were presented at a workshop with stakeholders to verify and prioritise them. The proposed measures were presented to the proposed implementers for verification.

Table 14 is shows the results of this analysis: the prioritised barriers to be overcome and the proposed measures to ensure the successful implementation of this technology.

Table 14: Reduce carbon emissions and vehicle operating cost by retrofitting existing vehicles with LPG Systems Barriers and Proposed Measures (own elaboration).

Type	Barrier	Proposed Measures
Economic		
Regulatory		
Institutional	Unregulated market Lack of enforcement of LPG standards	Regulate market by establishing regulations for LPG Kits Enforce LPG standards
Resources		
External Factors		
Social	Lack of public awareness of the technology	Have public awareness campaigns of the technology
Capacity	Lack of skilled labour force	Provide training for mechanics on technology

2.3.1. General description of "Reduce carbon emissions and vehicle operating cost by retrofitting existing vehicles with LPG Systems"

LPG is a mixture of butane and propane that have been pressurised to a liquid form. In Belize the composition of these gases is 70-30, i.e. 70% Propane and 30% Butane or it could be 70% Butane and 30% Propane.

Dual-fuel vehicles allow for an internal combustion engine to switch manually or automatically between two separate fuels (in separate storage tanks) at a time (J.E. Sinor Consultants, Inc., 1994 p. 24). This technology suggests that a gasoline vehicle be retrofitted to use LPG as an alternative fuel. Butane kits, currently offered in Belize, allow either manual or electronic switching from one fuel type to the other. The kits include all the necessary components including: tubes, brackets, and storage tank, along with controllers and injectors.

Compared to gasoline and diesel, LPG produces lower emissions of harmful substances. Carbon dioxide emissions are about 11% lower than that of gasoline (Emer, 2017).

LPG has a high-octane rating and low carbon and oil contamination characteristics, putting less pressure on the engine and thus a longer engine life (Plamer, et al., 2013 p. 2). Due to the lower energy density of LPG, its fuel consumption is higher than diesel or gasoline (Energy research Centre of the Netherlands), however, the fuel economy is observed when comparing the overall cost per distance travelled (US Department of Energy, 2017).

In Belize, LPG is legally sold by pounds. According to the July 2017 Consumer Price Index (CPI) Report prepared by the SIB the price, per US gallon (gal), of premium gasoline was BZ$ 11.04, regular gasoline is BZ$ 10.40 and LPG is BZ$ 99.67[2] per 100 pounds (lbs) (SIB, 2017a). The Government of Belize (GOB) does not apply general sales tax (GST) on LPG as a form as subsidy to alleviate poverty, being that the main use for this product is cooking.

The country has LPG fuelling stations (see Figure 3) mostly in the Cayo and Belize Districts, however depending on the adapter installed on the storage tank these can also be filled by most LPG retailers.

2.3.2. Identification of barriers for "Reduce carbon emissions and vehicle operating cost by retrofitting existing vehicles with LPG Systems"

Barriers were identified through stakeholder consultation during the first phase of the TNA and listed on the corresponding factsheet. Additionally, individual experts were interviewed and a legislation review was conducted to identify more barriers. These were presented at a workshop with stakeholders for verification and prioritisation.

2.3.2.1. Non-financial barriers

a. Unregulated market

There are no regulations for LPG kits, currently being sold in the Belizean Market. Some LPG kit suppliers install special filling adapter that limit the fuelling options for users, hence creating monopolies and limiting the number of fuelling stations available to users of this technology. This limitation is a barrier, caused by the effect of an unregulated market.

[2] This price is for every 100 lbs of LPG. The density of LPG depends on the composition of its components and can range from 4.38 to 4.84 lb/gal. The price of LPG per gallon thus ranges from $4.37 to BZ$ 4.82.

This unregulated market condition also does not ensure safety for users of this technology and to the general public. By not regulating the type of tanks, materials and fittings used for this installation, it causes insecurity to the user of this technology. Section 25 of the Dangerous Goods Act (GOB, 2000d) mentions that the Minister may make regulations regarding items such as: fire safety, handling of tanks and safety features on tanks, etc.

Figure 3: LPG fuelling station in San Ignacio, Cayo District [source: http://www.belizebutane.bz/]

Figure 3 shows an LPG fuelling station in the Cayo District.

b. Lack of enforcement of LPG standards

The Belize Bureau of Standards (BBS) is a local statutory body responsible for ensuring the quality and quantity of products sold in the market. They have drafted a standard that determines the quality for LPG sold in Belize. The BBS currently requests quality certificates upon importation of LPG as a form of verification procedure. Unfortunately, they do not have equipment to verify the composition of the product. Product testing at each depot and for every importation becomes too costly when samples need to be sent abroad for verification.

In addition, legally, the product is priced in pounds, and LPG retailers sell to retrofitted vehicles in gallons. The draft standard suggests methods for determining the density of the product and require that the retailer provide such information in order to give a price in pounds. However, this is not the current practice.

The BBS will also need to be able to prove LPG fuelling meters to ensure that consumers get the correct volume. Currently, BBS offers the service of proving fuel meters countrywide.

c. Lack of public awareness of the technology

The public in general is not aware of the savings they would have if they invest in this type of technology. Nor do they have access to this type of information.

The public is also concerned of the potential dangers this technology may pose. They believe that this technology is unsafe simply because they are not aware of the science behind the technology.

d. Lack of skilled labour force

Many mechanics in Belize do not have the knowledge and experience to install this type of equipment to ensure proper operations. They do not have a formal education, relying mostly on trial and error and their intuition on how engines work.

2.3.3. Identified measures

Measures to overcome each prioritised barrier were developed based on the mandates assigned to the respective governmental agencies and the national resources available. These measures were then presented to the relevant stakeholders (governmental agencies) for verification.

2.3.3.1. Non-financial measures

a. Regulate market by establishing regulations for LPG Kits

Standards for LPG kits will need to be drafted by the BBS to include specifications for the type of connections that will be permitted for fuelling and minimal standards for safety. Legislation, such as the Motor Vehicles and Road Traffic Act, will need to be amended to include regulations for vehicles modified for this technology.

DOT's Enforcement Unit would need to develop regulations for LPG kits, for this they will need to become familiar with this technology by researching it, it is proposed that they use the TNA Report as a guide for this purpose. The proposed regulations will need to be presented to the Chief Transport Officer (CTO), who will then present it to the Department's Minister for review and presentation to Cabinet for approval.

b. Enforce LPG standards

An increase in the demand for LPG retrofitted vehicles, will in turn justify the investment by BBS in appropriate testing equipment to test the composition of the LPG and for meter proving. They would then be able to verify the quality of the LPG and perform volumetric testing in the country, ensuring compliance with LPG standards. However, the BBS will also need to provide training and certification for LPG depots to determine the density of the LPG as it could vary with each new batch.

c. Have public awareness campaigns of the technology

The DOT should implement awareness campaigns focused on: the emission reduction objective; safety; and applicability of the technology. For the public to buy into the technology, they need to appreciate the benefits this technology can bring to them, in the form of savings, for example. The advantages of the technology are: this alternative fuel is much safer than gasoline, and its installation provides a dual fuel system. DOT should present the characteristics of the technology: what type of vehicles it is most appropriate for; the different options available on the Belizean market; and what results they should be looking for when they modify their vehicles. In addition, the public must know what measures GOB is putting in place to continue ensuring their safety.

Public Awareness would be done through talk show appearances, creating partnerships with other departments like DOE. NGOs and companies with similar objectives could be solicited for sponsorship and dissemination. Press releases through the Government of Belize Press Office and newspapers, the dissemination of fliers and brochures could be used to promote awareness. However, DOT will also need to evaluate the effectiveness of its awareness campaign.

d. Provide training for mechanics on technology

The DOT could get ITVET to offer in their training for mechanics or create a special course for mechanics to learn how the technology works. The training should include how to do proper installations and provide maintenance to the equipment, as well as troubleshooting. The course could include an installation and maintenance manual. Due to limited funds available for DOT, funding will need to be provided from external sources.

If a special course is offered a promotion campaign will need to be done to motivate mechanics to want to take the course.

2.4. Linkages of the barriers identified

Table 15 shows a matrix of linkages among the technologies in the transport sector identifying common mitigation measures to overcome barriers.

The major barriers identified that were common to both technologies are: cultural barrier, the lack of skilled labour force, the lack of adequate regulations or standards, and the lack of enforcement.

Both technologies require that Belizeans be made aware of these technologies and the benefits they can obtain by investing in them. The main barrier seems to be that people are not aware of the long-term saving but look at their short-term expenses.

The current labour force, both in the public and private sectors, lack necessary skills required to implement these technologies. In some departments of the Public sector, staff are not qualified to perform the tasks they were hired for, nor are they job-trained.

The current legislation is missing regulations to facilitate the introduction of these technologies. Standards are only in draft form and are unenforceable since the relevant authorities do not have the equipment to conduct tests.

Table 15: Common Measures in the Transport Sector Technologies (own elaboration).

Reduce carbon emissions and vehicle operating cost by retrofitting existing vehicles with LPG Systems / **Production of performance based (CO_2 emission) import duties on motor vehicles [VED – Vehicle Emission Duty]**	Regulate market by establishing regulations for LPG Kits	Enforce LPG standards	Have public awareness campaigns on technology	Provide training for mechanics on technology
Modify the focus of the technology application to licensing of vehicles				
Provide tariff incentives based on vehicle carbon emissions				
Enforce fuel quality standards	X	X		
Enforce vehicle inspections				
Draft and adopt vehicle regulations dealing with carbon emission	X			
Acquiring emissions testing equipment				
Training programme for DOT inspectors				X
Train local mechanics in new technology				X

2.5. Enabling framework for overcoming the barriers in Transport Sector

The Department of Transport in partnership with municipalities, and in collaboration with the National Climate Change Office, needs to plan educational campaigns to change the culture with respect to transport technologies that mitigate climate change and promote sustainable development.

To ensure the success of the diffusion of these technologies, employers, both in the public and private sectors, need to invest in their human resources, empowering them with know-how and know-why for sustainability.

The Department of Transport will need to do legal review of legislation and regulations for the transport sector, which are key for these technologies, to determine existing gaps that need strengthening. The GOB must also take into consideration that Enforcement Units need to be properly equipped and funded with adequate equipment and training to enforce regulations and standards. The GOB needs to strengthen DOT: restoring former powers entrusted in DOT so that they can operate with more autonomy and according to standard operating procedures. By extension the GOB should foster other ministries to operate in a similar systematic manner.

DOT and the municipalities will need to setup standard procedures for the processes involving their operations. These procedures need to include verification mechanisms such as audits to make sure that the procedures are being followed.

Performance-based motor vehicles will require registration schemes to be modified to change human behaviour in favour of this technology.

LPG retrofitting technology should include safety enforcement, capacity building, and bringing awareness of the laws to the police and transport officers, so that proper inspections of vehicles to determine road worthiness can be carried out with the use of checklists, when vehicles circulating on public roads are stopped at checkpoints.

The LPG retrofitting market needs standards and regulations in order to ensure safety and ensure free market conditions. In doing so, many barriers like the limited LPG stations, limited access to spare parts will become less important.

Chapter 3. Land Use, Land Use Change and Forestry Sector

Belize is the Central American and Caribbean country with the highest relative forest cover (Cherrington, et al., 2010). In 2014, the Food and Agriculture Organization (FAO) of the United Nations reported that 60.1% of the national land was under forest cover, 7% for agriculture (this includes arable land, permanent crops and permanent pasture) and 32.9% for other land use purposes, such as roads, built-on areas, etc. (FAO, 2017)

In a study conducted by Cherrington et al. (2010) to determine the deforestation rate in Belize for the period 1980 to 2010 using satellite imagery, it was found that Belize had lost 725,173 acres of forest, with a forest-cover loss averaging about 24,835 acres per year. That is, a loss of 17.4% of the forest cover at a deforestation rate of 0.6% per annum.

Cherrington et al. (2010) also reported that in 2010, 36% of Belize's land was categorized under some form of protected areas. The research found that these protected areas were effective in protecting the forests. The report indicated that in the 30-year scope considered in the study, only 6.4% of forest within protected areas were deforested.

Figure 4: Deforestation at the Vaca Forest Reserve. [Posted on March 2017 on Facebook by FCD]

The Protected Areas Conservation Trust Act, defines protected areas as areas protected under the National Protected Areas System Act, the Forests Act, or the Fisheries Act (GOB, 2015a).

Today, Belize's forests are being deforested to allow for urban expansions; the clearing of private lands for agriculture, housing sub-divisions and resorts; and by illegal logging and looting in the forests. Unfortunately, the extent of these damages is not fully quantified by the local authorities. The Vaca Forest Reserve (VFR) along with the Chiquibul National Park and Bladen Nature Reserve have an added effort to their conservation, due to their proximity to the Belize-Guatemala border, where there have been many incidents of intrusion by Guatemalans (National Climate Change Office, 2017). Figure 4 shows an area of the deforestation in the VFR.

In 2015 the estimated yearly carbon dioxide emissions for this sector were 3,300 Gg of CO_2. GOB has set a goal to reduce these emissions to 410.5 Gg of CO_2 by 2030 (GOB, 2016). The government hopes to achieve this target by reducing deforestation, managing forests in a sustainable manner, and increasing the climate change resilience of communities.

Thus, success of silviculture and management of forests becomes key aspects in addressing Belize's resilience to climate change and carbon emission reduction.

3.1. Key Stakeholders for Land Use, Land Use Change and Agroforestry Sector

The Forest Department (FD) is the government entity responsible for managing Belize's forests as is mandated in the Forest Act (GOB, 2000e). Currently they are working closely with Friends for Vaca which is a group formed by the farmers in the VFR. These farmers have diversified their activities: some in animal husbandry and others in vegetable production.

The Agriculture Department, through extension officers, works closely with farmers, providing technical assistance in agricultural techniques. They facilitate the transfer of technology to farmers and promote best agricultural practices. The Department also provides linkage with farmers to potential markets, as well as to other agencies like Cooperatives Department, Pesticide Control Board, and Belize Agricultural Health Authority.

Protected Areas Conservation Trust (PACT) is a statutory body that acts as the national environmental trust fund. As stated in the PACT Act, its functions are "... to encourage, promote, and assist the undertaking by suitable persons and bodies of any research, studies or other activities relating to the nationwide effort to establish, operate, maintain and enhance protected areas, and other natural and cultural protected resources for the purposes of conservation, maintenance of biodiversity, protection of ecological processes and for recreational enjoyment" (GOB, 2000f)

Revenues for the fund are mostly collected from a conservation fee charged to non-Belizeans when they are departing Belize, the fee is BZ$ 40; and 20% of all concession fees, recreation-related licence fees, cruise ship passenger fees, and permit fees collected in conjunction with the public protected areas. (GOB, 2000f)

The German Government is providing funding for the conservation of the Selva Maya, which covers areas of Belize, Guatemala, and Mexico. The first phase focused on "Protection and Sustainable use of the Selva Maya", the second phase on "Support for the monitoring of biodiversity and climate change in the Selva Maya" and the third and last phase is "The Programme for the protection of natural resources in the Selva Maya". The second phase is being led by Selva Maya, an NGO, in conjunction with the German Cooperation for Sustainable Development Agency (GIZ) in building the capacity of relevant stakeholders such as farmers in the VFR. The third phase will be targeting improvements to infrastructure including roads and control points.

GOB has obtained funding through the World Bank and Global Environmental Facility (GEF) for the Management and Protection of Key Biodiversity Areas (KBA) Project. Through this project a five-year Management Plan for the VFR has been developed and is currently being implemented.

3.2. Preliminary targets for technology transfer and diffusion

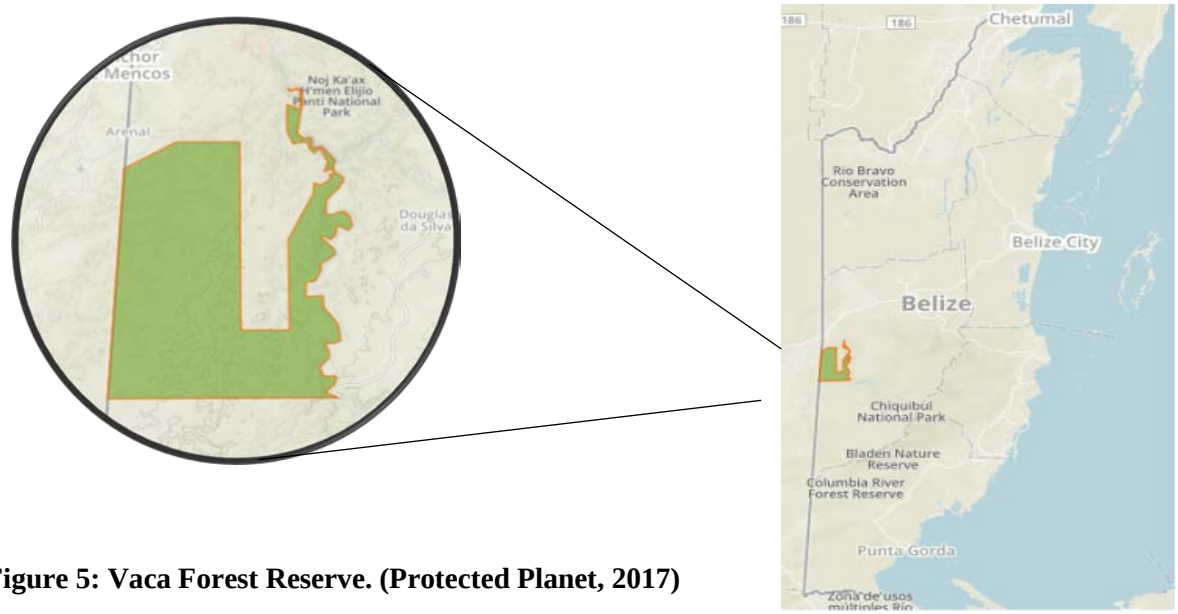

Figure 5: Vaca Forest Reserve. (Protected Planet, 2017)

The technology in Integrated Landscape Forest Management targets forest reserves that have been degraded due to agricultural activities, an example of such area is the VFR (shown in figure 5) for which the Forest Department is the main implementer for this technology as it is within its mandates according to the Forest Act. The FD must enlist the assistance of the Agriculture Department to provide technical guidance to farmers in these situations and assist in the achievement of the relevant components for this technology, namely: (National Climate Change Office, 2017)

- Activate a Landscape Management Strategy that recommends a set of mitigation, restoration, and production activities at the farm and landscape level that can benefit farmers and help maintain the natural environment and restore degraded areas.
- Establish nurseries for native and fast-growing timber species and develop and implement a comprehensive reforestation programme and silviculture system.
- Promote Integrated Farming Systems that are in alignment with the recommendations of the Technical Assessment Report of the Maya Mountain Massif that calls for the promotion of sustainable income generating activities such as apiculture, cacao, and

xaté production among others. Implement the FCD (Friends for Conservation and Development) Agro-ecology Practical Guide.

- Develop a five-year Agro-business and Marketing Plan with farmers and businesses in the communities, encouraging farmers to implement business marketing products.

3.3. Barrier analysis and possible enabling measures for Integrated Landscape Forest Management

During a series of small group meetings with stakeholders in the forestry sector, namely the Forest Department, Agriculture Department, local NGOs and other relevant stakeholders; barriers for the successful diffusion of integrated forest management and silviculture technology were discussed, and prioritised. Experts in the forestry sector were interviewed and a review of legislation was conducted to get a deeper understanding of the sector. A problem tree was developed from these sessions (see figure I-6 in Annex I), where the root causes for the degradation of forest reserves are presented.

Table 16: Integrated Landscape Forest Management Barriers and Proposed Measures (own elaboration).

Type	Barrier	Proposed Measures
Economic		
Regulatory	Weak legislations	Review and amend legislation
Institutional	Weak institution Difficulty with marketing of farm products Lack of road infrastructure	Strengthen the Forest Department; Form cooperatives or associations to market goods
Resources	Technical expertise in agriculture is lacking	Partner with national university to provide technical expertise
External Factors	Limited access to funding	Ensure access to funding
Social	Lack of awareness about protected areas and forest reserves	Develop and implement education and awareness programme on the needs and benefits of forest reserves and protected areas
Capacity	Challenges in changing farming practices	Change farming culture

A Solution Tree for the restoration of forest reserves (see figure I-7 in Annex I), was done to identify measures required to attain the proposed objective based on the Problem Tree. These proposed measures were presented to the relevant stakeholders responsible for implementation to confirm their applicability. A literature review of ongoing projects was also conducted to incorporate measures already being implemented.

Table 16 shows the prioritised barriers to be overcome and the proposed measures to ensure the successful implementation of this technology.

3.3.1. General description of Integrated Landscape Forest Management

The proposed forestry technology suggests the implementation of a Landscape Management Strategy involving farmers who are operating within a forest reserve or in the buffer zone. The technology will be focusing efforts on already impacted areas of a forest reserve. The strategy will include: a reforestation programme with native and fast-growing timber and silviculture system; an integrated farming system to generate income for the farmers in a sustainable manner; and assisting the farmers in developing business and marketing plans for their produce.

3.3.2. Identification of barriers for Integrated Landscape Forest Management

The first phase of the TNA revealed barriers that were mentioned during stakeholder meetings. These and other barriers were identified and categorised into procurement and long-term sustainability barriers, then presented to the stakeholders in various Focus Groups for their validation (See Barriers identified for land use, land use change and forestry sector in Annex1).

A meeting was also held with an FCD representative for the purpose of learning more of the challenges faced in the VFR. Conversations were held with key experts to learn more about the Forest Department and the legislation that governs them. A legal review of the Forest Act (2000) and the National Protected Areas Systems Act (2015) was conducted to get a better understanding of the situation. A problem tree was developed to determine root causes for deforestation of forest reserves (see Figure I-6), that were translated into barriers for the implementation of the technology. Additional barriers faced by the farmers in the implementation of the Integrated Landscape Forest Management are included based on Focus Group discussions.

3.3.2.1. Economic and financial barriers

a. Limited access to funding

The Forest Department requires more staff and resources to adequately manage forest reserves, because of the large expanse of areas that are difficult to access. To implement this technology the FD will have to have continuous presence and incur operational costs for the application of fertilizers, insecticides, and irrigation equipment that will have to be made available. Farmers will need training in farming techniques best suited to the conservation of forests, for their business development and for the marketing of their products. With these new expenses the FD will require access to more funds.

The limited access to funding was identified as a major barrier since a very similar project in the VFR area failed due to shortage of funding. The forest reserves will be competing with other projects for funding, thus a good proposal will be needed to secure funds for the duration

of the project. The FD receives its financing from national budget allocation approved annually by the legislature, but its Capital III expenditure require funding from other sources that need to be identified continuously.

3.3.2.2. Non-financial barriers

a. Weak legislations

The Forest Act (2000) does not have provision to stimulate or encourage reforestation, nor does it consider Climate Change. Unfortunately, the law is geared towards short-term forest management where the status of protected areas can be revisited every five years. This is in line with the frequency with which the government should call elections, making it tempting to de-reserve land in order to gain favour with voters. The Act also gives the relevant Minister the final decision to act. (GOB, 2000e)

The Forest Act also prohibits any type of agricultural activity in forest reserves. This will pose a legal challenge for farmers, however, if the Act is amended to encourage these activities, it will pose a greater threat to forest reserves, endangering these natural habitats.

b. Weak institution

The FD lacks funding and resources to sustainably manage forest reserves. The Forest Act places the FD as responsible for the management of the forest reserves (like the VFR), but makes no provision for co-management (GOB, 2000e). They have institutional deficiencies, like shortage of staff, standard operating procedures, limited budget, among others that make it difficult for FD to manage these reserves on its own. However, the FD has developed a management plan for the Vaca Forest Reserve where they zone-off the reserve and engage stakeholders to co-manage. This is a barrier because the amended National Protected Area Systems Act does contemplate co-management for national protected areas, relieving some of responsibility from the Department that lack the resources to oversee vast areas of land throughout the country (GOB, 2015b).

c. Difficulty with marketing of farm products

The local farmer is challenged by various barriers to sell his produce: produce is perishable, prices vary according to demand and supply, which are sometimes affected by contraband, there is no culture for organic products in the local market, the middle man controls the prices, and price fixing is a common practice in the market place. These are relevant barrier since the farmers need to generate income to ensure sustainability. These barriers economically cripple farmers by reducing their income and viability.

d. Lack of road infrastructure

A successful farmer needs good road infrastructure to take his produce to market without damaging its quality/appearance. The lack of road infrastructure also impedes the forest rangers to monitor the area.

On the other hand, providing a road in a forest reserve invites human activity that could be counterproductive for the conservation of the forest. The FD has stated their views that they do not wish to improve road infrastructure because it will invite farmers and other groups to enter the forest. Ultimately, the FD is the entity responsible for management of this reserve and the Forest Act does not make allowances for any type of agricultural activity.

However, the VFR Management Plan includes improvements to infrastructure, which includes roads and control points.

e. Technical expertise in agriculture is lacking

The technology proposes a diversification of produce to ensure sustainability for farmers who will need to be trained in various agricultural techniques. The FD does not have the technical expertise to train farmers on agricultural best practices to ensure that agricultural activities do not further degrade the forest ecosystem. This will require cooperation from various governmental and non-governmental organisations, some of which are already work closely with farmers.

f. Challenges in changing farming practices

Farmers have traditional methods of farming like slash-and-burn practice to do land clearing, and the use of chemicals (pesticides and fertilizers) that contaminate water bodies and are not selective of pests. A behavioural change needs to take place to ensure that they do not revert to old practices when the monitoring phase ends. Farmers in these areas typically have education limitations which must be considered by the agricultural extension officer who will train them.

3.3.3. Identified measures

Measures to overcome each prioritised barrier were developed based on the mandates assigned to the respective governmental agencies and the national resources available. These measures were then presented to the relevant stakeholders (Forest Department, Selva Maya) for verification.

3.3.3.1. Economic and financial measures

a. Ensure access to funding

A proposal could be submitted to PACT requesting that a percentage of its revenues be given to help finance FD’s operations. The FD will need to prepare a Management Plan for the department detailing how the funds will be used to manage forest reserves. The Management Plan developed for the VFR (2017), could be used as a guide to develop a Management Plan for the FD. PACT, as the funding agency, would then monitor the spending of the FD to ensure that the funds are properly managed.

The FD should also have personnel experienced in business administration to help with the management of the department.

3.3.3.2. Non-financial measures

a. Amend legislation

The Forest Act should be amended to include reforestation. The Forest Act and National Protected Areas Systems Act should also be aligned with the Horizon 2030 vision, the Growth and Sustainable Development Strategy (GSDS) and other policy documents. In other words, the law should be based on long-term planning and based on a development plan that includes the effects of climate change for the area. The Enforcement Unit will be hiring a legal consultant to do this law revision in 2018.

b. Strengthen the FD

The FD needs to be strengthened to take full responsibility of the forest reserves as is mandated in the Forest Act. Foresters will need to receive appropriate training in forest management, leadership, coordination, and project execution. The department will also need to revise its budget to make provision for enforcement and public awareness campaigns.

The Management Plan for the VFR could be used as a guide to develop management plans for the FD.

c. Form cooperatives or associations to market goods

If the farmers, with the support of the Agriculture Department, get together to form cooperatives or associations to market their products, it will reduce their marketing costs, improve their profit margins, and connect farmers with the Department of Cooperatives. Forming associations will give them leverage when seeking assistance from BELTRAIDE (Belize Trade and Investment Development Service) to export their products. Membership with the Belize Chamber of Commerce and Industry (BCCI) can also open doors to the regional or international markets for these farmers.

The GIZ-Selva Maya Project is currently promoting farmers cooperatives in the VFR.

d. Partner with national university to provide technical expertise

Under the guidance of FD and the Agriculture Department, University of Belize (UB) students could assist the GOB in providing training on agriculture related topics, as well as business and marketing. Internships with international students could also be offered during the months when UB is closed. UB students can assist in training farmers on specific topics related to their needs and based on UB's academic course syllabus. This in turn will give UB relevance to Belize's development, and relieve government agencies from responsibilities and spreading themselves too thin.

The programme will need to be developed in collaboration with UB so that they can plan their course work to include these activities. Consideration for UB's semesters will also need to be synchronised.

e. Change farming culture

Selva Maya has found that farmers are embracing eco-agricultural farming techniques more readily when they are presented with tangible demonstrations of results. Therefore, when training is provided to farmers it should be focused on field work (a hands-on approach).

They have also found that when farmers share their experiences with other farmers on achievements and difficulties with eco-agricultural practices, a bond is created among them and they help each other to provide an ecological solution. Farmers need to feel that they are not alone and that others are facing the same challenges, and that they have partners to provide them with support. This support can also be provided through a cooperative. In cases where a communication protocol is established, farmers can seek support from other farmers.

3.4. Enabling framework for overcoming the barriers in the Forestry Sector

The Forest Department needs to be committed to play a leadership role in the management of forest reserves. Stakeholders could be engaged to assist in the co-management of forest reserves, however, forest officers will still need to be trained or receive refresher courses in forestry management, leadership, coordination, and project management skills.

The FD could access funds from PACT through the implementation of a Management Plan for the department to justify the use of the funds. PACT would oversee of the management these funds.

The FD will need to coordinate and manage activities with stakeholders, such as: the farmers, the Department of Agriculture, and other stakeholders for the co-management of forest reserves through the implementation of the landscape management strategy.

A legal review will need to be done on all legislation pertaining to the jurisdiction of the FD, the review should make provision for long-term sustainability.

Farmers are encouraged to form cooperatives to give them more opportunities in getting their product to market and to provide support among members. Partnerships with the University of Belize can provide technology transfer on agriculture related topics, as well as business and marketing as part of the university's outreach initiatives.

Chapter 4. Conclusions

The implementation of these technologies will contribute to increase Belize's resilience to climate change. Governmental agencies mentioned throughout this document, like Ministry of Energy, Public Utilities Commission, Forest Department, Agriculture Department and the Department of Transport, need to coordinate their efforts in the work to achieve the smooth transfer and diffusion of these technologies. These government departments and partners in the private sector need to complement one another in a joint effort and common objective to bring about the success of each project. GOB needs to use its influence, and limited and capable human resources synergistically wherever they are available.

The Energy and Transport Sectors should conduct an assessment of the proposed technologies, focusing on determining the cost savings incurred with the adoption of these proposed technologies. The social benefit of these technologies should also be taken into account when conducting this study. The results should then be communicated to all levels of the Belizean Society to encourage the diffusion and adoption of these technologies.

The Off-grid Solar PV system appears to be a feasible solution for power generation for rural communities. The barriers found in Belize for this technology slow down its implementation, however, Santa Teresa – a village in rural Toledo District, isolated from the national grid, with a poor population of subsistence farmers – has proven that this technology can be achieved and can impact immensely the lives of residents of isolated and inaccessible rural communities. The Ministry of Energy should take the suggested measures in this document as a guide to implementing this technology.

Gasification is not feasible when employed in small scale for isolated communities that are not connected to a power distribution network. However, if this technology is installed for a building or buildings, like hospitals or eco-resorts, and feedstock production and supply is assured and sustainable, then this technology may become feasible.

The On-Grid Solar PV system requires that regulations for the selling of electricity to the national grid be put in place to accommodate this technology, along with effective awareness campaigns to encourage businesses and households to buy-into this technology. The measures that are recommended aim to make the technology more attractive for most middle-class Belizeans.

The implementation of performance-based (CO_2 emission) import duties on motor vehicles technology may encounter external barriers –in the form of WTO– that do not allow for importation duties to be modified. However, if adoption is focused on licensing of vehicles, it will yield better results for Belize, as vehicles will be checked continually to ensure low GHGs emissions and not just at the time of importation. The institutional strengthening of DOT will guarantee the success of this technology.

The technology to reduce carbon emissions and vehicle operating costs by retrofitting existing vehicles with LPG Systems, has already been adopted in a noticeable scale by motorists. Nevertheless, there are still some barriers that need to be overcome to make the technology more widespread. Awareness campaigns focused on safety and market regulations become important measures for the diffusion of this technology.

Both technologies in the Transport Sector will also be dependent on other actions taken by the government, otherwise these technologies will not realise their full potential. Settlements in Belize tend to follow the four main highways; and the Government, to ensure the safety of pedestrians, have placed at least two speed bumps at every village and school. This causes an increase in fuel usage, and therefore increased GHGs emissions, which negates the potential benefits of these technologies and impacting on the productivity of the country.

Integrated Landscape Forest Management technology is doable; however, the Forest Department must be committed to this technology transfer and build its capacity to manage forest reserves efficiently and effectively. This will imply that the government will need to provide financial and strategic support and empowerment to the FD, to allow the department to fulfil its obligations as prescribed in the law. Securing financing will be integral in ensuring the FD's capability to fulfil its mandate. Key modifications need to be made to the legislation to ensure its long-term effectiveness in protecting this vulnerable and vital resource.

The final step of the TNA process is a balanced and practical Technology Action Plan (TAP) that incorporates the findings of previous TNA steps. The TAP will require the active participation, buy-in and ownership of key stakeholders, a clear process for moving forward, and the methodical commitment by a country TAP team, spearheaded by the NCCO and its Director. In this connection, a well-defined roadmap should enable the team to produce a clearly articulated strategic plan and specific, convincing request for financial and technical resources to help promote the uptake, transfer and diffusion of a specific technology, or several of the prioritized technologies identified for productive sectors vulnerable to the impacts of Climate Change.

In short, the TAP serves as the bridge connecting the analysis on prioritised technologies and their implementation. Consequently, the country TAP team should lead the way for the successful outcome of the TNA process in Belize.

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Annex I: Market maps for the Energy Sector and Transport Sector

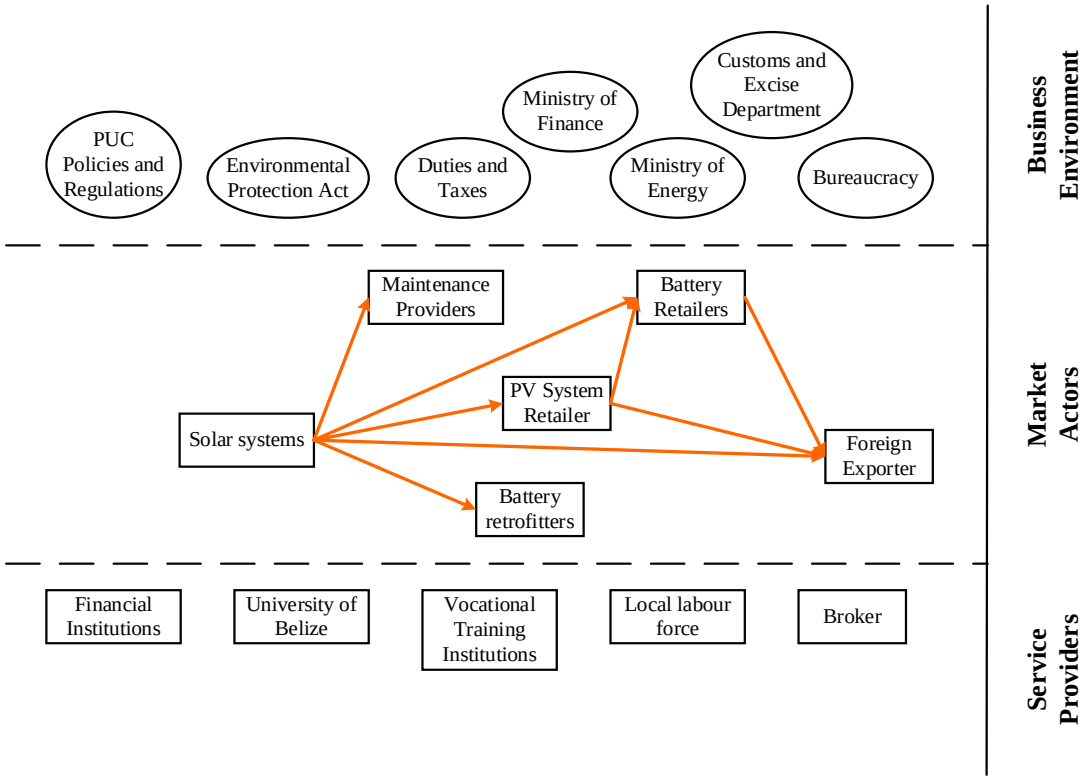

Figure I-1: Market Map for Off-grid Solar PV System.

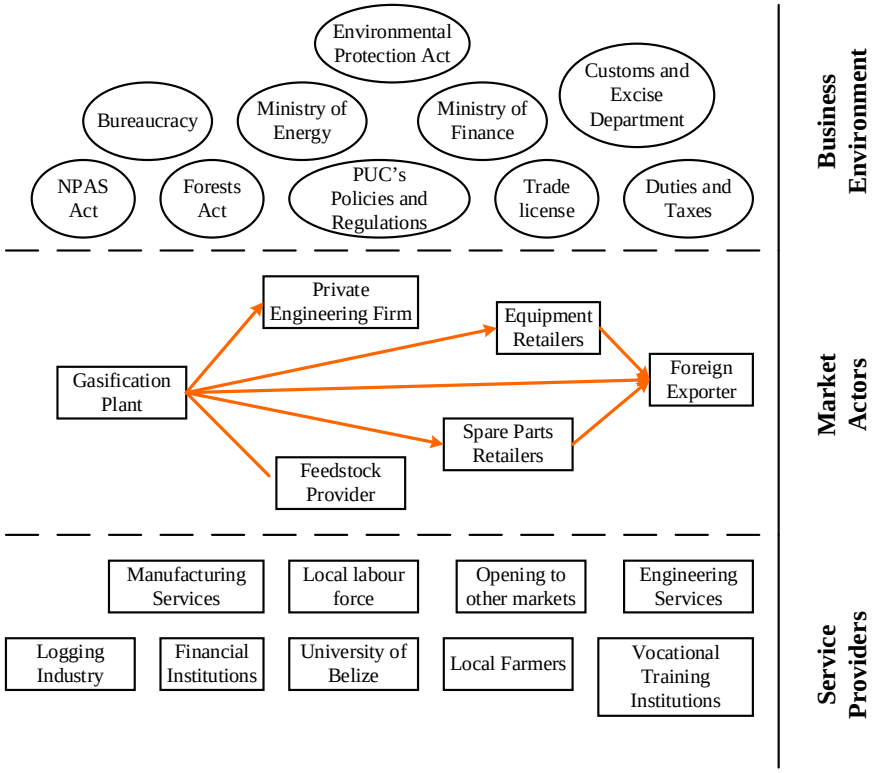

Figure I-2: Market Map for Gasification.

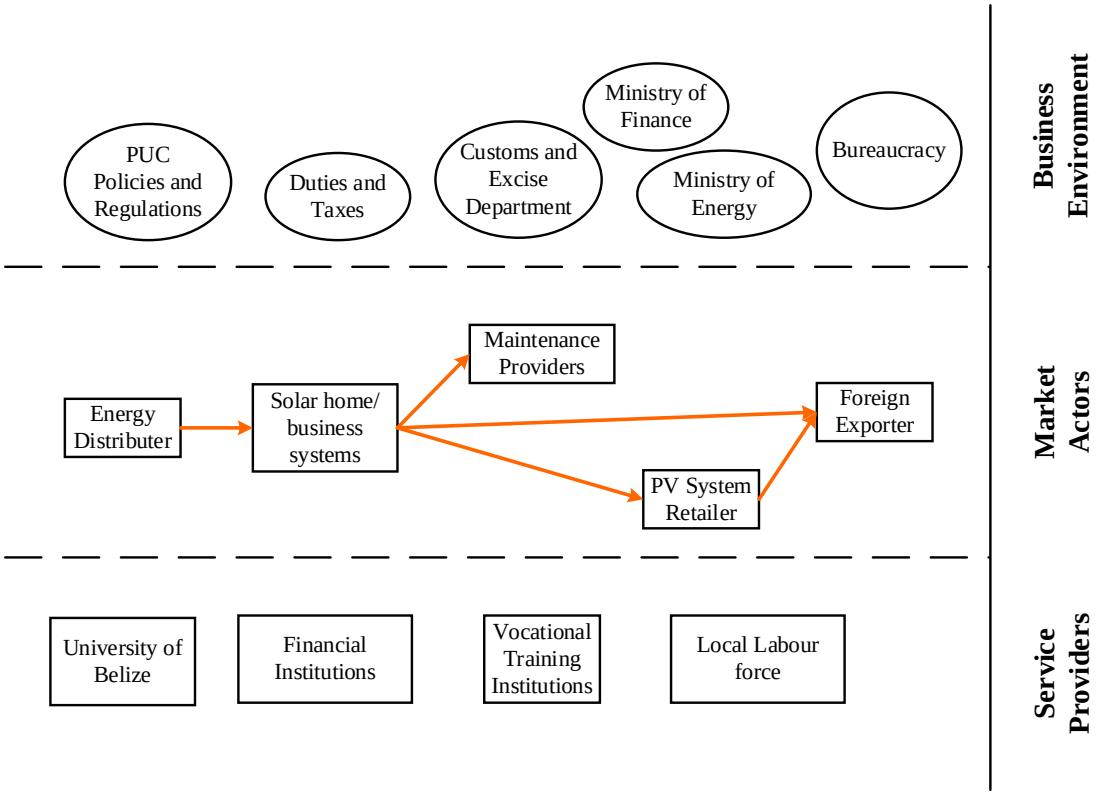

Figure I-3: Market Map for On-grid PV System.

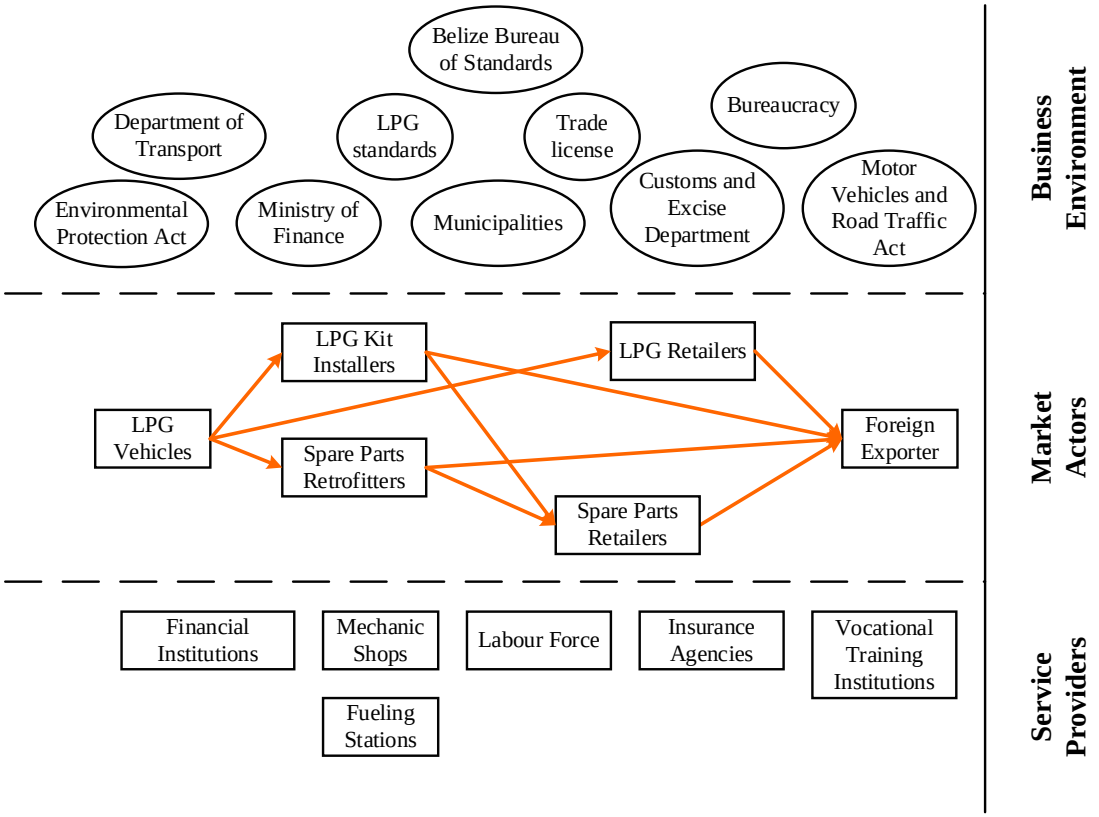

Figure I-4: Reduce carbon emissions and vehicle operating cost with retrofitted Liquefied Petroleum Gas (LPG) Systems.

Annex II: Problem and Solution Tree for Transport Sector and Land Use, Land Use Change and Forestry Sector

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Barriers in identified for Transport Sector

- High initial capital investment required
- Vehicles needs to be purchased from abroad
- Few financial incentives from GOB
- Public's acceptance to invest in technology
- Culture shift to driving fuel efficient vehicles
- Poor road infrastructure
- Too many speed bumps on roads that reduce vehicle fuel efficiency
- Untrained for mechanics for new technologies.
- Lack of access to clean fuel that is required for new technology (diesel with high Sulphur content)
- Political will

Problem and Solution Tree Analysis

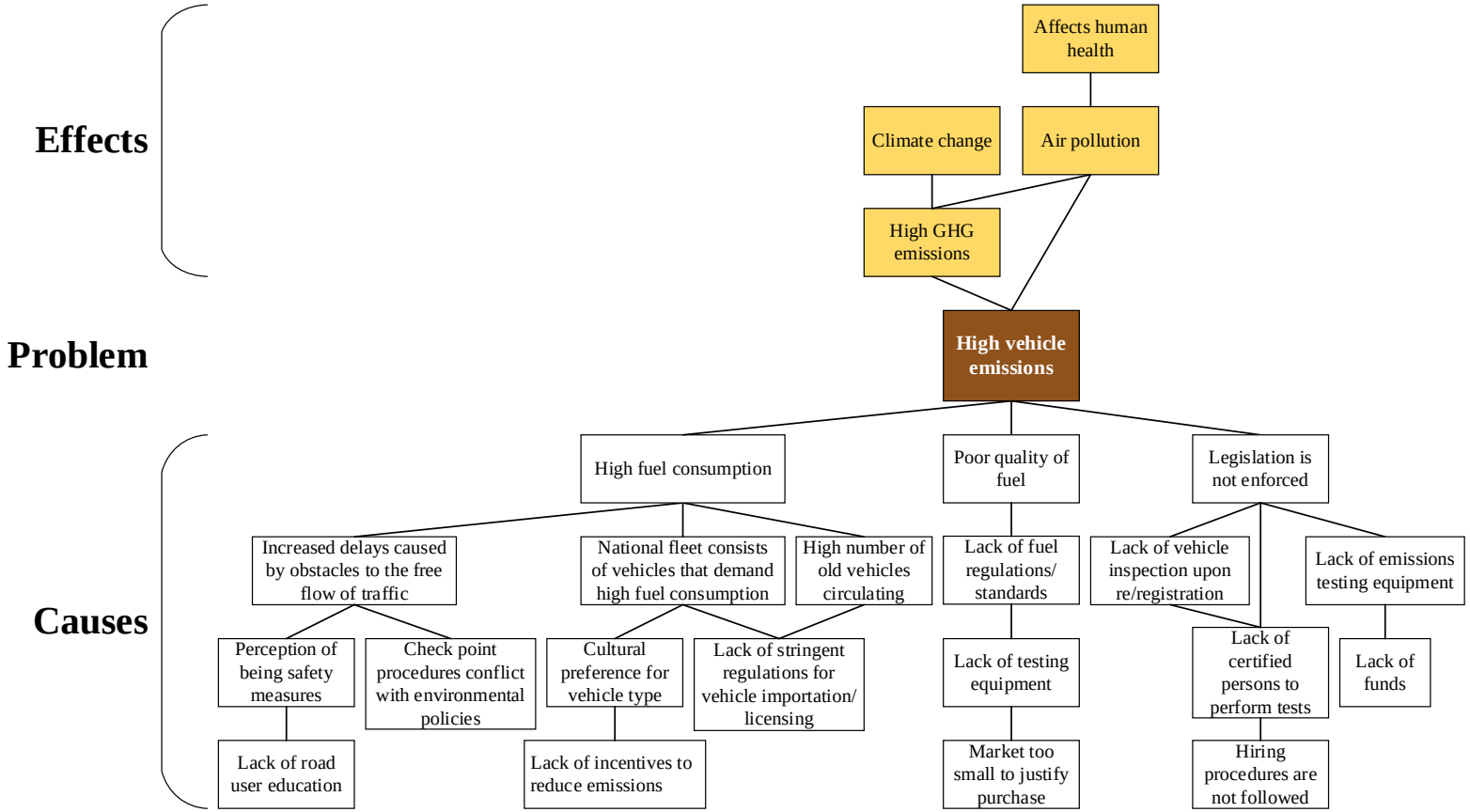

Figure II-5: Problem Tree – High vehicle emissions.

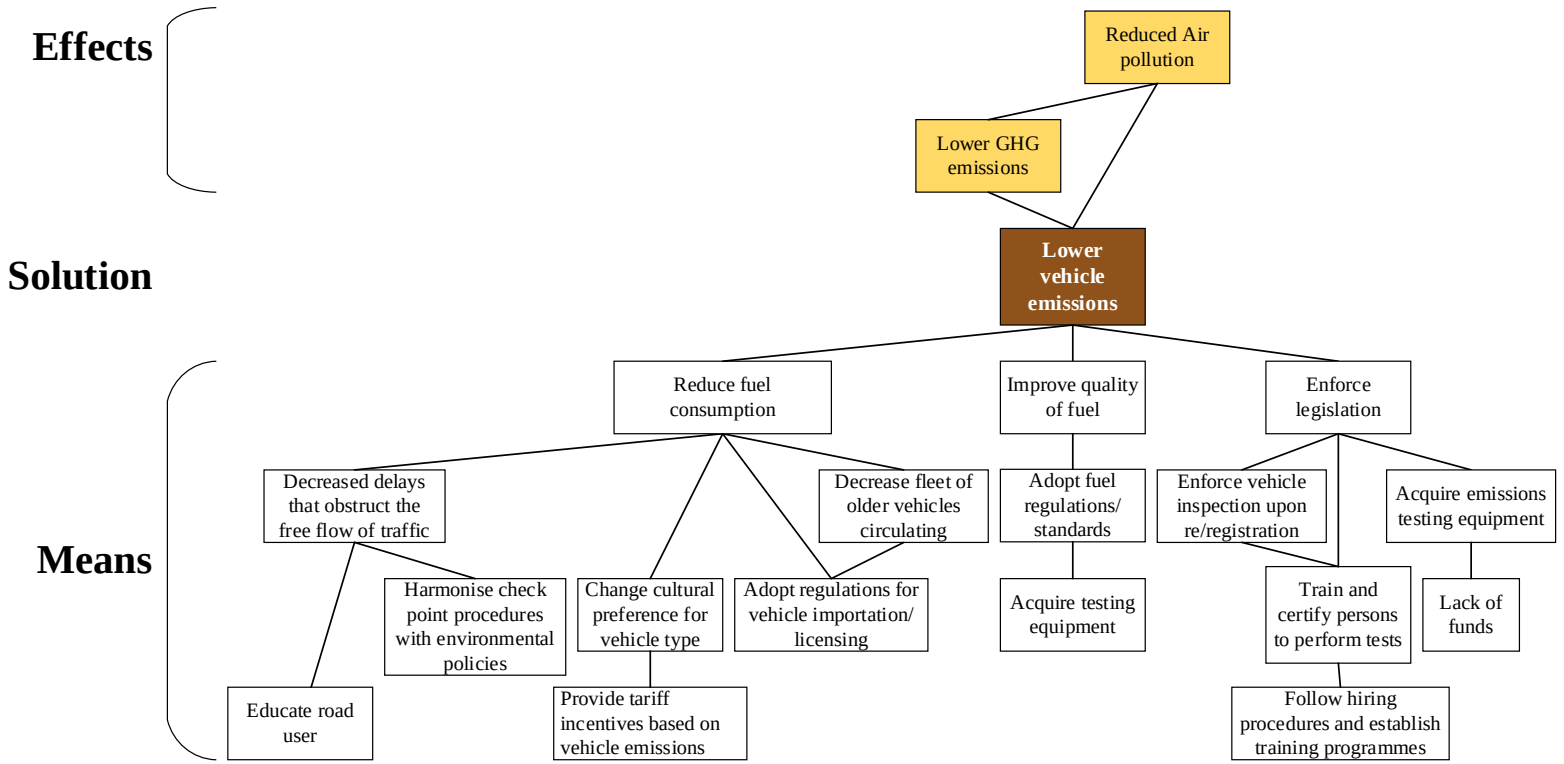

Figure II-6: Solution Tree – Lower vehicle emissions.

Barriers in identified for Land Use, Land use Change, and Forestry Sector

Procurement Barriers

- Access to funding
- Coordination among agencies
- Technical expertise is required
- Capital cost may be too high.
- Lack of institutional capacity of leading NGOs to facilitate most of the proposed programs
- Weak state and stakeholder ties with respect to the management of the VFR
- Weak technical capacity of leading NGO.
- Limited knowledge of climate change and education of most farmers.
- Lack of interest among some farmers to participate.

Long Term sustainability Barriers

- Operational costs
- Misappropriation of funds
- Forest legislation does not have any provision to stimulate or encourage reforestation. Does not consider Climate Change.
- Security of the area
- Weak institutional capacity among some stakeholder agencies
- Extreme weather events and bushfires
- According to a legal review of the Belize Forest Act (FCD, 2010), the Act does not make provision of the co-management of forest reserves.
- However, it calls for buffer community involvement/cooperation to ensure that there is proper use and management of the reserve.
- Difficulty with marketing of farm products.
- Sustainability of the Agro Forestry and Silviculture programmes after project phase out.
- Inaccessibility during rainy season
- Culture clash changing farming procedures

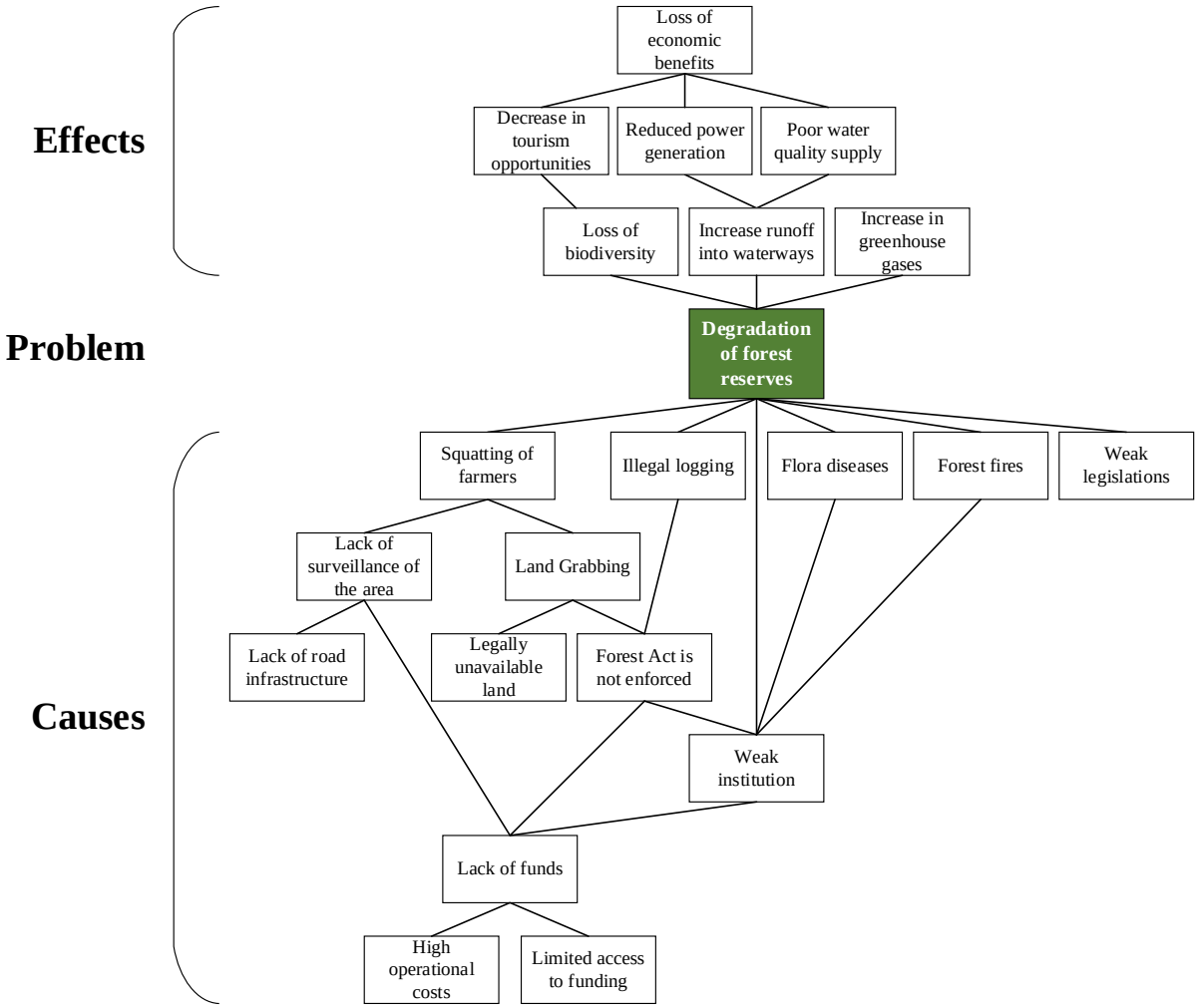

Figure I-7: Problem Tree - Deforestation of forest reserves.

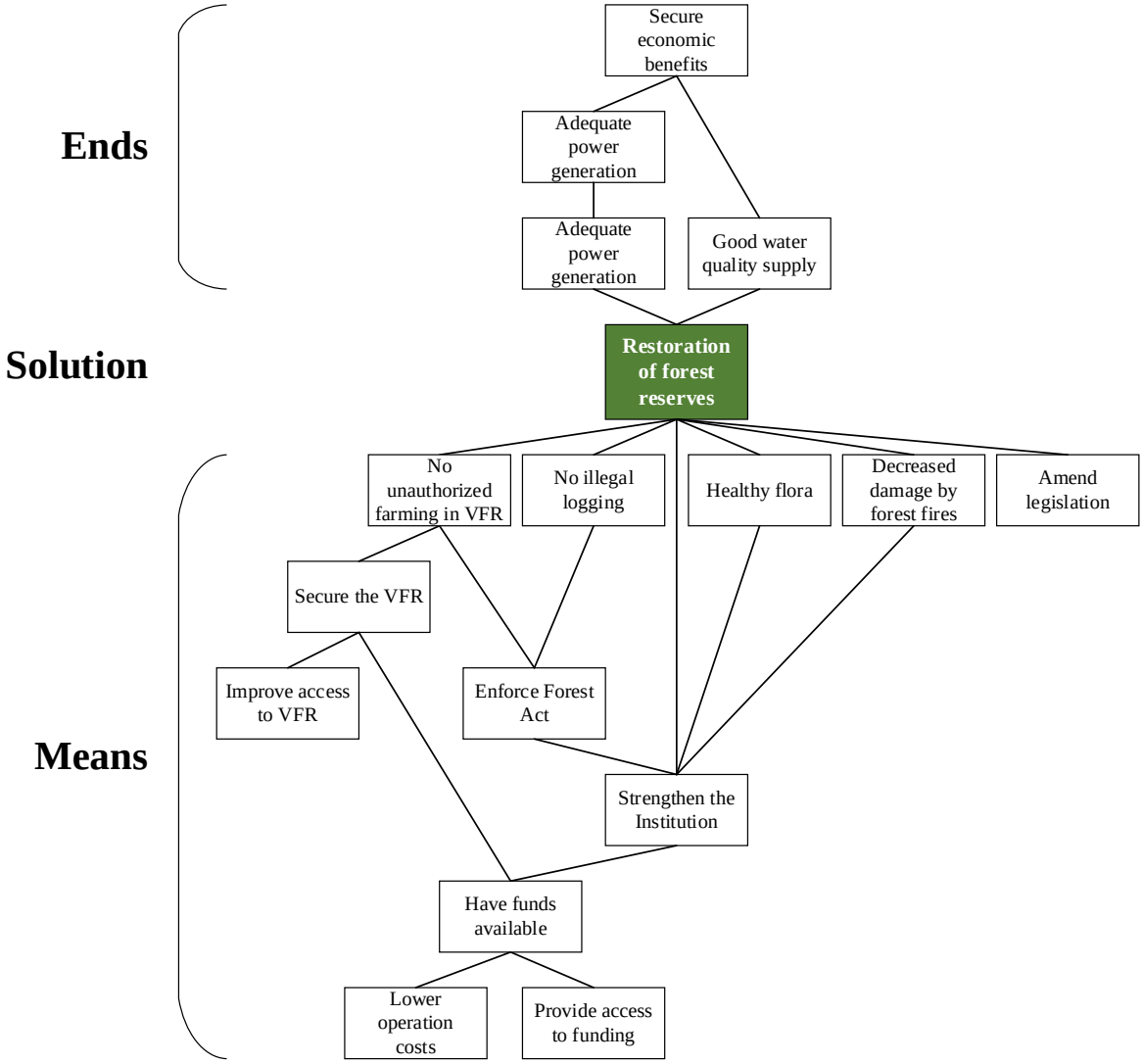

Figure I-8: Solution Tree - Reforestation of forest reserves.

Annex III: List of stakeholders involved and their contacts

Name	Organisation	Approach	Time	Topics
Peter Williams	Department of Transport	Interview	3 hours	Barriers in Ministry of Transport
		Interview	2 hours	Verification of measures for Transport Sector
Claudia Elena	Development Finance Corporation	Work Group	3 hours	Verification and prioritisation of barriers
Vallan Hyde	Department of Transport	Work Group	3 hours	Verification and prioritisation of barriers
Santos Chicas	University of Belize	Work Group	3 hours	Verification and prioritisation of barriers
Eli Mendez	ProSolar Engineering Ltd.	Work Group	3 hours	Verification and prioritisation of barriers
Maria Petkan	ProSolar Engineering Ltd.	Work Group	3 hours	Verification and prioritisation of barriers
Felipe Rivera	Customs and Excise Department	Work Group	3 hours	Verification and prioritisation of barriers
Lloyd Orellano	Belize Bureau of Standards	Work Group	3 hours	Verification and prioritisation of barriers
		Interview	15 minutes	Verification of measures
Gian Hernandez	BELTRAIDE	Work Group	3 hours	Verification and prioritisation of barriers
David Perera	Forest Department	Work Group	3 hours	Verification and prioritisation of barriers
Jorge Nabet	Forest Department	Work Group	3 hours	Verification and prioritisation of barriers
		Work Group	1 hour	Barriers for Integrated Landscape Forest Management
Ramon Frutos	Adaptation Consultant TNA	Work Group	3 hours	Verification and prioritisation of barriers

Name	Organisation	Approach	Time	Topics
Aureliano Bautista	Tomza Gas Ltd.	Work Group	3 hours	Verification and prioritisation of barriers
Jose Sanchez	Tomza Gas Ltd.	Work Group	3 hours	Verification and prioritisation of barriers
Oscar Alonso	Belize Electricity Company Limited	Work Group	1 hour	Barriers for Integrated Landscape Forest Management
Clifford Martinez	Agriculture Department	Work Group	1 hour	Barriers for Integrated Landscape Forest Management
Ryan Cobb	Ministry of Energy	Work Group Interview Interview	3 hours 1 hour 30 mins	Verification and prioritisation of barriers Verification of Measures for Energy Sector
Ester Sanchez	Friends for Conservation and Development	Interview	2 hours	Barriers for Integrated Landscape Forest Management
Rashida Garcia	Forest Department	Phone conversation Meeting	10 minutes 2 hours	Fact check on potential barrier Verification of Measures for Integrated Landscape Forest Management
German Novelo	Forest Department	Meeting	2 hours	Verification of Measures for Integrated Landscape Forest Management
Victoria Cawich	Forest Department	Meeting	2 hours	Verification of Measures for Integrated Landscape Forest Management
Wilber Sabido	Forest Department	Meeting	2 hours	Verification of Measures for Integrated Landscape Forest Management
Dr. Jennie Garcia-Saqui	Selva Maya	Meeting Interview	2 hours 1hour	Verification of Measures for Integrated Landscape Forest Management Selva Maya Project
Mateus Furtado	Belize Natural Energy Ltd.	Phone conversation	3 hours	Fact check on gasification and LPG retrofitting technology.

Name	Organisation	Approach	Time	Topics
George Hanson	Self employed (Former employee of Forest Department)	Phone conversation	1 hour	Fact check on Forest Legislation
Roberto Sho	Toledo Teacher's Credit Union Ltd.	Phone conversation	15 minutes	Credit unions in Toledo
	LP Gas Supplies	Interview	15 minutes	LPG retrofitting technology
Mark Miller	Plenty – Belize	Phone conversation	15 minutes	Solar programme in Santa Teresa, Toledo
Ernesto Gomez	Belize Electricity Ltd.	Phone conversation	15 minutes	Energy Sector
Mr. Hulse	Department of Environment	Phone conversation	15 minutes	Emissions legislation
Ambrose Tillett	Public Utilities Commission	Interview	2 hours	Energy Sector and Verification of measures
Margaret Ventura	Ministry of Investment Trade and Commerce	Phone conversation	15 minutes	Belize Competition
Mr. Quiroz	Forest Department	Interview	15 minutes	Forestry Legislation
Darrell Audinette	PACT	Phone conversation	10 minutes	FD funding
Julianne Pasos	University of Belize	Phone conversation	10 minutes	Agroforestry