CONSULTANCY SERVICES FOR DEVELOPING A "SOLAR WATER HEATING (SWH) NAMA CONCEPT FOR THE INDUSTRIAL, COMMERCIAL AND RESIDENTIAL SECTORS IN BELIZE"

Santiago, Chile

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Contents

Acronyms

BBS	:	Belize Bureau of Standards
BEL	:	Belize Electricity Limited
BTIA	:	Belize Tourism Industry Association
BWS	:	Belize Water Service
CBA	:	Central Building Authority
CCCCC	:	Caribbean Community Climate Change Centre
CDM	:	Clean Development Mechanism
CPBL	:	Citrus Products of Belize
EE	:	Energy Efficiency
GHG	:	Greenhouse Gas
GIZ	:	Deutsche Gesellschaft für Internationale Zusammenarbeit
IEA	:	International Energy Agency
INDC	:	Intended Nationally Determined Contribution
IPCC	:	Intergovernmental Panel on Climate Change
IPP	:	Independent Power Producers
LBA	:	Local Building Authority
MRV	:	Measurement, Reporting and Verification
NAMA	:	Nationally Appropriate Mitigation Actions
NAVCO	:	National Association of Village Councils
NCCO	:	National Climate Change Office
NDC	:	Nationally Determined Contribution

OLADE	:	Latin American Energy Organization
PBF	:	Programme for Belize
PPA	:	Power Purchase Agreement
PUC	:	Public Utilities Commission
RE	:	Renewable Energy
SIB	:	Statistical Institute of Belize
SIEE	:	Energy-Economic Information System
SWH	:	Solar Water Heating
UNFCCC	:	United Nations Framework Convention on Climate Change

1. Introduction

Nationally Appropriate Mitigation Actions (NAMA) are any actions that aim to reduce GHG emissions in developing countries with the support of the national government and access to technology, financing and capacity-building. In this context, a Solar Water Heating (SWH) NAMA in Belize is proposed.

The SWH NAMA in Belize is a project that aims to implement the solar water heating technology for the industrial, commercial and residential sectors, with the objective of reducing the emission of greenhouse gases from the use of fossil fuels for water heating through the installation and use of solar collectors and storage tanks.

The development of an efficient and effective Solar Water Heating NAMA concept for the industrial, commercial and residential sectors in Belize requires, as a first approximation, the collection of general and strategic information, and the classification and understanding of it. Furthermore, meetings with the key stakeholders of the relevant sectors are highly necessary for a better understanding of the current situation of the several sectors involved in the project in Belize.

The evaluation of institutional stakeholders aims to assess the level of readiness, strength and weakness, and main characteristics of the identified stakeholders, in order to define the specific roles for the NAMA implementation.

The estimation of the impacts of the NAMA consists, first, in the estimation of the GHG emission reductions expected for the implementation of the project, considering several scenarios according to the current situation and using appropriate methodologies to assess these estimations. On the other hand, the implementation of a NAMA brings side effects that may be positive or negative. These impacts must be assessed in order to have a complete vision of the effects of the SWH NAMA.

The barriers analysis has the objective of identifying and analysing the way and the level in which the barriers would affect the implementation of the SWH NAMA. Any situation that may limit the improvement and promotion of solar water heating technologies will be considered as a barrier.

The analysis of the financial and technical support required and estimation of the financial and technological resources needed, allows the identification of the most relevant requirements for the proper development of the SWH NAMA. It also helps with the establishment of the main planning priorities, before and during the SWH NAMA operation.

The development of an MRV framework is also key step for a NAMA since the results of this process enables the country to consistently track the performance of the project. Additionally, the MRV framework would reliably account for the emission reductions and the related effects of the NAMA, along with financial and technical capacities and requirements, in order to ensure transparency for all the involved parties.

Finally, the next steps are identified, showing the required activities in order to achieve the proper implementation of the SWH NAMA.

2. Relevant information for the SWH NAMA

The following is a summary of the relevant information for the SWH NAMA concept, showing important data available in the consulted documents.

2.1. National context

2.1.1. Population

According to the 2010 census, Belize has a population of 322,453 and a density of 14.1 (Pop/km^2). Because of this, Belize has one of the lowest population densities in Central America. Urban population corresponds to 52%, with a 3.1% urbanization rate estimated between 2005 and 2010. Poverty rate in Belize is 41.3%[1].

2.1.2. Economy

Belize has a small economy, based primarily on agriculture, commerce, tourism and construction. Agriculture represents 30% of the GDP and provides 70% of the importations incomes. The most relevant products are bananas and sugar cane. The most developed industries are textile, agri-food, tourism and construction.

According to the Central Bank of Belize, in 2015 the tertiary sector represented 61% of the country's GDP, of which the wholesale and retail trade is the most relevant sub sector[2].

The travel and tourism sector in Belize has grown considerably in the recent years, and it has become an important industry of the nation, with a direct contribution of 495.5 BZDmn in nominal prices in the year 2015 (14% of the GDP) and a total contribution of 1,309.1 BZDmn in nominal prices in the same year (40% of the GDP), including other impacts in the domestic supply chain, capital investment, other related incomes[3].

Belize has high energy dependence because of the percentage of imported energy, which leads to high costs and inadequate energy data; although the energy sector is a main source of government revenue (e.g., fuel taxes, license fees and royalties)[4].

[1] http://www.sib.org.bz/statistics/population

[2] https://www.centralbank.org.bz/rates-statistics/general-statistics

[3] https://www.centralbank.org.bz/rates-statistics/general-statistics
https://www.wttc.org/-/media/files/reports/economic-impact-research/countries-2017/belize2017.pdf

[4] https://www.reeep.org/sites/default/files/Toward%20a%20national%20energy%20policy-%20Assesment%20of%20Belize.pdf

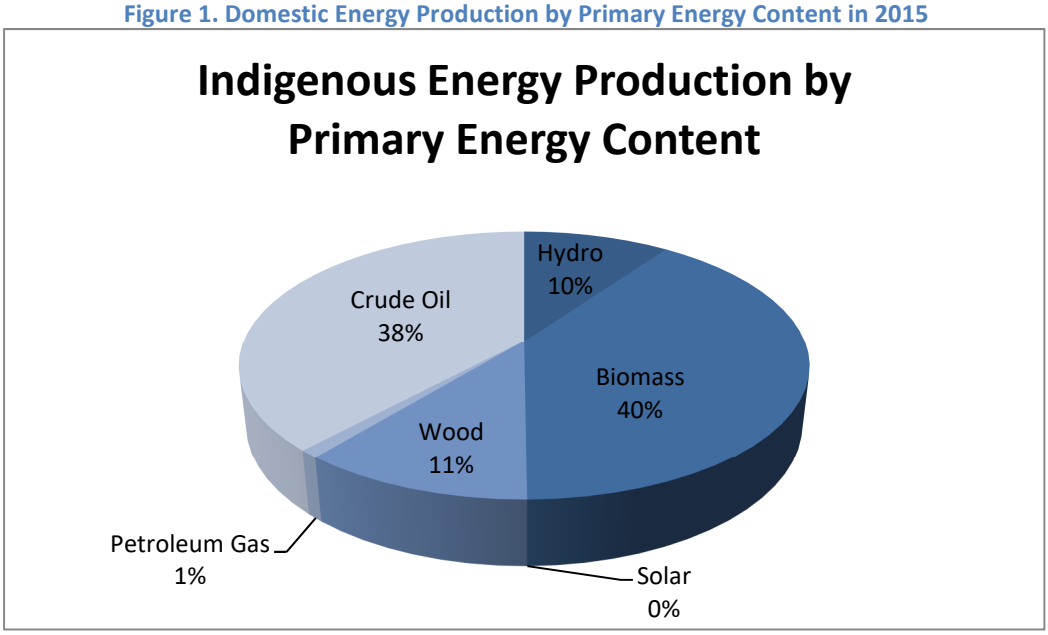
2.1.3. Energy sector

The Energy Report 2015, made by the Ministry of Public Service, Energy and Public Utilities, presents the general data of the energy sector, showing the total consumption and production in Belize during 2015.

According to the report, the energy generation in Belize during 2015 was 8,592 TJ, comprising of:

- 528,142 barrels of crude oil;
- 74,735 scf of petroleum gas;
- 235,936 MWh of hydro-electricity;
- 412,171 metric tons of bagasse (for steam and electricity generation); and
- 51,439 metric tons of wood fuel (firewood).

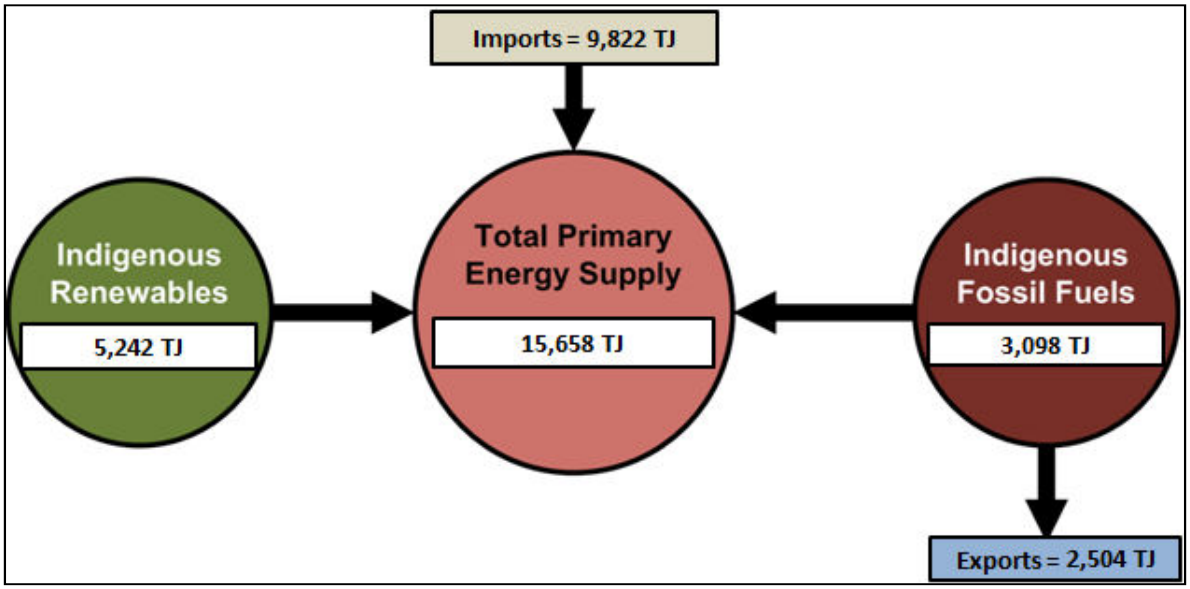
Figure 1. Domestic Energy Production by Primary Energy Content in 2015



Source: Ministry of Public Service, Energy and Public Utilities, 2015

On the other hand, Belize imported 9,822 TJ, most of its total energy supply, as shown on Figure 2:

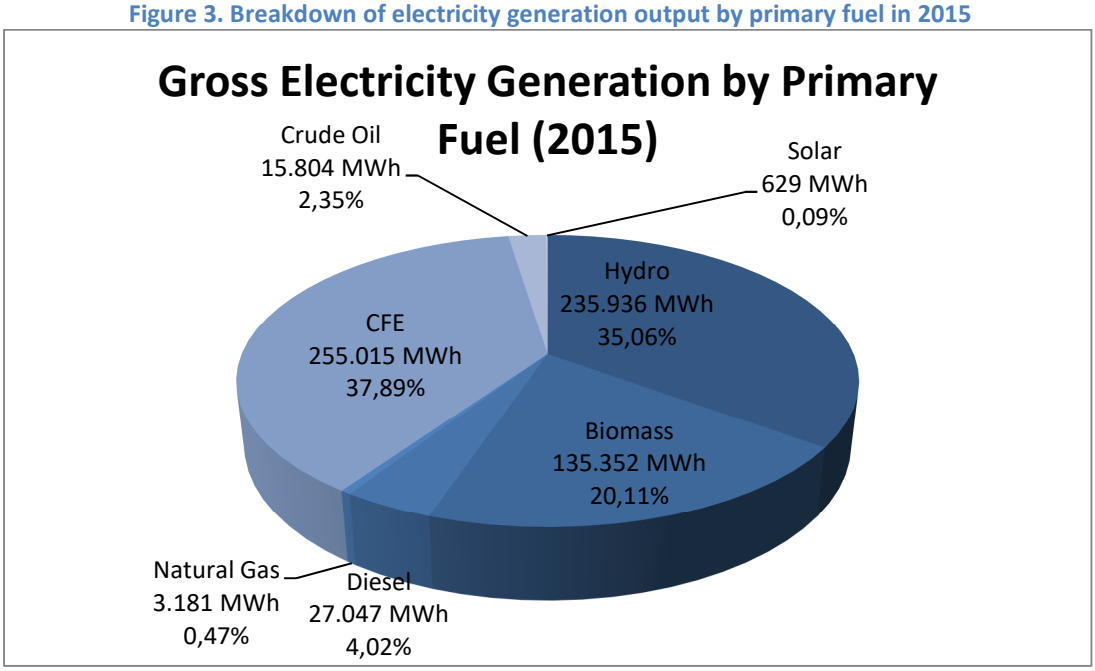
Figure 2. Belize's primary energy supply in 2015



Source: Ministry of Public Service, Energy and Public Utilities, 2015

In the case of electricity generation, during 2015, a total of 656,530 MWh were produced with a total installed capacity of 141.78 MW. The fuel distribution of this generation is shown in Figure 3.

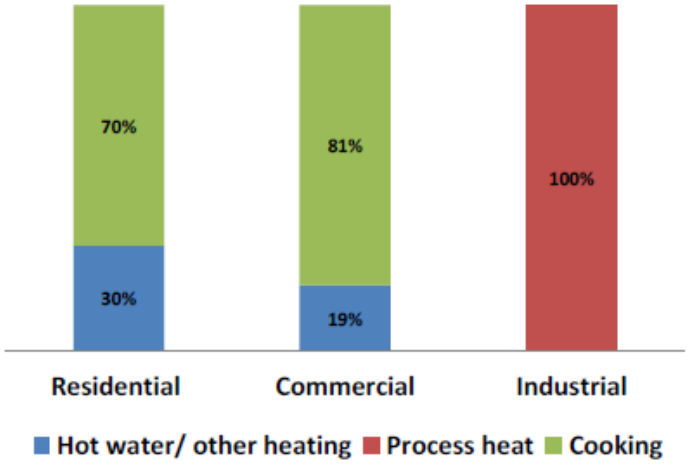
Figure 3. Breakdown of electricity generation output by primary fuel in 2015



Source: Ministry of Public Service, Energy and Public Utilities, 2015

The document "Overcoming barriers EE and RE" presents a series of graphics with information that explains the energy consumption by several classifications, as the ones below:

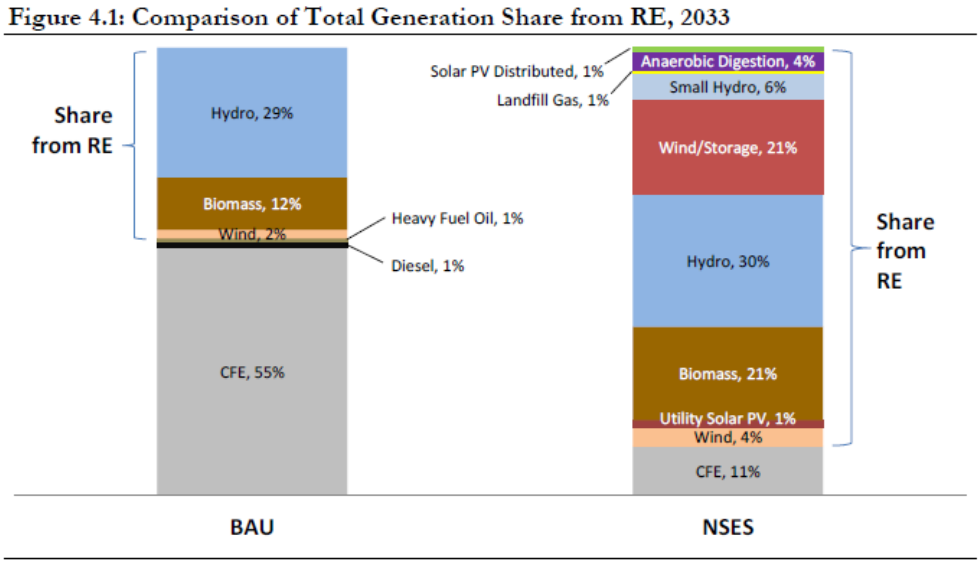
Figure 4. Purpose of heat energy by sector



Source: Castalia, 2014

The graphic shows the uses of the heat consumption in the Residential, Commercial and Industrial sector. Hot water for sanitary purposes is only used in the residential and commercial sector; and cooking is the main use in these sectors. In the other hand, the industrial sector uses heat for several processes, according to its entry.

Figure 5. Generation share in Belize



Source: Castalia, 2014

As shown above, BAU scenario for Generation share includes a high dependence on electricity imports (CFE, 55%), which is expected to change with the introduction of renewable energy technologies to Belize's grid.

The document "Toward a national energy policy. Assessment of the energy sector in Belize" presents information about the characteristics of energy generation in Belize and the main fossil fuels that are used in the country for lightning and cooking. Furthermore, it also includes the actual description of the renewable energies share.

The National Energy Policy Framework presents estimated comparative costs for the electricity sources which includes the installation of solar water heaters. This – as opposed to solar PV - makes sense in Belize's context because the per-KWh cost of solar thermal ($0.11 USD per KWh on average) is lower than grid electricity ($0.12 USD per KWh); but the cost of solar PV is much higher than grid electricity".

The same document also presents some projections to 2040, for lightning and water heating. The predictions are as follows:

a) Shift away from electric to solar lighting. By 2040: electric lighting (75%) and solar lighting (25%). b) Shift towards using solar and geothermal technologies for cooling. By 2040: electric cooling (50%), geothermal cooling (25%) and solar cooling (25%). c) Total phasing out of electric water heating. By 2040: LPG water heating (10%), solar water heating (70%) and geothermal water heating (20%).

Furthermore, it includes potential policies for the implementation of SWH systems, which are presented in the Policy section below.

2.1.4. Climate Change

The following paragraphs show the information included in Belize's INDC and National Communications.

Belize has submitted its INDC to the UNFCCC during the COP21, and its NDC in April 2016, in matters of mitigation in the energy sector, the NDC shows that the Sustainable Energy Strategy and Action Plan states the goal of becoming a low carbon economy by 2033, improving energy efficiency and conservation, with an energy intensity reduction of at least 30% by 2033 and a fuel imports dependency reduction of 50% by 2020 due to increasing renewable energies.

The specific goal is to increase the share of renewable energies up to 85% by 2030 by implementing hydropower, solar, wind and biomass, and reduction of transmission and distribution losses.

Furthermore, Belize has submitted three National Communications to the UNFCCC. The first National communication was submitted on July 2002 and contained the National Inventory of Sources and Sinks of Greenhouse Gases of the year 1994. The document stated that Belize is a net sink for greenhouse gases as it absorbs more than it emits. Yet, it is obvious that Belize is

extremely vulnerable to adverse impacts of climate change. Therefore, the national objective must be to identify feasible adaptation options to address climate change.

The Second Communication, prepared on July 2009, comprises GHG inventories for the years 1997 and 2000 for the following sectors: Energy, Industrial Processes & Solvents, Agriculture, Land use, Land-Use Change & Forestry and Waste. For this document, the emissions of Greenhouse Gas for the 1994 reference years were re-calculated, using the revised UNFCCC software.

The Third Communication presents Belize's national inventory of anthropogenic emissions by sources and removals by sinks. Key source assessments for reference years 2003, 2006 and 2009 were conducted and sought to capture new sources and sinks in addition to those described in the Initial and Second National Communications that might have arisen because of recent developments in the country.

Table 1. Emissions estimates

Table 1: Summary Estimates of Emissions and Sinks by Gas

Reference Years	CO_2 Emissions (Gg)	CO_2 Removals (Gg)	CH_4 (Gg)	N_2O (Gg)	NOx (Gg)	CO (Gg)	Total Emissions (Gg)
2000	11,950	3,862	40	0	10	349	8,487
2003	18,168	9,666	43	0	11	376	8,932
2006	17,375	9,208	41	0	10	361	8,579
2009	13,449	8,778	40	0	10	346	5,067

Source: National Climate Change Office, 2016

2.1.5. SWH information

The document "Overcoming Barriers EE and RE" includes SWH as one of the proposed technologies to displace electricity consumption as an energy efficiency measure:

Solar water heating	RES, CO1, CO2	Solar water heaters use the heat of the sun to warm water in a roof-mounted system; they can displace over 80 percent of electricity

And also to displace LPG use in the residential and commercial sectors:

Solar water heating	Residential, commercial	Solar water heaters use the heat of the sun to warm water in a roof-mounted system; they can displace over 80 to 100 percent of LPG use

Another report that includes SWH is "Belize's Sustainable Energy Strategy Final (Vol 2)".It presents a financial assessment for the installation of SWH systems in the commercial, industrial and residential sectors.

Commercial Solar Hot Water

The main fuel that would be displaced is LPG, with a displacement rate of 95%. Costs would reach an average of BZ$15,000[5] for the installation of a 5kWth system, which would be paid off in 5.5 years.

Table 2. SWH in commercial sector

Target Sector	Target Fuel	Capital Cost (BZD / TJ)	Incremental O&M Costs (BZD / TJ)	Annualized Cost of Savings (BZD / TJ)	Simple Payback Period (yrs)
Commercial	LPG	25,097	1,439	26,537	5.5

Source: Ministry of Energy, Science &Technology and Public Utilities, 2015

Solar Industrial Process Heat

In the industrial sector, the solar heating technology considered was the concentrated solar power with parabolic trough devices; this would result in higher capitals costs for the industrial sector compared with the residential and commercial sector. This application is to produce steam and not hot water, which makes the payback period longer (60 years).

Table 3. SWH in industrial sector

Target Sector	Target Fuel	Capital Cost (BZD / TJ)	Incremental O&M Costs (BZD / TJ)	Annualized Cost of Savings (BZD / TJ)	Simple Payback Period (yrs)
Industrial	Crude Oil	160,186	0	160,186	60.0

Source: Ministry of Energy, Science & Technology and Public Utilities, 2015

Residential Solar Hot Water

In the case of residential SWH, the displacement of an 85% of the annual LPG use would mean an average investment of BZ$3,500 which should be paid off in 1.3 years.

[5] 1 USD = 2 BZ

Table 4. SWH in residential sector

Target Sector	Target Fuel	Capital Cost (BZD / TJ)	Incremental O&M Costs (BZD / TJ)	Annualized Cost of Savings (BZD / TJ)	Simple Payback Period (yrs)
Residential	LPG	5,896	338	6,234	1.26

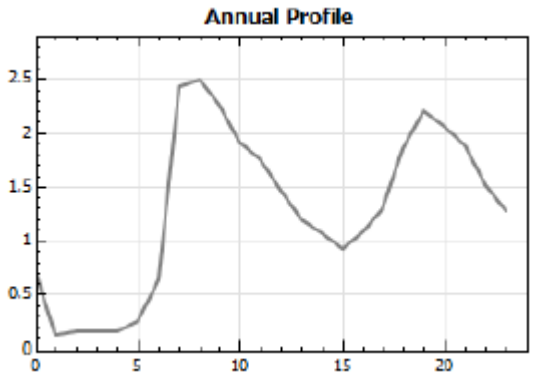
Source: Ministry of Energy, Science & Technology and Public Utilities, 2015

Solar Hot Water Production Potential

The potential of SWH technologies in Belize were assessed for two scenarios, both for a typical residential unit and a commercial user (a hotel). The estimated demand for a US residential building considered for a 12.2 gallons per person per day demand. On the other hand, the hotel demand was estimated considering 24 rooms serving 12,000 persons-day per year.

Figure 6 shows the annual average daily load profile for hot water demand in kWth.

Figure 6. Annual profile



Source: Ministry of Energy, Science & Technology and Public Utilities, 2015

The results of the analysis shows that for the residential sector the optimum system displaces 94% of the conventional fuel with a 9.9% capacity factor, and for the commercial sector the optimum system displaces 64% of the fuel with a 16.9% of the SWH capacity factor, as shown on Table 5.

Table 5. SWH Demand assessment

Scenario	Typical Size (kWth)	Hot water Demand (gal/day)	Annual SHW Supply (kWh)	Solar Fraction of DHW	SHW Capacity Factor
Residential	1.4	44.2	1,225	94%	9.9%
Commercial	4.8	377	7,093	64%	16.9%

Source: Ministry of Energy, Science & Technology and Public Utilities, 2015

Even though the study "Belize's Sustainable Energy Strategy Final (Vol 2)", shows targets and potential of GHG reduction due to the implementation of SWH, this NAMA Concept will estimate a potential according to the field validation as a result of the first mission (please see Annex 1 for details regarding the mission).

2.2. Purpose and objectives of the SWH NAMA

The SWH NAMA aims to implement solar water heaters in the residential, commercial and industrial sectors in Belize; its main objective is to reduce the GHG emissions of the country, to generate a more sustainable scenario for the energy sector and a global access to clean and renewable energy.

A gradual implementation of the SWH systems is expected, considering a 13 years term in order to meet the "Belize Sustainable Development Strategy" goals related to climate change. The primary scope for the NAMA is to reach an 80% of the buildings, considering the ones that are, at the moment, capable of sustain the SWH system. Additionally a pilot project is intended to be applied in the early years of the project, in order to identify further requirements and to test the proposed planning and implementation terms.

2.3. Analysis of institutional stakeholders

The stakeholder analysis is a key topic for the determination of the actual capacities of the country for the NAMA management and implementation. Also, it can be helpful for the planning and coordination needs through the lifetime of the project.

In this context, an institutional stakeholder is any organisation related to the NAMA, who will be actually implementing the action or providing necessary conditions for the NAMA implementation. These institutional stakeholders could be public sector stakeholders (e.g. the related ministries or related units/offices), private sector stakeholders (e.g. providers and private banks) and supporting entities (e.g. development banks).

The identified institutional stakeholders for the SWH NAMA are the following:

- Energy Unit of the Ministry of Public Service, Energy and Public Utilities
- National Climate Change Office
- Public Utilities Commission
- SWH systems providers
- Private financial institutions
- Development Finance Corporation

The following tables shows the institutions identified as relevant stakeholders for the SWH NAMA. It gives information about their actual role, an institutional assessment and the potential role for the NAMA implementation.

Table 6. Energy Unit: stakeholder assessment

Energy Unit of the Ministry of Public Service, Energy and Public Utilities	
Role	The Energy Unit of the Ministry of Public Service, Energy and Public Utilities has the role of planning, promoting and managing the production, delivery and use of energy. Also, it promotes energy efficiency and cleaner production, contributing to the sustainable development of Belize.
Institution assessment	The personnel of the Energy Unit have the knowledge, experience and advocacy to advise on public and private initiatives related to sustainable energy. It has limited human resources and requires more support, and is expecting to create 2 new units within the department. On the other hand, it is desirable that it could contribute to the information for the development of the NAMA with, for example, disaggregated information of the final use of energy.
Potential role for the NAMA	The Energy Unit has been identified as the NAMA implementing entity, responsible of the design and implementation of the SWH NAMA, collaboration with the NCCO.

Source: Own elaboration, 2017

Table 7. NCCO: stakeholder assessment

National Climate Change Office (NCCO)	
Role	Under the Ministry of Agriculture, Fisheries, Forestry the Environment, Sustainable Development and Immigration, the NCCO is responsible for the coordination of Belize's national, regional and international response to climate change.
Institution assessment	The office has the required knowledge and experience in matters of climate change as resilience, adaptation and mitigation. Nevertheless, it has limited human resources

National Climate Change Office (NCCO)	
	as it is composed by only 3 persons. At the moment, the office does not have a budget for the SWH NAMA. A request should be made to the Ministry responsible for finance and economic development regarding the development of a budget for the NAMA.
Potential role for the NAMA	The NCCO is considered to be the coordinating entity for NAMA planning and implementation in Belize.

Source: Own elaboration, 2017

Table 8. Public Utilities Commission: stakeholder assessment

Public Utilities Commission	
Role	The Public Utilities Commission has the role of regulating the electricity, water, and telecommunications sectors in Belize with the aim of providing the highest quality services at affordable rates and ensuring the viability and sustainability of each sector.
Institution assessment	The institutions currently have the advocacy, knowledge and capacity to develop the necessary regulation for the SWH systems, which should facilitate the certification of equipment and plumbers. Human resources capacities and related budget are currently unknown.
Potential role for the NAMA	The Public Utilities Commission could facilitate the effective implementation of the SWH NAMA through the certification of proposed equipment and relevant technicians for the project.

Source: Own elaboration, 2017

Table 9. SWH systems providers: stakeholder assessment

SWH systems providers	
Role	The technology providers supply the SWH systems and technical support to the users for the NAMA implementation.
Institution assessment	At the time, two formally established providers have been identified in Belize: GreenSun (Chromagen) and Pro Solar. They have the capacity to provide technical support for the maintenance and installation of the SWH systems. According to current information, the human resources and the stock are appropriate for the current demand.
Potential role for the NAMA	The SWH providers should contribute by providing the SWH systems and technical support for installation and maintenance, in coordination with the NAMA planning entities.

Source: Own elaboration, 2017

Table 10. Private financial institutions: stakeholder assessment

Financial institutions[6]	
Role	Delivering financial services
Institution assessment	Credit unions don't offer specific loans for energy projects. However, these institutions offer loan for consumer purposes or for house improvement, which can be used for installing and maintaining SWH systems. St. John's credit union has already financed the installation of 2 photovoltaic systems. The loan conditions of the credit unions are related to the individual risk assessment and the customer's payment history. Because of the price of a SWH (USD 1,500) collateral would not be needed. The National bank doesn't offer specific loans for energy projects; however, these institutions offer consumer loans and business/commercial loans. Collateral requirements are determined on a case by case basis, based on the perceived risk of the client.
Potential role for the NAMA	The Private financial institutions could provide finance for implementing SWH systems through loans. Depending on the financial institution and the risk of the client, collateral could be required.

Source: Own elaboration, 2017

Table 11. Development Finance Corporation: stakeholder assessment

Development Finance Corporation (DFC)	
Role	The Development Finance Corporation is Belize's only Development Bank. Their role is to support the strengthening and expansion of Belize's economy by providing developmental financing on an economically sustainable and environmentally acceptable basis to individuals, businesses and organizations.
Institution assessment	The DFC has a renewable energy and energy efficiency financing program consisting of loan financing with a 6% interest rate. This provides the opportunity for businesses to invest in renewable energy and energy efficiency technologies, in order to save money and increase competitiveness by reducing long-term operational costs. The SWH projects are eligible for financing under this program.
Potential role for the NAMA	The DFC could provide finance for implementing SWH systems, through loans for Belizean citizens and residents, and legal entities with Belizean majority

[6] For this assessment, information from credit unions and private banks is considered.

Development Finance Corporation (DFC)	
	shareholdings.

Source: Own elaboration, 2017

Additionally, there are relevant institutions that, besides not being directly related to the SWH NAMA during the information collection phase of the project, can play an important role in the development of the project. These are shown in the following table.

Table 12. Additional stakeholders

Institution	Potential Role
Ministry of finance	The Ministry has the capacities and could finance the human resources related to the NAMA design and implementations, it can also implement tax credits and/or reduce the import duties for the SWH systems
Statistical Institute of Belize	The Institute has the capacities and the means to collect relevant information for the planning and development of the SWH NAMA, especially on data required to calculate the emission reductions.
Belize Bureau of Standards	The proper development of a SWH market and implementation through the residential, commercial and industrial sectors of Belize require an appropriate definition of codes and standards in which the Belize Bureau of Standards should play a key role.
Central Building Authority and Local Building Authorities	In order to complement the actual necessities of the SWH NAMA, the definition of building standards to meet the minimum construction requirements for the SWH systems installation.

Source: Own elaboration, 2017

2.4. Policies

Main policies related to SWH are:

National Energy Policy Framework: It includes SWH as an energy alternative to displace fossil fuels consumption, under the micro-generation technologies proposal. It also shows estimations on how SWH could be implemented according to Belize's conditions, as the following paragraph stands:

"If we assume that all concrete houses are capable of supporting solar water heating systems, then almost all of the water heating needs of 50% of the households in Belize can be met by using solar water heaters, particularly during the warmer and sunnier days of the year. This conclusion is

drawn from insights gotten from the IEA Buildings Technology Roadmap 2010 which reports that "solar water-heating systems for single-family dwellings are relatively small, with collector areas of 4 m^2 to 6 m^2, and meet 20% to 70% of average domestic hot water needs".

Belize Sustainable Energy Strategy: This document presents technical information for several technologies, which includes solar water heating as one of them.

Growth Sustainable Development Strategy: Besides this document does not state SWH specifically, it aims to guide the development of Belize for the period 2016-2019, considering sustainable development as one of its principles. This strategy is based on critical success factors, where renewable energy and low-carbon development are accounted.

The most relevant information included in this document is shown in the Solar Water Heating information section.

3. Estimation of the impacts of the SWH NAMA

The Solar Water Heating NAMA will be implemented in these 3 sectors:

Table 13. SWH NAMA accounted sectors

Residential	Household sector, composed of all the houses in Belize that fulfil the conditions for the installation of a SWH system.
Commercial	Buildings with commercial purposes, mainly the hotel sector and other related buildings with hot water demand.
Industrial	Industrial buildings that have several purposes, such as meat and fruit processing, which requires hot water for different uses.

Source: Own elaboration, 2017

3.1. Baseline scenario

The Baseline scenario for the SWH NAMA in Belize is usually developed by calculating the GHG emissions generated by the fuel and electricity consumption from the water heating processes across the country; particularly in the aforementioned sectors. As the required information for the specific fuel and electricity consumption is not available, a baseline emissions scenario can't be

directly calculated. Nevertheless, based on the emissions savings calculations of the SWH systems implementation and estimation of the baseline, GHG emissions can be determined.

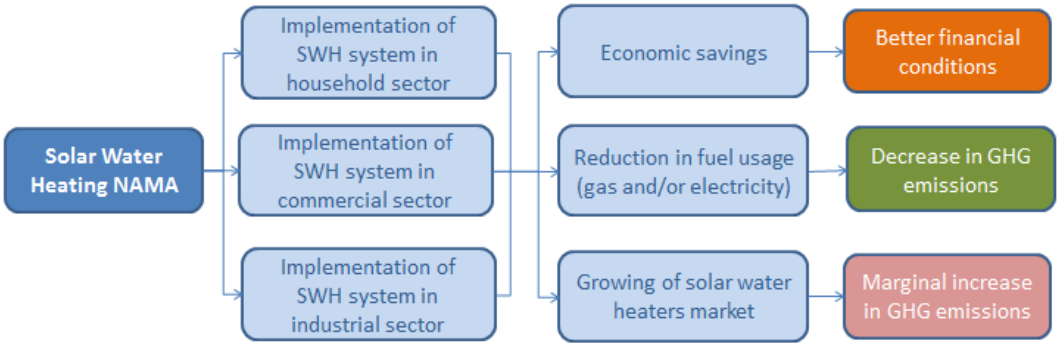
3.2. NAMA scenario

The NAMA scenario corresponds to the situation in which the SWH systems are already installed in the determined buildings and households, reducing the GHG emissions from the previous use of electricity and fossil fuels. The emission reduction produced in the NAMA scenario was calculated according to the hot water demand and the share that was covered by the SWH system, taking into consideration its size and performance.

3.3. Potential impacts of the NAMA

The implementation of the NAMA will potentially result in reduction of the GHG emissions and it can also have other non-GHG impacts, which would include the potential sustainable development benefits of implementing SWHs in Belize. In order to identify all the effects, a causal chain will be mapped, following the Policy and Action Standard document of the Greenhouse Gas Protocol[7].

Figure 7. Causal chain



Source: Own elaboration, 2017

A causal chain represents a diagram that "trace the process by which NAMA brings different effects through a series of logical and sequential related stages". Due to complexity of possible cause effect relations of NAMA actions and the impossibility of mapping all possible effects, a causal chain will be always incomplete.

[7] http://www.ghgprotocol.org/sites/default/files/ghgp/standards/Policy%20and%20Action%20Standard.pdf

3.4. GHG impacts of the NAMA

In order to define the methodology that was used to calculate the GHG emission reduction of the SWH NAMA, a research of available applicable methodologies from climate change related mechanisms as CDM, VCS or CAR was carried out. Nevertheless, the only methodology that fits the requirements of the NAMA is the CDM Small Scale Methodology "AMS-I.J.: Solar water heating systems (SWH) --- Version 1.0".

This methodology is focused on residential and commercial SWH systems for hot water production, presenting guidelines for the determination of the Baseline scenario and the Emission Reductions calculation according to the energy savings from the project. This is then multiplied by an emission factor for the electricity and/or fossil fuel displaced, as shown on the following equation.

$$ER = (IFC - AFC) * EF$$

Where,

ER : Emission reduction (tCO_2e)

IFC : Initial fuel consumption (kWh)

AFC : Actual fuel consumption (kWh)

EF : Fuel emission factor (tCO2e/kWh)

As mentioned above, the complete baseline scenario cannot be calculated considering the available information. Instead, an estimation of the fuel and electricity consumption by building unit (household, commercial or industrial) has been made from the emission reduction calculation.

3.4.1. Projections

Considering the values for the emission reduction, a projection for each sector was made using the following data:

Table 14. Projection input values

Term	13 years (2018-2030)[8]
Scope	30%, 50% and 80%[9]

Source: Own elaboration, 2017

Available information, geographical data and general estimations were used as input for the emission reduction calculation using the RETScreen software; its results are shown in the following paragraphs.

3.4.2. Residential and commercial sectors

The emission reduction calculation for the residential and commercial sectors considers two fuel types: LPG and electricity; both are separated estimations, as they assume a 100% use of the corresponding fuel and are not relatable between them before final calculations. This is due to lack of specific fuel information for hot water generation methods.

The following graphics and tables show the yearly and total estimated emission reduction for the residential and commercial sector, considering a 13 years horizon according to Belize's NDC (2030), and a goal of 30%, 50% or 80% for comparison matters.

Residential sector LPG

The residential sector, considering LPG (propane) powered water heaters, would reduce an initial amount of 981 tCO_2e considering an 80% goal, the following table shows the detailed results.

Table 15. Residential sector LPG ER

Year	30% (tCO_2e)	50% (tCO2e)	80% (tCO2e)
1	368	613	981
2	736	1,227	1,964
3	1,104	1,841	2,946
4	1,473	2,455	3,928
5	1,841	3,069	4,910
6	2,209	3,682	5,892
7	2,577	4,296	6,874
8	2,946	4,910	7,857
9	3,314	5,524	8,839

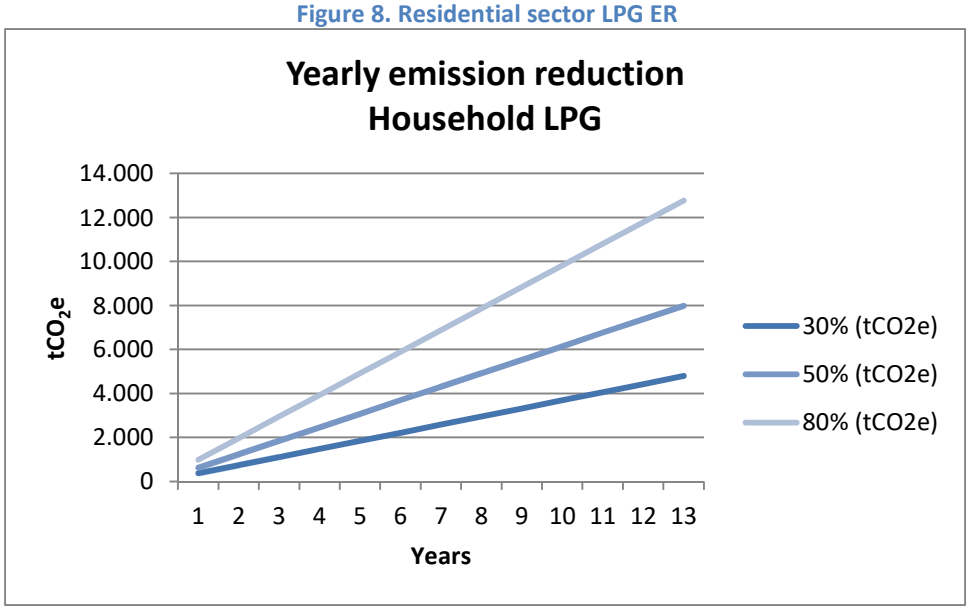
[8] Considering Belize's NDC
[9] Based on Belize's Sustainable Energy Strategy

Year	30% (tCO_2e)	50% (tCO2e)	80% (tCO2e)
10	3,682	6,138	9,821
11	4,051	6,752	10,803
12	4,419	7,365	11,785
13	4,788	7,980	12,768
Total	**33,508**	**55,852**	**89,368**

Source: Own elaboration, 2017

The following graph shows the emission reduction results of the table above.

Figure 8. Residential sector LPG ER



Source: Own elaboration, 2017

Residential sector Electricity

The following table shows the yearly emission reductions for the household sector, considering electricity powered water heaters, which considering and 80% goal results in a 1,309 tCO_2e emission reduction in the first year.

Table 16. Residential sector electricity ER

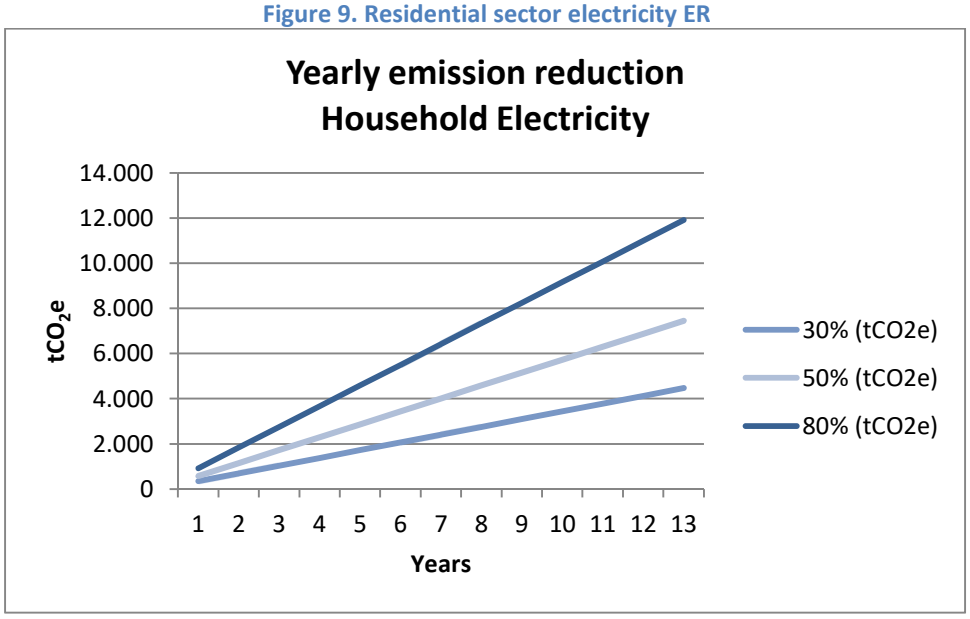
Year	30% (tCO_2e)	50% (tCO2e)	80% (tCO2e)
1	490	818	1,309
2	982	1,636	2,618
3	1,473	2,455	3,928
4	1,964	3,273	5,238
5	2,455	4,092	6,547
6	2,946	4,910	7,857

Year	30% (tCO_2e)	50% (tCO2e)	80% (tCO2e)
7	3,437	5,729	9,166
8	3,928	6,547	10,476
9	4,419	7,366	11,785
10	4,910	8,184	13,095
11	5,401	9,002	14,404
12	5,892	9,821	15,714
13	6,384	10,640	17,024
Total	**44,681**	**74,473**	**119,161**

Source: Own elaboration, 2017

The following graph shows the emission reduction results of the table above.

Figure 9. Residential sector electricity ER



Source: Own elaboration, 2017

Commercial sector LPG

The commercial sector, considering LPG (propane) powered water heaters, would reduce an initial amount of 62 tCO_2e considering an 80% goal, the following table shows the detailed results.

Table 17. Commercial sector LPG ER

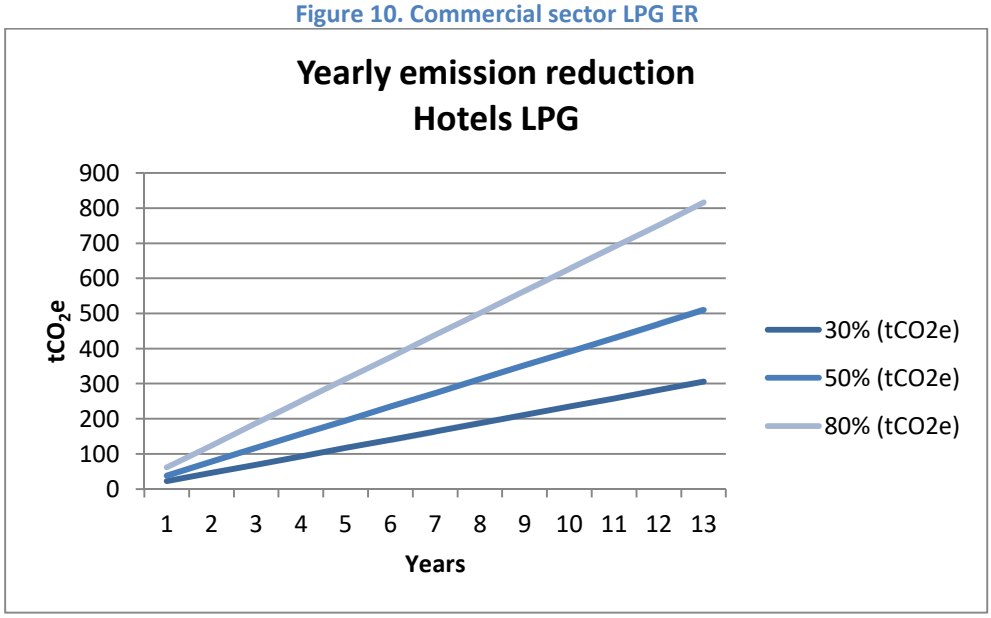
Year	30% (tCO_2e)	50% (tCO2e)	80% (tCO2e)
1	22	38	62
2	46	78	124
3	69	117	187
4	93	156	250

Year	30% (tCO_2e)	50% (tCO2e)	80% (tCO2e)
5	117	195	313
6	140	235	375
7	164	273	439
8	187	313	501
9	211	352	564
10	235	391	627
11	258	430	690
12	282	470	752
13	306	510	816
Total	**2,130**	**3,558**	**5,700**

Source: Own elaboration, 2017

The following graph shows the emission reduction results of the table above.

Figure 10. Commercial sector LPG ER



Source: Own elaboration, 2017

Commercial sector Electricity

The following table shows the yearly emission reductions for the commercial sector, considering electricity powered water heaters, which considering and 80% goal results in an 88 tCO_2e emission reduction in the first year.

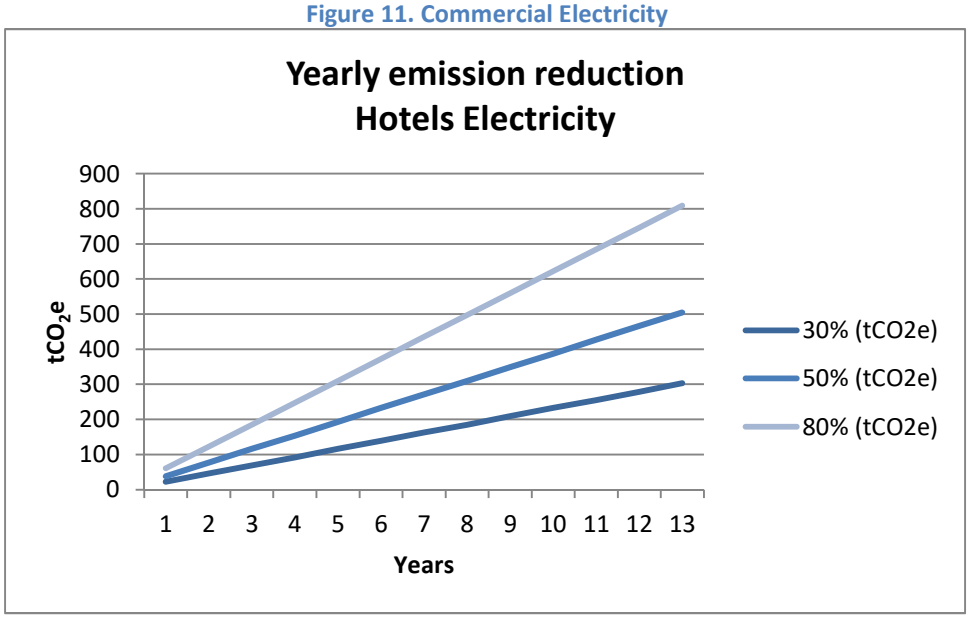
Table 18. Commercial sector electricity ER

Year	30% (tCO_2e)	50% (tCO2e)	80% (tCO2e)
1	32	54	88
2	66	110	176
3	98	166	265
4	132	221	355
5	166	277	443
6	198	333	532
7	232	387	622
8	265	443	710
9	299	499	799
10	333	554	889
11	365	610	977
12	399	666	1,065
13	433	722	1,156
Total	**3,018**	**5,042**	**8,077**

Source: Own elaboration, 2017

The following graph shows the emission reduction results of the table above.

Figure 11. Commercial Electricity



Source: Own elaboration, 2017

Total emission reduction for household and commercial sector

The total cumulative emission reductions are shown on the table below, stating that considering the amount of buildings reached, the major emissions reduction occurs in the household sector, over the commercial, beside its individual emission reduction.

Table 19. Total emission reduction (13 years) (tCO2e)

Sector	Fuel type	30% Goal ER	50% Goal ER	80% Goal ER
Household	LPG	33,508	55,852	89,368
	Electricity	44,681	74,473	119,161
Commercial	LPG	2,130	3,558	5,700
	Electricity	3,018	5,042	8,077

Source: Own elaboration, 2017

3.4.3. Industrial sector

Considering that the industrial sector is at the moment, only covered with the information of Citrus Products of Belize (CPBL) and Quality Poultry, the following table shows the total amounts of tCO_2e reduced yearly and over the already mentioned 13 years scope.

Table 20. Industrial sector emission reduction (tCO2e)

Industry	Yearly Emission Reduction	13 years
CPBL	76	988
Quality Poultry	62	806
Total	**138**	**1,794**

Source: Own elaboration, 2017

3.4.4. Total emission reductions

The following table shows the total emission reductions considering the separate fuel types scenarios.

Table 21. Total emission reductions

Emission reduction (tCO_2e)				
Sector	Fuel type/Industry	30% Goal ER	50% Goal ER	80% Goal ER
Household	LPG	33,508	55,852	89,368
	Electricity	44,681	74,473	119,161
Commercial	LPG	2,130	3,558	5,700
	Electricity	3,018	5,042	8,077
Industrial	CPBL		988	

Emission reduction (tCO_2e)				
Sector	Fuel type/Industry	30% Goal ER	50% Goal ER	80% Goal ER
	Quality Poultry		806	
Total LPG		**37,432**	**61,204**	**96,862**
Total Electricity		**49,493**	**81,309**	**129,032**

Source: Own elaboration, 2017

3.4.5. Sensitivity analysis

Considering that the present emission factor for Belize's electricity grid is being revised, a sensitivity analysis for the electricity related calculations was made in order to know the possible influence of a 10, 20 and 30 percent reduction in the emission factor, since a decrease is highly expected.

In the case of the residential sector, the following table shows the values, reaching a minimum value of 31,273 tCO_2e, in the case of the 30% scope and 83,410 tCO_2e for the 80% scope.

Table 22. Sensitivity analysis for residential sector

Residential	30% (tCO2e)	50% (tCO2e)	80% (tCO2e)
Base	44,681	74,473	119,161
-10%	40,209	67,024	107,242
-20%	35,743	59,576	95,327
-30%	31,273	52,128	83,410

Source: Own elaboration, 2017

Regarding to the commercial sector, since the emission reduction amount is smaller than the residential sector one, the differences between base scenario and the sensitivity analysis values are always less than 3,000 tCO_2e.

Table 23. Sensitivity analysis for commercial sector

Commercial	30% (tCO2e)	50% (tCO2e)	80% (tCO2e)
Base	3,018	5,042	8,077
-10%	2,715	4,534	7,267
-20%	2,414	4,032	6,459
-30%	2,111	3,526	5,651

Source: Own elaboration, 2017

In the case of the total emission reduction, adding residential and commercial sectors the values vary between 33,384 and 47,699 tCO_2e for the 30% scope scenario and between 89,061 and 127,238 for the 80% scope scenario.

Table 24. Sensitivity analysis for residential and commercial sector

Total	30% (tCO2e)	50% (tCO2e)	80% (tCO2e)
Base	47,699	79,515	127,238
-10%	42,924	71,558	114,509
-20%	38,157	63,608	101,786
-30%	33,384	55,654	89,061

Source: Own elaboration, 2017

3.5. Sustainable development benefits of the NAMA

Beside from GHG emission reductions from the SWH NAMA implementation in Belize, there are several benefits to other areas of the country's development; those can be classified as social, economic, environmental, technological and institutional, and may be contributions to achieving the Sustainable Development Goals.

Figure 12. Belize Sustainable Development Goals

Source: United Nations Development Programme in Belize, 2017

As seen on the figure above, there are 17 Sustainable Development Goals, from which the most relevant for the SWH NAMA are:

1. No poverty

Even though the SWH NAMA is not directly related to economic issues, it certainly contributes to fighting poverty, allowing people to access to sustainable energy and long-term savings from the fuel and electricity consumption that was avoided.

7. Affordable and Clean Energy

The implementation of SWH systems across the country would increase and improve the access to hot water through sustainable technologies, making it affordable for the population, commercial establishments and industries.

9. Industry, innovation and infrastructure

The SWH NAMA aims to implement solar water heaters in several types of buildings, introducing and promoting this technology across the country.

11. Sustainable cities and communities

The implementation of SWH systems certainly contributes to more sustainable cities replacing the electricity and fossil fuel consumption with renewable energy for water heating.

13. Climate action

The SWH NAMA aims directly reduce the GHG emissions in Belize through the replacement of fossil fuels and electricity consumption, contributing to the country's NDC.

4. Identification and analysis of barriers

The SWH implementation in Belize could face different type of barriers, such as economic and financial, regulatory and institutional, technical and market barriers at different levels: government, users, financial institutions and providers. The analysis of barriers provides useful information in order to define the potential interventions of the NAMA, aiming to reduce and overcome the barriers.

4.1.1. Typology of barriers

Based on a literature review of the potential barriers for the implementation of NAMAs, and for the implementation of SWH systems, a typology of barriers was defined with the purpose of representing the analytical framework for the barriers analysis. The following table summarizes the defined types of barriers, as an example of the possible present barriers.

Table 25. Types and examples of barriers

Level	Type of barrier	Barrier
Government and institutional stakeholders	Economic and financial	Budget constraint from public resources
	Regulatory and institutional	Weak sense of program ownership and commitment among stakeholders
		Lack of incentives to support the early market development
		Lack of performance standards
		Lack of procurement policies

Level	Type of barrier	Barrier
		Fossil fuel subsidies distort the economy of SWH
	Technical and capacity	Lack of knowledge
		Lack of skilled labour
Residential sector	Economic and financial	High up-front cost of the technology
		Limited access to capital
	Technical and capacity	Lack of confidence in the technology
		No awareness of economic benefits and other benefits
		Lack of metering to track the impact of installing SWH
Commercial and industrial sector	Economic and financial	High up-front cost of the technology
		Limited access to capital
	Technical and capacity	Lack of confidence in the technology
		No awareness of economic benefits and other benefits
		Lack of metering to track the impact of installing SWH
Financial institutions	Economic and financial	Risk aversion
	Technical and capacity	Lack of bank expertise or experience to tailor SWH loans
		Negative perception of profitability of SWH
Market and providers	Economic and financial	High amount of import duties and taxes
	Regulatory and institutional	Lack of incentives to adopt new technologies
	Technical and capacity	Technology not yet available in the market
	Market	Low volume demand for products
		Monopolies/limited market competition

Source: Own elaboration, 2017

Types of barriers listed above are described below:

Economic and financial:

According to the "Guidance for NAMA Design, Building on Country Experiences"[10] economic and financial barriers are usually related to limited access to capital, high upfront costs, small project sizes, split incentives, conflicting allocation of resources for investments and financially stable support.

[10] http://namapipeline.org/publications/guidance_for_nama_design_2013_.pdf

Regulatory and institutional:

This barrier refers to difficulties in the establishment of standards and regulations for the accomplishment of the project which can lead to market failures or limited access to technologies and/or markets. It also considers the lack of programs, incentives and capacity building for the NAMA.

Technical and capacity:

Lack of technical capacities of the relevant stakeholders, affecting the planning and development of a NAMA. This type of barrier considers the population's lack of access to relevant information, commercial sector's lack of confidence on technologies and awareness of financial benefits, and lack of knowledge and technical requirements in the relevant institutions.

Market:

This barrier type refers to market failures and limitations, as monopolies and lack of demand for the required technology makes it difficult to create a proper market that is an essential part of the SWH NAMA.

This typology allows a structured and broader analysis of the barriers, based on the typical barriers categories identified in similar contexts.

Based on the typology of barriers described above, a table showing the identified barriers and its qualification is presented.

Table 26. Identified Barriers

Type of barrier	Barrier	Level
Regulatory and institutional	Lack of managing structure and related budget	High
Technical and capacity	Lack of awareness about SWH technologies	Medium
Technical and capacity Regulatory and institutional	Lack of specific information on energy consumption	High
Economic and financial	Lack of financing capacities	High
Economic and financial Technical and capacity	Different priorities for lower incomes families	Medium

Source: Own elaboration, 2017

Lack of managing structure and related budget

The implementation of a solar water heating project at national scale requires a multi-disciplinary institutional structure to manage all aspects of the project, in addition to a related budget for the implementation of all tasks. At the moment, according to the information that was collected, relevant institutions for the NAMA such as the National Climate Change Office or the Energy Unit of the Ministry of Public Service, Energy and Public Utilities, do not have the required institutional structure for the project. In planning for the implementation of the SWH NAMA, a management structure and an appropriate budget should be provided according to the needs of the project.

Lack of awareness about SWH technologies

The people in Belize have different viewpoints related to water heating, which differ according to their conditions and necessities. For some of them the use of hot water is a common practice while others do not even have a water heating system in their homes. Considering this, the benefits or Solar Water Heating are not commonly known among Belize's population.

The SWH NAMA in Belize aims to implement SWH systems with the intention of reducing GHG emissions at the highest possible level. For this, the NAMA would include the provision of information to several stakeholders, considering appropriate SWH systems specifications and sizing, with the aim of generating knowledge and capacities relating to the environmental and economic benefits of solar water heating.

Lack of specific information on energy consumption

Currently, Belize's information on energy consumption for water heating is not sufficient to assist in determining the specific potential of solar water heating systems for generating GHG reductions since the fuel and electricity consumption for water heating has not been calculated. This also reduces the awareness of the contribution of water heating to GHG emissions among the population and the relevant stakeholders.

The planning and implementation of the SWH NAMA would help to provide information through specific studies with estimations on fuel and electricity consumption for water heating; aiming to allow the calculation of GHG emission reduction of the NAMA.

Lack of financing capacities

The implementation of Solar Water Heating systems, besides having economic benefits in the mid-long term, is expensive due to the high upfront cost of the devices and also because of the taxes and duties that are charged for the importation of the solar water heater components. Thus, it's difficult low income people to afford the SWH system by their own. Also, for hotels and industries, the investment costs can be high. Because of this, more economic incentives are needed in order

to decrease the upfront cost and decreasing the payback period. There is also need for a proper regulatory framework that encourages the implementation of SWH in Belize. The SWH NAMA aims to address these issues, by executing an assessment of the cost to implement the SWH project.

Different priorities for lower incomes families

In Belize, lower incomes families have basic priorities still to fulfil; this makes solar water heating or even any kind of water heating a relegated priority for them. Considering this, the definitive scope of the SWH NAMA should take into account the proper determination of the population that could have access to this technology and the financial and infrastructure requirements for it.

4.2. Successful cases

4.2.1. Barbados

General description

Barbados, taking into account the need for climate change-resilient development, has considered solar water heating as a source of energy for both domestic and commercial purposes; thus replacing gas and electricity consumption. The country has a population of 200,000 inhabitants, and now they have more than 50,000 SWH installations and save over 100,000 MWH per year.

Identified barriers

- Accessing star-up capital: Difficulties to find investment capital from banks, despite having contracts with the government.
- Sustaining regulatory support: Uncertainty because of modifications in taxes regulations.
- Developing an effective product
- Building consumer awareness

Key Factors for success

The main reasons for success of SWH implementation in Barbados are:

- The early pioneers: The development of the SWH industry was supported by a small number of people who strongly carried the weight of introducing this technology in the country.
- Financial support and regulatory certainty: The Barbados government introduced a series of measures since early 1970's, ensuring an appropriate investment climate. Those measures continued and grew until 2000's and contributed by providing tax benefits for homeowners.

- Consumer acceptance: Consumers in Barbados accepted the technology because the size of the systems was appropriate for households. This in in contract to countries such as Jamaica, where SWH systems were too small to fulfill family's requirements. Also, in purchasing the SWH systems, the payback period was spread over 3 years; thanks to appropriate credit conditions.

4.2.2. Georgia: Access to affordable low-cost solar water heating solutions as a basis for the first gender-sensitive Nationally Appropriate Mitigation Action (NAMA) in Georgia.

General description

The project aimed to address the problem of a lack of access to safe and sustainable energy in Georgia, especially in rural areas, and also considering that women have less access and control over income and assets as gender roles are traditionally divided in Georgia.

Identified barriers

The main barriers for the implementation of SWH systems in Georgia are:

- Financial issues: most of people with lack of access to affordable energy aren't capable of affording a technology that has a payback period of 2 or 3 years.
- Lack of capacities for installation and maintenance of SWH systems.
- Traditional gender roles.

Key Factors for success

- Building local capacities was very important for NAMA success.
- Despite high technology costs, top quality components should be ensured, considering financial support for the lowest income group.
- Properly planning the dissemination of the project is a key activity in order to acquaint the population with the SWH technology and its benefits.
- Financing facilities for the population should be considered in order to guarantee availability and universal access to SWH systems.

5. Analysis of the financial and technical support required and estimation of the financial and technological resources needed

The various NAMA implementation and operation stages require different technical and financial resources. The initial assessment of the required technical and financial resources is presented in this section.

5.1. Administration and financing

The National Climate Change Office (NCCO) is the entity that must be in charge of the SWH NAMA administration and financing management, assuming a coordination role for the development of the project. Additionally, other institutions should collaborate with the implementation of the NAMA. The Energy Unit of the Ministry of Public Service, Energy and Public Utilities can be responsible for the design and implementation of the project during its development; the Public Utilities Commission can also be part of the implementation process, through the certification and supervision of the equipment and technicians.

The organisation in charge of the SWH NAMA management needs to administrate the financial resources for the several requirements of the NAMA: Investment for pilot projects, financing mechanisms for the industrial and commercial sector.

5.2. Direct investment on SWH

The development of the SWH NAMA will require a proper investment and budget management for the following:

- NAMA development and implementation: The development of the SWH NAMA will require appropriate management of its financial resources in order to achieve all the project administration needs
- Technical capacities development: Improvement of the management capacities for the SWH NAMA administration and implementation; Suppliers registration in order to keep updated records of the available providers, installers and maintenance technicians for the project.

5.3. Divulgation and communication

In order to ensure the expected results of the SWH NAMA implementation, divulgation and communication of the NAMA features for all the interested parties and relevant stakeholders should occur, with special emphasis on the population of Belize, the commercial and industrial sector. Communication should include information on the responsible parties, objectives of the project, opportunities for participation, and general conditions and requirements for beneficiaries.

5.4. Local technical capacities

The institutions in charge of the management of the SWH NAMA should acquire and improve the technical capacities requirements for the effective development and implementation of the NAMA, the sustainment of its results and the maintenance of the equipment. For example, some minimum requirements to be strengthened are:

- Solar radiation and solar potential analysis and operative maximization of the resource, by districts.
- Sizing of the several types of solar water heaters, according to their operative differences and beneficiary requirements.
- Installation and maintenance of the several SWH systems.
- Identification of technical feasibility: Requirements for correct installation of SWH systems, as water quality, roof load capacity, installation point optimization for loss reductions, radiation gains, and costs reduction on intervention in structures.

5.5. Standards or regulation definitions

Standards, regulations or guidelines for technical requirements for imports, selection and installation of solar water heaters must be clearly defined, considering:

- Material resistance of solar water heaters should meet special climate conditions (hurricanes, for example).
- Water quality, considering calcium concentrations in some areas in the south-west region.
- Load capacity of the roof structure.

5.6. Pilot projects

A public outreach activity should be promoted in order to identify non-government associations that could access funds to develop demonstrative SWH projects. Those SWH systems must be installed by certified professionals and provide maintenance for two years at least, including training for at least two members of the community association.

Bidding rules and eligibility criteria must be developed according to technical documents (prefeasibility studies). Also, areas of socioeconomic interest, disposition of the association to data collection for MRV and the ability to cooperate with other entities that want to replicate their experience, must be considered for the selection.

5.7. Technical information

The availability of public radiation records is a key requirement for the development of solar potential studies. Additionally, a list of suppliers containing at least the available equipment, sizes, reference prices, installation options, and technical services should be developed.

5.8. Monitoring, report and verification

For the MRV framework, the following considerations should be fulfilled:

- The emissions and energy consumption baseline should be improved with more reliable data, informed by industries, hotels and a significant sample of households.

- Installation of SWH systems must be recorded, including size, replaced energy consumption and solar fraction data.
- Monitoring and reporting horizon should be clearly stated.
- Communication channels for monitoring should be determined, along with data recording, measuring and gathering requirements.

5.9. Financial and technical resources needs estimation

The estimation of the financial and technical requirements estimation is based on referential values for the proposed activities of the SWH NAMA development and implementation.

First, for the direct implementation of SWH devices, considering the referential values of the different SWH systems, provided by Chromagen, the implementation costs for the several sectors are shown in the table below.

Table 27. Unit costs of SWH system

Sector	Number of collectors	Total cost (BZD)
Hotel	5	16,307
Household	1	4,112
CPBL	150	457,313
Quality Poultry	600	1,829,250

Source: Own elaboration

With the values presented in the table above, and considering the amount of buildings to be covered by the NAMA, as detailed in the previous report, the total values for the full implementation are shown in the table below. These costs are expected to be covered by the users (private sector).

Table 28. Total costs by sector

Sector	Total buildings	Total cost (BZD)
Hotel	680	11,088,675
Household	42,560	175,001,400
CPBL	150	457,313
Quality Poultry	600	1,829,250
Total		**188,376,638**

Source: Own elaboration

On the other hand, the costs of the planning and the technical requirements of the SWH NAMA are shown in the following table.

Table 29. Technical requirement costs

Item	Includes	Annual Cost (BZD)	Comments
Administration	- One employee	$50,000	One person exclusively dedicated to the NAMA management
Dissemination and communication	- Campaign - Capacity building for households, and private sector	$60,000	- Dissemination strategy and materials - Capacity building: 4 sessions per year
Capacity Building	- Capacity building for institutional stakeholders	$30,000	4 sessions per year
Standard definitions	- Part-time employee	$60,000	- Referential value
Pilot projects	- Installation of SWH Systems in 1% of Households and Hotels	$2,326.000	Competitive funds
MRV	- Design and building of technology system	$400,000	Complete MRV system implementation
MRV	- QA/QC - Audits - Verification	$30,000	Annual operational costs
Total		**$2,956,000**	

Source: Own elaboration, 2017

It is important to note that the costs presented represent the total needs for the SWH implementation, and are expected to be afforded by several financing parties, such as international donors, public sector and private investments.

6. Elaboration of an MRV framework design for the SWH NAMA

The main objective of the elaboration of an MRV framework is to generate an appropriate evaluation system for the SWH NAMA impacts, considering the measurement, reporting and verification specific requirements of this project. This MRV system must accurately account for the expected GHG emission reductions from the use of solar water heating systems, replacing fossil fuel based heaters.

The system is intended to have a gradual approach, according to the implementation of the NAMA. Thus, the MRV system can be equally applied to earlier phases of the project and also fully operational ones.

The MRV system will be based on several indicators that aim to consistently measure the impacts of the NAMA, considering the values of transparency, consistency, comparability completeness, and accuracy according to the IPCC 2006 guidelines. All the data from the project activity must be collected and stored by the NAMA coordinating entity, while using an integrated system to allow access to all the information.

The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), in the document entitled "MRV Tool: How to set up National MRV Systems"[11] states a series of success factors for NAMA MRV systems. These are listed as follows:

- The quality of information collected through the whole system is a key point for its success. This relies on proper communication between the entities involved in the process.
- Roles and responsibilities must be clearly defined and each entity must have sufficient guidance to ensure the reliability and consistency through the process.
- Methods for the calculation of emission reductions must be credible and proven, using the best available data.
- The data must be collected ensuring quality and reliability and access to information should be open and transparent in order to increase the efficiency of the MRV system
- Existing MRV systems must be examined to ensure that the current system is designed according to national requirements.
- Continuous review and improvement of the process are important for the improvement of the plan; also, organizations with different expertise should be involved to maximize technical capabilities.

6.1. Measurement

Monitoring activities from the MRV framework have two main purposes, according to the Greenhouse Gas Protocol's document "Policy and Action Standard":

- To monitor and measure relevant indicators to assess the implementation progress of the SWH NAMA.
- To estimate GHG impacts through data collection for the ex-post GHG emission reduction calculation.

[11] https://www.transparency-partnership.net/sites/all/modules/contributed/pubdlcnt/pubdlcnt.php?file=/sites/default/files/u1585/mrv-tool-4-2.pptx__0.pdf&nid=2544

Those two functions will be taken into account by the monitoring plan, which will consider the proper set of key indicators for the assessment of the implementation of the SWH NAMA. On the other hand, proper planning will ensure the collection of high quality data for the accurate calculation of the GHG emission reduction.

The monitoring procedures for the data collection must have clear responsibilities for those involves and should ensure correct management of the process. The National Climate Change Office will lead the actions for the completion of the monitoring procedures requirements.

6.1.1. Monitoring procedures

The monitoring process will cover several data collection activities, considering the relevant indicators required for the assessment of the SWH NAMA development.

The main data collection method will be the development of specific surveys to be applied to a representative sample of the household and commercial sectors. This sample will be determined for each district, in order to assess the results of the SWH NAMA in each one, considering the different conditions and situations across the country. Furthermore, for the industrial sector, surveys may be applied to all the available industries.

The development of the surveys above mentioned should be begin to take place before the start of the SWH NAMA itself, with the intention of complementing the already available data and to develop a more complete baseline scenario for the GHG emission reduction and the energy and monetary savings.

The collected data for the monitoring process should be stored in a specifically designed system for the SWH NAMA, which allows the data input from several locations and access to the updated data.

6.1.2. Indicators

The following table shows the proposed indicators to be measured for the assessment of the SWH NAMA results.

Table 30. MRV indicators

Indicator	Unit	Frequency	Collection type
Implementation progress			
Number of installed SWH systems	Number	Annual	Measured
Investments on SWH technology	BZ$	Annual	Measured
Maintenance procedures	Number	Annual	Measured
GHG effects			

Indicator	Unit	Frequency	Collection type
GHG emission reduction	tCO_2e	Annual	Calculated
Fossil fuel consumption	m^3	Annual	Measured
Electricity consumption	kWh	Annual	Measured
Hot water Consumption	L	Annual	Measured
Hot water temperature	ºC	Annual	Measured

6.2. Reporting

Reports under the MRV framework of the SWH NAMA will meet international requirements, providing detailed and consistent information for decision making at the national level on programmes and policies. International standards on GHG emission reductions will be considered for reports, in order to make a proper comparison between NAMA and baseline scenario. Also, considering the measurement methodologies described above, emission reduction results will be available in both disaggregated and complete data.

The MRV system will provide relevant information for the national reports of Belize to the UNFCCC, considering the scope, actions and results of GHG mitigation from the SWH NAMA implementation. Nevertheless, the information provided by the NAMA reports won't match the level of detail required by the national reports, serving only as an input. Nevertheless, in the long term, it is expected that the data collected and calculated by the NAMA could be improved and be useful for GHG Inventories and National Communications. Also, annual reports will be delivered and will be available for relevant stakeholders, both private and public institutions.

6.3. Verification

Data and calculations for GHG emissions reduction of the SWH NAMA will be subject to a series of verification processes to ensure the values of transparency, consistency, comparability completeness, and accuracy according to the IPCC 2006 guidelines. Initially, collected data will pass through a basic verification, analysing its internal and temporal consistency, and correcting or excluding atypical values if necessary. This measure will ensure that any error can be minimized.

Emission reduction calculation and data entered will be subjected to an independent audit, by a government agency or organization, analysing the data collection, transcription and emission reduction calculation process. According to the IPCC 2006 guidelines, a good practice "includes reviews and audits to assess the quality of the inventory, to determine the conformity of the procedures taken and to identify areas where improvements could be made. Quality control

procedures may be taken at different levels (internal/external), and they are used in addition to the general and category-specific quality control". The MRV framework for the SWH NAMA will consider these recommendations.

Additionally, emission reduction calculations will be verified by a third party independent institution which will reproduce the calculations with the collected data, including comparisons between the calculations and relevant information as National Greenhouse Inventories.

The MRV framework stated above is matched with the IPCC 2006 guidelines as it includes the verification of the activities and procedures to ensure the reliability of the data and results. The scheduling of audits by external institutions can guarantee those requirements.

7. Next steps for the SWH NAMA

A series of activities have been identified in order to continue with the NAMA preparation and implementation. The most relevant next steps for the SWH NAMA preparation and implementation are the completion of the NAMA proposal, designing the specific MRV system and the financial mechanism for the implementation of the NAMA. The following table summarizes the proposed next steps and their related outcomes, responsible and timeframe.

Table 31. Next steps for the SWH NAMA

Outcome/ Activity	Description of outcome/activity	Main responsible	Timeframe
Outcome 1	**NAMA implementing entity and institutional arrangements in place**		
Activity 1.1	Definition and implementation of a managing structure for the NAMA (NAMA implementing entity)	Energy Unit	NAMA preparation
Activity 1.2	Development of institutional arrangements between the NAMA implementing entity and related institutional stakeholders	Energy Unit	NAMA preparation
Activity 1.3	Capacity building for institutional stakeholders	Energy Unit	NAMA preparation
Outcome 2	**Technical capacities and baseline information are available**		
Activity 2.1	Data collection (water heating needs, service temperature, water flow, actual energy source for water heating) for main industries	Energy Unit/SIB	NAMA preparation
Activity 2.2	Update of emission reduction calculation for the industry sector	NCCO/ Energy Unit	NAMA preparation

Outcome/ Activity	Description of outcome/activity	Main responsible	Timeframe
Activity 2.3	Development of standards and codes (SWH devices, water quality, buildings)	BBS, CBA/LBA	NAMA preparation
Activity 2.4	Certification of technicians and equipment	PUC	NAMA implementation
Outcome 3	**MRV system established**		
Activity 3.1	Design of a MRV system	Energy Unit/ NCCO	NAMA preparation
Activity 3.2	Implement information gathering system	Energy Unit/ SIB	NAMA implementation
Outcome 4	**Funds for the adoption of the SWH are delivered to eligible activities**		
Activity 4.1	Design of the financial mechanism for the NAMA	Energy Unit/ NCCO	NAMA preparation
Activity 4.2	Establishment of policies (incentives)	Energy Unit/ Ministry of Finance	NAMA preparation
Activity 4.3	Establishment of a MRV for financial mechanism	Energy Unit/ NCCO	NAMA preparation
Activity 4.4	Dissemination of the financial mechanism	Energy Unit	NAMA implementation
Activity 4.5	Execution of the financial mechanism	Energy Unit	NAMA implementation
Outcome 5	**SWH technology adopted by the users (residential, commercial and industrial sector)**		
Activity 5.1	Definition of eligibility criteria and bidding rules	Energy Unit/ NCCO	NAMA preparation
Activity 5.2	Design and development of an ongoing dissemination program of the SWH technology and the SWH NAMA	Energy Unit	NAMA preparation and implementation
Activity 5.3	Implementation of pilot projects in the residential and tourism sector in the different districts of Belize	Energy Unit	NAMA implementation
Activity 5.4	Capacity building for the users (pilot projects)	Energy Unit	NAMA implementation
Activity 5.5	Maintenance program for the pilot projects (2 years)	Energy Unit	NAMA implementation

8. Conclusions and recommendations

The relevant institutional stakeholders are identified and assessed in this NAMA concept. The different roles and actual capacities of each of the relevant institutional stakeholders, as well as the potential role for the implementation of the NAMA are described. The identified NAMA implementing entity is the Energy Unit of the Ministry of Public Service, Energy and Public Utilities, working with the collaboration from the NCCO.

Currently, the main barriers that this technology faces in Belize are the high cost of the devices, which is partially explained due to high import taxes; the lack of incentives to install the devices; and the lack of knowledge about the technology. In addition, in the residential sector the hot water demand is not constant over the year (hot water is mainly demanded in winter), and some of the existing households need to be retrofitted to incorporate the additional plumbing for installation of SWHs. The lack of human resources and technical capacities, and also the unavailability of national public funds to support the implementation of the NAMA are important limitations that should be addressed for implementation of the NAMA.

The GHG emission reduction for the residential and tourism (commercial) sector was calculated. For the industrial sector, the GHG emission reduction was calculated for two industries with available information. However, this sector has a much higher emission reduction potential if all the industries are taken into account. The overall GHG emission reduction calculated in this NAMA concept represents an initial estimation of the GHG emission reduction potential of the SWH NAMA, and could be improved if new data is collected in the future. Thus, additional efforts are required in order to collect enough data to improve the GHG emission reductions estimation.

An MRV framework is proposed, consistent with the principles of transparency, consistency, comparability, completeness, and accuracy according to the IPCC 2006 guidelines. The IPCC Guidelines provide an internationally recognized framework for the development of MRV systems. This approach allows ensuring the consistency with other monitoring in the country in the context of the GHG National Inventory Report. The proposed MRV framework will require the participation of the different stakeholders from Belize, such as the Energy Unit, NCCO, SIB and BBS, in order to achieve a robust system to follow up the progress and results of the SWH NAMA.

The implementation of the MRV system will require institutional arrangements to manage the process and the development of procedures, including the definition of responsibilities. A dedicated unit or person is proposed to be directly responsible of the implementation and operation of the MRV. This unit or person will be responsible for developing the measurement methodology, providing guidance on measurement and reporting and defining the process for verification.

The identified financial and technical needs for the SWH NAMA implementation involve administration and financing of the NAMA, direct investment on SWH (expected to be covered

directly by the SWH users, who should be given the proper incentives and technical support), divulgation and communication, local technical capacities, definition of standards or regulation, implementation of pilot projects, availability of technical information and implementation and operation of a MRV system. These activities will help to overcome the identified barriers for the implementation of SWH NAMA.

In this context, a key factor of success will be the implementation of pilot projects, which will serve as demonstrative projects to get the acceptance and interest among the local population in order to increase the awareness of the SWH technology among the population of the country. In addition these pilot projects will be considered as the first stage of a phased implementation of the NAMA. Thus, the functioning of the MRV system for the pilot projects will provide critical information to domestic stakeholders that should inform any changes to elements of the proposed system as part of the final design of a national system. In this way the pilot projects can be seen as part of an incremental step-wise approach to the final development of a national system. The dissemination and divulgation, as well as the capacity building among the institutional stakeholders and the private sector is also relevant for the success of the SWH implementation and operation, to ensure that the stakeholders as able to acquire the necessary skills.

The next steps towards the SWH NAMA implementation involve the completion of the NAMA proposal, designing the specific MRV system and the financial mechanism for the implementation of the NAMA, among other activities. The development of the financial mechanism for the implementation of the NAMA shall assess and include the appropriate financial instruments to provide the right incentives to consumers as well as to reduce the upfront costs. The establishment of policies, such as reducing the import taxes and to provide additional support to afford the initial cost of the technology, is important to help to overcome the identified barriers.

An initial workshop for the development of the SWN NAMA concept proposal was executed, with the purpose of bringing together the different stakeholders, such as providers, final users and the public sector. It was also useful to introduce them to the project, collect some relevant inputs and to teach them the relevant technical aspects of the technology as applied to Belize's context. This was important in order to improve the awareness of the technology and its benefits within the country.

The current NAMA concept proposal has the acceptance of the relevant institutional stakeholders, who have validated this proposal through a second workshop, where the NAMA concept was presented and discussed.

Annex 1

Methodology

a. Desktop review

In order to have a first glimpse of Belize's situation in matters of energy generation and consumption, climate change and general information, a review of the available relevant documents was carried out. This took into consideration the primary documentation provided by Belize's team and information taken from the peer-reviewed published literature and 'grey' literature (i.e. non-peer reviewed information from a variety of sources) as this latter category often contains information that is highly relevant for these type of studies.

The reviewed documents were the following:

1) National Context

- Annual Report. 2015. Belize Electricity Limited.
- Belize Sustainable Energy Action Plan. 2015. Ministry of Public Service, Energy and Public Utilities.
- Belize Sustainable Energy Strategy. 2015. Ministry of Energy, Science & Technology and Public Utilities.
- Energías Renovables en América Latina 2015: Sumario de Políticas. 2015. IRENA.
- Energy Report. 2015. Ministry of Public Service, Energy and Public Utilities.
- Mitigation and Carbon Markets Investor's Guide BELIZE – Chapter 4.6: NAMAs as a Mitigation Option for Belize and Roadmap for Implementation. 2014. National Climate Change Office.
- Mitigation Project Portfolio and NAMA Ideas for the Energy and Waste Sectors in Belize. 2014. National Climate Change Office.
- National Energy Policy Framework. 2011. Locke et al.
- Overcoming Barriers to Belize's RE and EE Potential. 2014. Castalia
- Proposal for a National Energy Policy for Belize. 2011. The Government of Belize.
- Statistical Institute of Belize. 2010. Belize Population and Housing Census Country Report.
- Strategic Plan 2012-2017. 2012. Ministry of Energy, Science & Technology and Public Utilities.
- The Energy Sector in Belize. 2014. Inter-American Development Bank.
- Technical Report. 2016. Li *et al.*
- Toward a national energy policy: Assessment of the energy sector in Belize. 2011. Department of Sustainable Development.
- Growth and Sustainable Development Strategy, 2015

2) Climate Change

- Belize INDC. 2015 and Belize NDC, 2016
- First National Communication to the Conference of the Parties of the United Nations Framework Convention on Climate Change. 2002. Minister of Natural Resources, the Environment, Commerce and Industry
- Second National Communication United Nations Framework Convention on Climate Change. 2011. Ministry of Natural Resources and the Environment.
- Belize's Third National Communication to the United Nations Framework Convention on Climate Change. 2016. National Climate Change Office.
- Third National Greenhouse Gases Inventory Report. 2015. Caribbean Community Climate Change Centre
- A National Climate Change Policy, Strategy and Action Plan to Address Climate Change in Belize. 2014. Caribbean Community Climate Change Centre.
- Low Carbon Development Roadmap (Revised),

The data collected was compiled and evaluated to generate a summary of the available information and after that it was elaborated to assess the quality and relevance of the information.

b. First Mission

With the intention of obtaining a better understanding of Belize's in-country situation, a mission to Belize was executed with the objective of gathering valuable information for the construction of the NAMA concept through consultation with the key stakeholders of the relevant sectors involved in the project.

The mission incorporated a series of meetings with the relevant stakeholders and a workshop to present the considerations and general information of the project to the interested parties, who are listed in the table below.

The schedule of meetings was developed by the National Climate Change Office, in collaboration with relevant stakeholders and the consultancy team.

Although the schedule of meetings was planned in advance, the schedule and the question scheme for each stakeholder were adjusted during the visit as per the availability of the persons to be interviewed.

The agenda included the following activities:

1. Coordination of the activities to be developed during the first mission.

2. Meeting with the Energy Unit of the Ministry of Energy, Science & Technology and Public Utilities
3. Meeting with the Ministry of Economic Development, Petroleum, Investment, Trade and Commerce
4. Meeting with the NCCO of the Ministry of Forestry, Fisheries, and Sustainable Development
5. Workshop: Development of a solar water heating NAMA concept for the industrial, commercial and residential sectors in Belize.
6. Interview with personnel from the Dream Valley Jungle Resort
7. Site visit to the Citrus Products of Belize
8. Meeting with the Santa Elena Education Center, Ministry of Education, Youth and Sports
9. Meeting with the Belize Electricity Limited
10. Meeting with the Central Building Authority
11. Meeting with the Public Utilities Commission
12. Meeting with the Holy Redeemer Credit Union
13. Visit to the Princess Hotel
14. Meeting with the Belize Bureau of Standards
15. Meeting with St. John's Credit Union Belmopan
16. Interview to the personnel from The Inn at Twin Palms Hotel