**BOTSWANA’S NATIONALLY**

**APPROPRIATE MITIGATION ACTIONS**

**By**

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# Acronyms

BAU Business-as-usual

BPC Botswana Power Corporation

CBA Calculation Based Approach

CFLs Compact Fluorescent Lamp

CH4 Methane

CO2 Carbon Dioxide

COP Convention of Parties

CSO Central Statistics Office

DFRR Department of Forestry and Rangeland Resources

DoE Department of Energy

DMS Department of Meteorological Services

DTRS Department of Transport Roads and Safety

DWMCP Department of Waste Management and Pollution Control

Eq. Equivalence

GDP Gross Domestic Product

GIZ Deutsche Gesellschaft fur Internationale Zusammenarbeit

Gg Giga gram

GHG Greenhouse Gases

GoB Government of Botswana

GWP Global Warming Potential

HH Household

IPCCC Inter Panel Convention on Climate Change

IPPs Independent Power Producers

LED Light Emitting Diode

LFG Landfill Gas

LPG Liquid Petroleum Gas

MBA Measurement Based Approach

MJ Mega Joules

MRV Monitoring, Reporting and Verification

NAMAs Nationally Appropriate Mitigation Actions

NPV Net Present Value

PV Photovoltaic

RE Renewable Energy

REFIT Renewable Feed In Tariff

UNFCCC United Nations Framework Convention for Climate Change

WUC Water Utilities Corporations

# Executive summary

This report details Nationally Appropriate Mitigation Actions (hereinafter NAMAs) for the Government of Botswana. The NAMAs were initially proposed in 2007 at the Thirteenth Conference of the Parties (COP-13) in Bali (GIZ, 2011). NAMAs encompass a set of policies, strategies and programmes that developing countries pledge to undertake on a voluntary basis with the objective of reducing GHGs emissions, while achieving a sustained economic growth and development over time. The NAMAs for Botswana emphasise on energy sector both the transformation and mobile energy sectors, and the waste sector. Conceivably, the identified sectors have feasible and cost-effective mitigations. Though these projects have been known to have the potential to reduce GHGs emission, they have not been implemented due to existing barriers. Therefore, this document identifies the barriers and recommends instruments to incentivise their implementation. Aptly, the document also details the monitoring, reporting and verification (hereinafter MRV) for the NAMAs. Fundamentally, MRV is designed for GHGs emissions, implementation progress for the Mitigation measures and international support for mitigation.

**Key findings of the analysis**

**GHGs Inventory**

The baseline GHGs for the major gases (CO2, CH4 and N2O) is estimated at 75 000 Gg of CO2 eq. 100 years GWP based on energy, waste, livestock, industrial processes and land use change and forestry sectors. The major emitting sector is land use and forestry contributing over 90 percent of total national emissions. CO2 accounts for 90% of total national GHG emissions. By 2030, it is projected that total GHGs emissions would be approximately 128 000 Gg CO2 eq. 100 year GWP. This increase would mainly be due to land use changes and forestry. Under land use change and forestry, deforestation from veldt fires accounts for over 50% of the total emissions. As the objective of the assignment is to define a low emission pathway for the country, the following are some of the mitigation actions that have the potential to achieve a low emission pathway for the country:

**Solar power station**

This is one of the identified mitigation actions which are in line with the GoB initiatives of achieving sustainable energy supply in the country. Currently, there are plans to for construct two (2) 50 MW Solar power stations in the country. This mitigation measure will result in reduced electricity production of approximately 350 million KWh per year from the coal fired power station and the resultant emission reduction will be approximately 761 Gg of CO2 eq., which translates into 9% emissions reduction from the non land use change and forestry sector.

**Efficient appliances**

This is another avenue which is actively pursued by the GoB, mainly through replacement of the incandescent light bulbs with efficient CFLs and LED bulbs. Another mitigation measure that has been identified under efficient appliances is gradual penetration of the efficient refrigeration system into the household sector. Based on the developed penetration scenario of these efficient electrical appliances, it is estimated that by 2030, they will contribute to emissions reduction of 399 Gg of CO2 eq.

**Solar Geysers**

This is another mitigation measure that can contribute to GHGs emissions reduction in the country. Due to the high cost of solar geysers, a slow penetration scenario was adopted and by 2030 it is projected that this mitigation will contribute approximately 87.7 Gg of CO2 eq. emission reductions.

**Improved Public Transport sector**

Improved public transport sector is another possible mitigation project. The country consumes significant petroleum products in excess of 800 million litres (diesel and petrol) due to high use of private vehicles. Therefore improving public transport sector would reduce GHGs emissions in the country. It is projected that by 2030, improved public transport system would result in emissions reduction of approximately 1350 Gg of CO2 eq.

**Land use change and forestry**

This is another possible mitigation project. It is the major GHG emitter in the country which contributes approximately 90% of the national emission. The most contributing factor to Land use change and forestry is deforestation mainly from veldt fire which contributes approximately 50% of the land use change and forestry. The mitigation measure under land use change and forestry is improved land management and optimal veldt fire management. Based on the ALU mitigation scenario of managing 30% of the deforested area cleared for mitigation, it is projected that by 2030, land use change and forestry would result in emissions reduction of approximately 16 000 Gg of CO2 eq.

Based on the identified mitigation actions and the developed scenarios, the country would reduce total GHGs emissions from 128,895 to 108,747 Gg CO2 eq. 100 year GWP by 2030. This would represent approximately 15% emission reduction by 2030 based on 2010 as the baseline year.

**Barrier to financing mitigation projects**

Climate mitigation actions have been known for the past 20 years. However, their implementation has lagged behind. This is mainly due to the existence of a number of barriers. Some of the barriers include the following:

* Lack of enabling and conducive environment for operations of the mitigation projections.
* High and long term investment nature of the projects.
* Existing subsidies on substitutes of climate mitigation projects.
* Existence of externalities and public good nature of the environment.
* Competing developmental priorities and limited resources.
* Stiff competition for available climate change funds.
* Lack of trained personnel to develop climate change proposal.

**Policy instruments to support operations of climate mitigation projects**

Based on identified barriers, it is fitting that policy instruments are identified and implemented to create conducive environment for operations and financing of mitigation projects. The table below depicts proposed instruments for effective implementation and operations of the proposed mitigation projects.

|  |  |
| --- | --- |
| **Policy instrument** | **Anticipated impacts** |
| Removal of subsidies on coal power electricity generation | * Cost reflective market price of coal based electricity which would make solar based electricity to be competitive and economically viable * Internalise the externalities associated with coal based electricity and reflect the true cost of producing coal based electricity |
| Introduce REFIT | * Encourages and promotes electricity generation from renewable energy resources * Ensures that producers of electricity from renewable sources have a guaranteed market and a reasonable rate of return * Ensures that RE is a sound long-term investment for investors * Encourages foreign direct investment |
| Introduce subsidies on solar generated electricity | * Reflect the benefits associated with solar electricity * Lower the unit cost of solar electricity to increase demand and take up |
| Introduce tax on petroleum products | * Increase the cost of using private vehicle * Discourage individuals to use large engine vehicles |
| Introduce parking fees and control parking on empty spaces | * Increase the cost of using private vehicles * Increase the number of people using public transport |
| Introduce subsidies on solar appliances | * Encourage use of solar appliance mainly solar geysers |
| Tax exemptions on environmentally friendly and energy efficient houses | * Encourage individual to invest in solar energy, environmentally friendly and energy efficient houses |
| Government as guarantor on climate loans | * Reduce country risks for foreign direct investment * Increase foreign direct investment |
| Introduce carrying capacity quotas. | * Avoided land degradation and increase ecosystems functions and services. |
| Introduce optimal charges for torching | * Discourage torching of rangeland |
| Introduce adequate allowances for voluntary community fire-fighting exercises | * Encourage voluntary fire fighting |

**Conclusions**

The report details the feasible and cost-effective mitigation measures that the GoB can implement without necessarily impeding economic growth and development. In fact, some of the identified mitigation measures have a positive net return on investment over a defined time period. The proposed mitigation measures include energy efficiency with specific focus on efficient lighting, efficient appliances such as refrigeration, switch to solar appliances mainly solar geysers, increase share of new and renewable sources energy, improved public transport system, landfill gas capture and improved land use change with emphasis on optimal management of veldt fire. It is projected that implementation of these mitigation actions would potentially reduce the country’s total GHG emissions by 15% by year 2030 based on 2010 as the baseline year. This emission reduction is based on the country generating its electricity with exports.

In order for the emission reductions target to be achieved, there is a need to have an enabling and conducive environment for the mitigation actions to work optimally. This would entail implementation of instruments such as removal of subsidies on coal based electricity generation, removal of subsidies on petroleum products and subsidies on solar electricity generation and increase charges related to starting veldt fire.

It is also important that MRV is undertaken for GHG emissions, mitigation actions implementation and international assistances in terms of financial flows and technical skill transfers.

**Recommendations**

Based on the findings of the assignment, the following recommendations are made for implementations:

* Implement the identified policy instruments to create a conducive environment for operation of the mitigation actions.
* Improve public transport by replacing mini-buses with buses, develop public transport infrastructures to encourage use of public transport.
* It is also critical that methane from LFG is exploited. The co-benefits of this project would be to reduce the import bill on Liquid Petroleum Gas (hereinafter LPG) and also create employment opportunities for the locals.
* Government guarantees high investment climate mitigation projects to encourage foreign and local direct investment into these projects.
* Lastly invest on fire management systems mainly surveillances, early warning systems and fire fighting technologies.

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# Introduction

This document presents the Nationally Appropriate Mitigation Measures (hereinafter NAMAs) for the Government of Botswana (hereinafter GoB). The NAMAs were originally proposed in 2007 at the Thirteenth Conference of the Parties (COP-13) in Bali (GIZ, 2011). Since the NAMAs proposal, they have eminently become the vehicle for international climate negotiations (Economic and Social Commission for Asia and Pacific, 2014). The formulation of the NAMAs was in recognition of the urgency to fulfil the ultimate objective of the Convention of stabilising the Greenhouse Gases (hereinafter GHGs) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Parties have recognised the need to take urgent action to meet the long term goal of holding the global average temperature increase below 2 oC above pre-industrial levels. Thus, for the developing countries, it was resolved that they should develop the NAMAs which would guide them to a low GHGs emission pathway while achieving sustained economic growth/development.

Essentially, NAMAs encompass a set of policies, strategies and programmes that developing countries pledge to undertake on a voluntary basis with the objective of reducing GHGs emissions, while achieving a sustained economic growth and development over time. The NAMAs proposal for Botswana emphasise on energy sector; both the transformation and mobile energy sectors, and the waste sector. Conceivably, the identified sources are feasible and perceived to be cost-effective in attaining a low emission path. Additionally, the NAMA proposal identifies barriers to financing the mitigation measures and the policy instruments under each mitigation action that can facilitate their optimal functioning. Aptly, this document also details the monitoring, reporting and verification (hereinafter MRV) for the NAMAs. Fundamentally, MRV is designed for GHGs emissions, implementation progress for the Mitigation measures and international support for mitigation.

# Methods used for national GHG inventory and mitigation potential

Various methods were used to estimate the country’s GHG emission and the identified mitigation measure emission reduction potential. For the energy sector, Long Range Energy Alternatives planning system (hereinafter LEAP) was used for both stationary and non-stationary sectors. LEAP is a computer-based model that calculates the country’s energy balance (supply and demand) and the corresponding GHGs emissions over a defined time slice. Incidentally, almost all GHGs emissions with the exception of Land Use Change (hereinafter LUC) are driven by the energy demand and consumptions making LEAP the suitable and appropriate model for GHGs emissions simulation. LEAP model has two modules, being; the energy demand module and the Technology and Environmental Database (hereinafter TED) module. The Energy Demand Module is used to estimate the energy requirements at sectoral, sub-sector and end-user level based on the energy intensity values and the type of fuel used. Whilst the TED module is used to estimate the emissions based on energy utilisation and the emission factors of different fuel types during the planning time slice. Using the functions of interpolation, extrapolation or growth rate, the future energy demand and corresponding emissions were estimated. Therefore, energy requirements and sources for all sectors (residential, commercial, industrial, transport, agriculture etc) will be simulated as well as the corresponding emissions.

Estimating emissions from land use change and forestry was based on Estimating GHGs emissions was based on the Agriculture and Land Use National Greenhouse Gas Inventory Software hereinafter (ALU). The software calculates emission based on land classification at the national and uses IPCCC emission factors. For other sectors such as agriculture (livestock), waste sector, industrial processes IPCCC emission factors mainly the default values were adopted for the country. most importantly, the IPCCC spreadsheets were used will requires activity.

# Projected GHG emissions over time

GHGs emissions in the country are from various sources with primary ones being energy (mobile and stationary), waste and agricultural sectors. Consequently, emissions are a function of socio-economic variables mainly population and growth rates, national income and economic growth. These variables drive the country’s GHGs emissions through the demand for energy source (electricity, fuel-wood and petroleum products) and waste generation. The country’s GHGs emissions were modelled based on the energy balance approach and IPCC emissions guidelines. It is important to note that the GHGs emissions estimates were based on meeting the country’s energy demands as opposed to exporting energy. Figure 1 to Figure 3 depicts the country’s GHGs emissions over time for both stationary and mobile energy sector.



Figure 1: GHG emission for the mobile sources of the energy sector

Figure 2: GHG emission from the stationary sources



Figure 3: Total GHG emissions for the Energy sector

## Livestock sector

The livestock sector mainly emits methane through the enteric fermentation and manure management. Estimating methane from enteric fermentation was based on the assumption that the country has reached the livestock carrying capacity and therefore the methane from enteric fermentation would be constant throughout the years. However, it is acknowledged that over time there will be fluctuations due to changes in mortality rates from droughts episodes. Estimation of the GHG emissions from the livestock sector was based on IPCC Tier 1 emission factors which are the simplified GHG emissions. Consequently, there are some levels of uncertainty in this default values due to the simplicity of the models. Based on the assumptions, methane emissions from the ruminant species is projected at 2415 CO2 eq 100 year GWP which is assumed to be constant throughout the projecting period.

## Waste sector

Waste sector produces GHGs through anaerobic process where bacterial activities break down organic matter under deprived oxygen environmental conditions. Within the waste sector, majority of GHGs emissions takes place at the managed landfills in the country. IPCC waste sector spreadsheet was used to estimate the GHG emissions based on the default values. Figure 4 depicts Methane production from the landfills in the country which shows a decline over time due to decomposition of the waste over time.

Figure 4: Methane emission from the landfill

## Land use change and Forestry

Land use change and forestry is globally one of the highest GHG emitters mostly through deforestation. Thus, through conversions from forestry to settlements and ploughing, deforestation occurs which results in GHG emissions mainly CO2. Additionally, ploughing of the agricultural fields disturbs the soil carbon which inevitably results in GHG emissions. It is important to note that some of the deforested carbon stored in the trees that have been deforested is emitted either through the energy sector or slowly released during tree decay. Therefore, caution must be exercised when estimating GHG emission from land use change and energy sector to avoid double counting. Estimating GHGs emissions was based on the Agriculture and Land Use National Greenhouse Gas Inventory Software hereinafter (ALU) was used to simulate GHG emission from the land use and forestry sector. Based on the prevailing land use classification and categorisation GHG emission for the land use change and forestry was estimated at approximately 59 271.71 Gg 100 GWP CO2 eq. deforestation mainly from veldt fires accounted for approximately 29,361 Gg GWP CO2 eq. which is about 49.5 % of all emissions from land use change. Figure 5 below depicts the projected emission from land use change and forestry up to 2030.

Figure 5: Projected Land Use change and forestry emissions

## Industrial processes

Industrial process in the country is another economic activity that emits significant amount of GHG worldwide. Two processes that significantly emit GHG include cement production and soda ash production. CO2 is produced from the production of cement through both chemical process and energy consumption. In this section only chemical process is estimated to avoid the problem of double counting. Cement production involve a process known as calcination or calcining which entails heating Calcium Carbonate (CaCo3) in a cement kiln to form lime. This process culminates in emission of CO2 as a by-product. Additionally CO2 is also emitted from cement kil dust (CKD) which is not recycled to the production process. The GHG emissions is estimated at about 10.8 Gg CO2 eq.

Soda ash production processes also culminate in the production and emission of CO2 in the atmosphere. In the country, industrial processes that emit significant amount of carbon dioxide is soda ash production. CO2 is produced when….

Based on the IPCC emission factor and spreadsheet and the current production of at Soda Ash Botswana, total GHG emission is estimated at 529.88 Gg of CO2 eq.

## Total GHG emissions

Projection of the country’s total GHGs emissions based on mobile and stationary energy sector, waste sector and the livestock sectors is as depicted in figure 5 below. Evidently, the country would achieve a steady increase in the GHGs emissions over time. This is generally attributed to population growth rates, incomes and economic growth which drives the demand for energy, number of vehicles and waste production.

Figure 6: National total GHG emission over the years

# Identified feasible NAMA s

This section of the report discusses the NAMAs for GoB. The NAMAs comprises of the mitigation actions by sector and their emission reduction potential based on prevailing assumptions and socio-economic scenarios. The NAMAs targets the energy sector (mobile and stationary), waste sector as these are point-sources with highly feasible mitigation actions and the land use change and forestry as it is the major emitter contributing approximately 90% of national GHGs emissions. Consequently, business as usual (hereinafter BAU) and low emission pathway for the country is defined based on the identified mitigation actions. The proposed technology for the target sectors include;

* Solar Power station
* Solar geysers
* Improved public transport system
* Waste to energy biogas
* Efficient appliances e.g. CFLs and LEDs and fridges
* Solar street lamps
* Solar Panels
* Land use change and forestry

Below is a detailed description of the mitigation actions, their GHGs emissions reduction impacts, co-benefits and policy instruments required for optimal performance of the measures and estimated costs.

## Energy Efficient appliances

One of the feasible and cost-effective ways of reducing GHGs emissions in the country is through a switch towards efficient electrical appliances. Efficient electrical appliances reduce GHGs emissions by reducing the overall electricity demand and automatically energy transformation from coal based electricity. Some of the efficient electrical appliances include efficient lights, efficient refrigeration and solar lights. These mitigation actions are discussed below.

### Energy Efficient lighting

Lighting is one of the major users of electricity at the domestic and institutional sectors, estimated at approximately 25% and 50% respectively. GoB through Botswana Power Corporation (hereinafter BPC) has made significant efforts in replacing incandescent light bulbs with more efficient Compact Fluorescent Lamps (hereinafter CFLs). It is generally estimated that CFLs are 25% more efficient relative to the incandescent bulbs while LEDs are 50% more efficient. Consequently, this translates into an electricity consumption reduction of 25% and 50% for CFLs and LEDs respectively. Based on increased penetration of more efficient lighting at both rural and urban household and institutional, figure 6 depicts electricity demand over time.

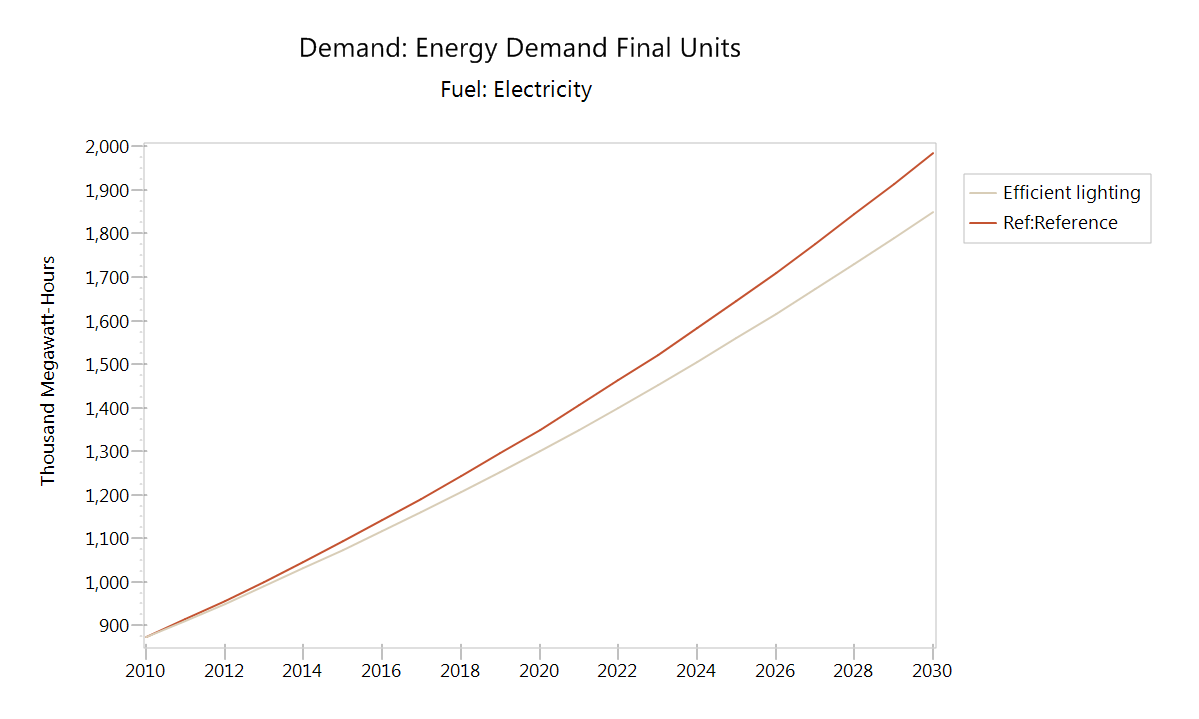


Figure 7: Domestic electricity consumption over time in Million KWh

Based on the projected reduced electricity demand from efficient lighting, figure 7 depicts the reduction in CO2 in 100 year GWP over the years. By 2030, it is estimated that efficient lighting would contribute approximate 5% reduction in GHG emissions from the transformation sector. On the other hand, figure 8 depicts N2O emission reductions in CO2 eq. 100 year GWP.

Figure 8: Reduced CO2 emission from efficient lighting

Figure 9: Reduced N2O emission in Gg CO2 eq. from efficient lighting

### Efficient refrigeration

This is another mitigation measure that has the potential to significantly reduce the GHGs emission in the country. Efficient refrigeration similar to the efficient lighting would reduce the electricity demand at the household levels by limiting the demand for electricity and corresponding GHGs emissions. Figure 9 depicts energy consumption for electricity based on efficient refrigeration and current less efficient refrigeration.

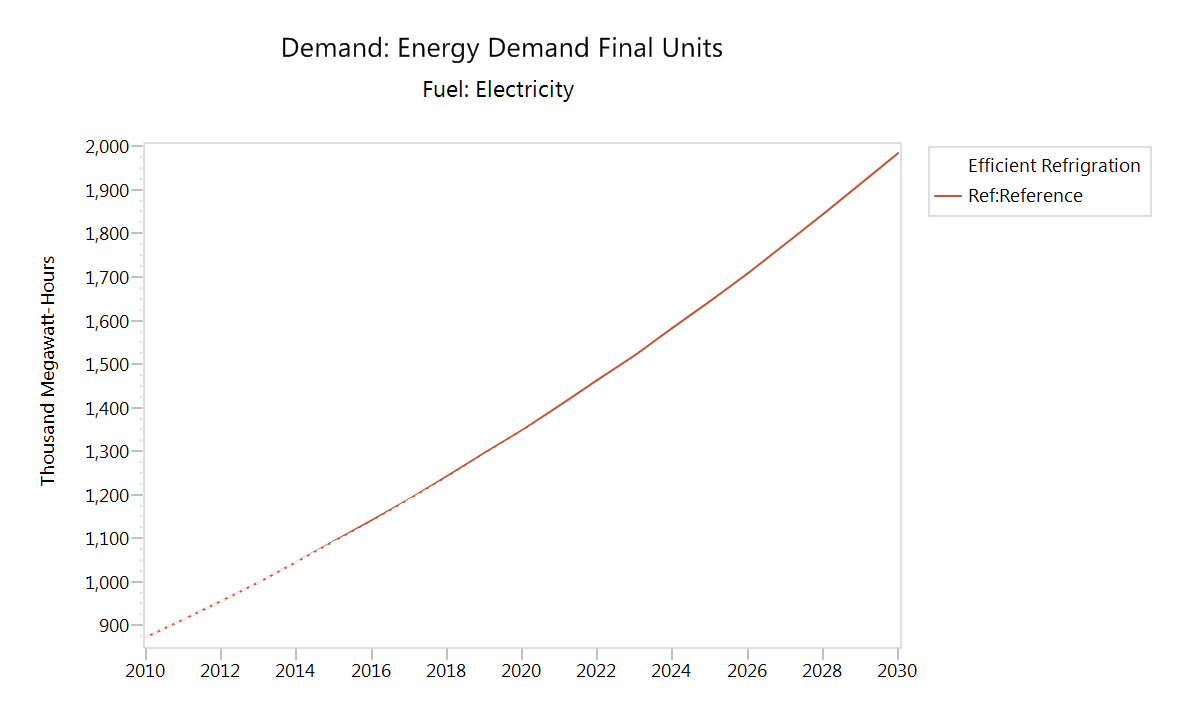


Figure 10: Domestic electricity consumption by refrigeration

Figure 10 shows the projected reduction in CO2 emission from the transformation sector based on efficient refrigeration. Conversely, efficient refrigeration results in reduced demand for electricity. This represents approximately 0.5 percent of CO2 emission from electricity generation.

Figure 11: Reduced CO2 emission in Gg from efficient Refrigeration

### Climate smart buildings

Climate smart buildings comprise of a combination of efficient lighting in addition to natural cooling. Heating and cooling are some of the major household and institutional energy demand. It is estimated that these activities (cooling and heating) constitutes approximately 10% of the household and institutional electricity demand. However, it is noted that the effect of climate smart building will be insignificant as most of the houses have already been constructed.

### Co-benefits

The co-benefits for these mitigation measures include the following:

* Income saving: Through energy efficiency, electricity users (households, business community, civic communities etc) save a significant amount of revenue from electricity savings.
* Environmental benefits: in addition to reduced GHGs emissions, there will be improved environmental quality which will translate into health benefits from the communities in the proximity of the coal power station.
* Reduced water consumption: water is a scarce resource in the country and coal based electricity generation is one of the major consumers of water resources. Therefore by reducing electricity consumption through energy efficiency and savings this will translate into reduced water consumption.

### Cost estimates

The overall cost of the project assuming 80% and 50% penetration for the efficient lighting will be in the region of approximately BWP 50 million per annum. However, based on time frame of 15 years, this translate into a net present value (hereinafter NPV) of approximately BWP 40 million which shows that the project is financially viable

### Current barriers to switch to efficient appliances

Despites lack of their widespread uses in the country, efficient appliances have been in the markets for a long time. Some of the factors impeding their uptake are as follows:

* Costs: generally the initial costs of purchase for the efficient appliances are higher compared to the substitutes and this inhibit the users from purchasing them.
* Existence of externalities: this is another factor that inhibits the use of efficient appliances as users do not internalise the social costs associated with their uses. Therefore, when making economic decision, the users only integrate the private cost and end up using inefficient appliances. Linked to the existence of externalities is the fact that the environment is a public good.
* Electricity subsidies: the result of subsidies is such that the cost of inefficient use of electricity becomes insignificant low to force users to be efficient in the use of electricity.

### Policy Instruments

In order for the proposed mitigation actions to function optimally and achieve the projected emission reduction targets, there is need for an enabling environment in the form of instruments. The proposed instruments for this mitigation action are:

* Tax on inefficient appliances such as incandescent light bulbs
* Subsidy on CFLs and LEDs
* Removal of electricity subsidies

These instruments will promote use of efficient appliances relative to the inefficient ones which are currently cheaper.

### Proposed funding options

It is proposed that government and electricity users will jointly fund this mitigation action through revenue obtained from taxing inefficient appliances and purchasing efficient appliances. Therefore a fund must be established where revenue obtained from taxes will be deposited. This mitigation action will be domestically funded.

### Planned activities for mitigation action implementation

A switch to the use of efficient appliance requires mind set change from the consumers’ side. Emphatically, information dissemination is paramount on the types of efficient appliance and their associated benefits. The following are the activities that must be undertaken for implementation of this mitigation action:

* sensitisation of the general public on the existing efficient appliances with emphasis on CFLs and LEDs
* development of optimal tax on inefficient appliances
* development of a government fund to collect tax revenue generated from sale of inefficient appliances
* implementation of tax

## Solar electrical appliances

One of the major users of the fossil fuels mainly diesel is groundwater pumping by both the state owned parastatals such as Water Utilities Corporation (hereinafter WUC) and the private cattle owners. A switch from diesel powered pumps to solar electrical pumps is one of the feasible GHGs emissions reduction mitigation actions. Figure 11 depicts projected emission reduction by switching to solar energy at the cattle post and Water Utilities boreholes.

Figure 12: GHGs emission reduction due to switch to solar energy

### Co-benefits

The co-benefits for this mitigation action are:

* Environmental benefits: reduced emissions which translate into improved environmental air quality and health benefits.
* Income savings: the variable costs of solar powered appliances are minimum hence a saving to farmers and WUC over time.

### Cost

Solar energy switch encompasses appliances such as solar geysers, solar pumps amongst other. The cost projected for this mitigation action is approximately BPW 600 million and the NPV is negative estimated at around BWP 16 billion, hence the project is not viable over a 1o year period. However, economically the action could be viable.

### Barriers to use of solar appliances

The following are some of the barriers that inhibit use of solar appliances:

* Costs: solar appliances are relatively more expensive compared to conventional appliances
* Existence of externalities: this is another factor that inhibits the use of solar as users of conventional appliances are not forced to internalise the social costs associated with their uses thus lowering the cost of electricity use.
* Electricity subsidies: this results in the cost of electricity to become cheap which does not encourage users to switch to solar energy as a way of saving electricity bill
* Vandalism and theft of electricity appliance: solar appliances are prone to vandalism and theft particularly solar panels and this discourages their uses.

### Policy instruments

Similar to efficient lighting, there is need to incentivise the public to switch to renewable energy. One of the factors currently inhibiting a switch to solar appliances is the current high initial investment costs of purchasing solar pumps. Therefore the following instruments would incentivise the public into purchasing solar appliances:

* Tax on petroleum products: currently petroleum products are cheaper in Botswana compared to South Africa where they are imported from.
* Subsidies on solar appliances: all solar appliances should be subsidised to encourage farmers to use them
* Removal of petroleum products subsidies: it is also important that subsidies on petroleum products are removed to make solar energy alternatives to be competitive.

### Proposed Funding Options

It is proposed that government and the users will jointly fund this mitigation measure through revenue obtained from petroleum tax. The revenue will be used to subsidise solar pumps.

### Proposed implementation activities

The following are the proposed activities for implementation of this mitigation action:

* Information dissemination on benefits associated with renewable energy appliances
* Identification of optimal tax on alternatives (petroleum products and coal based electricity)
* Implementation of the tax and subsidies on solar energy

## Solar street lights

This is another feasible mitigation measure that is on-going to reduce the cost of lighting the cities and their settlements in the country. Replacing the electric bulbs with solar streetlights would reduce the demand for coal produce electricity and thus reduce emissions from the energy sector. Based on the replacement scenarios, figure 13 depicts GHG emission reduction thus this mitigation measure

Figure 13: Reduced GHG emission in CO2 eq. from solar streetlights

### Co-benefits of installing solar streetlights

The benefits associated with the implementation of this proposed mitigation action includes:

* Environmental benefits: reduced emissions which translate into improved environmental air quality and health benefits.
* Avoided costs from paying electricity tariffs
* Reduced risk from power cuts and reduced incidents of crime associated with unlit streets

### Cost estimates

Based on a 15 year period, the NPV for the mitigation action is estimated at a loss of BWP1.6 billion and therefore the project is not financially viable.

### Barriers to implementing solar lights

The following are some of the barriers that inhibit use of solar appliances:

* Costs: solar appliances are relatively more expensive compared to conventional appliances
* Existence of externalities: this is another factor that inhibits the use of solar as users of conventional appliances are not forced to internalise the social costs associated with their uses thus lowering the cost of electricity use.
* Electricity subsidies: this results in the cost of electricity to become cheap which does not encourage users to switch to solar energy as a way of saving electricity bill
* Vandalism and theft of electricity appliance: solar appliances are prone to vandalism and theft particularly solar panels and this discourages their uses.

### Policy instruments

The recommended policy instruments, to optimise the operations of the mitigation actions are:

* Removal of subsidies on electricity and Introducing tax to internalise externalities
* Subsidies on solar appliances

### Proposed funding options

It is proposed that the initial investment costs will be funded both the international funding organisations and the Government of Botswana.

### Proposed implementation activities

Implementation of solar streetlights will involve the following activities:

* Develop and submit proposal for international funding
* Replace the existing electric powered streetlights with solar lights

## Installation of solar power system to primary school

This is another mitigation measure that is targeting reduction in energy demand from coal fired power station and thus automatically reducing the national GHG emission. Consequently, this mitigation measure is on-going and target to install solar power system in 65 primary schools. The proposed project is targeting schools in remote areas and will only be used for television operation and computer labs. Based on the installation scenario, the avoided electricity consumption is estimated at about 5000 kwh and therefore it contribution to emission reduction is insignificantly low.

## Transport sector

Transport sector falls under the energy sector and classified as mobile sources. It can be categorised as rail, road, water and air. The Draft Energy Policy indicates that the sector relies on imported petroleum fuels (well over 800 million litres per annum) and is the major consumer of petroleum products in Botswana (38%), of which more than 90% of the petroleum is being used on road transport. All rail traction is diesel powered and accounts for some 3 % of diesel usage in the transport sector. Road and air transport and associated transport fuels are consumed primarily as intermediates and benefit from petroleum products being regulated where appropriate.

One of the factors that contribute to high consumption of fossil fuel is the high use of private vehicles as opposed to public transportation. The poor service offered by the public transport sector has fuelled the demand for private vehicles. Thus, one of the feasible mitigation action is improved public transportation system. This will involve replacement of the mini-buses with buses, improved roads infrastructures and buses to run on cleaner LPG and biodiesel. Figure 12 to 14 depicts the GHGs emissions based on BAU and improved public transport systems.

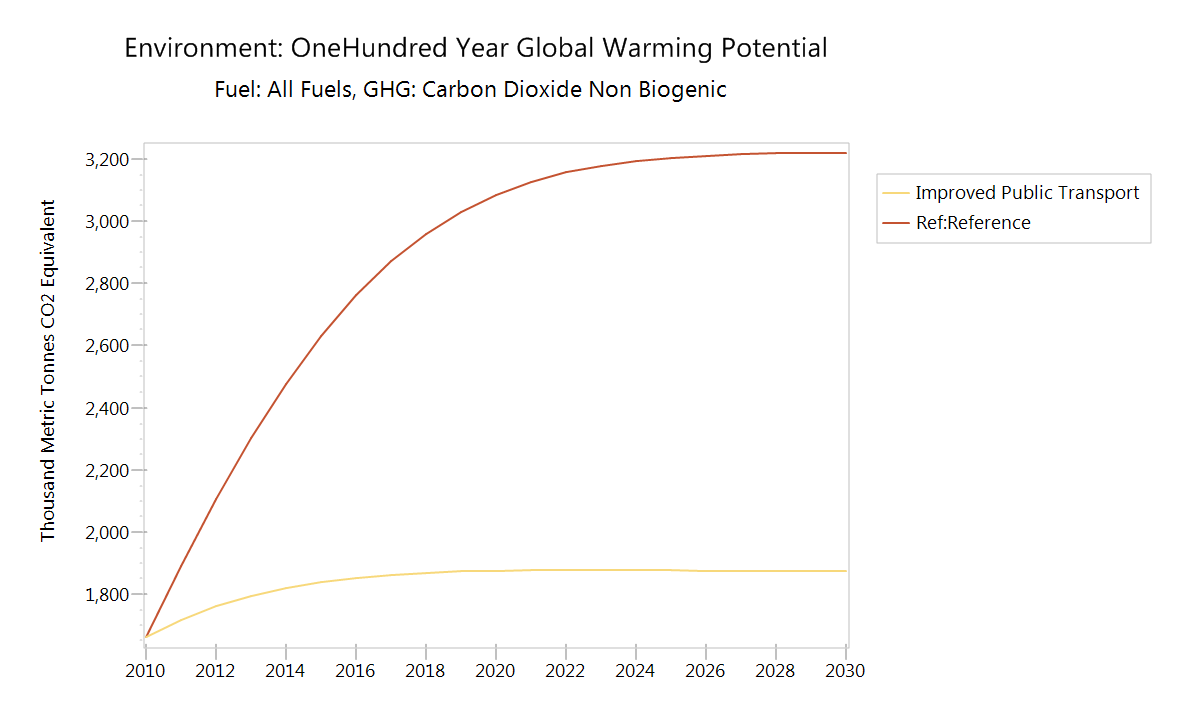


Figure 14: Projected CO2 emission for the transport sector

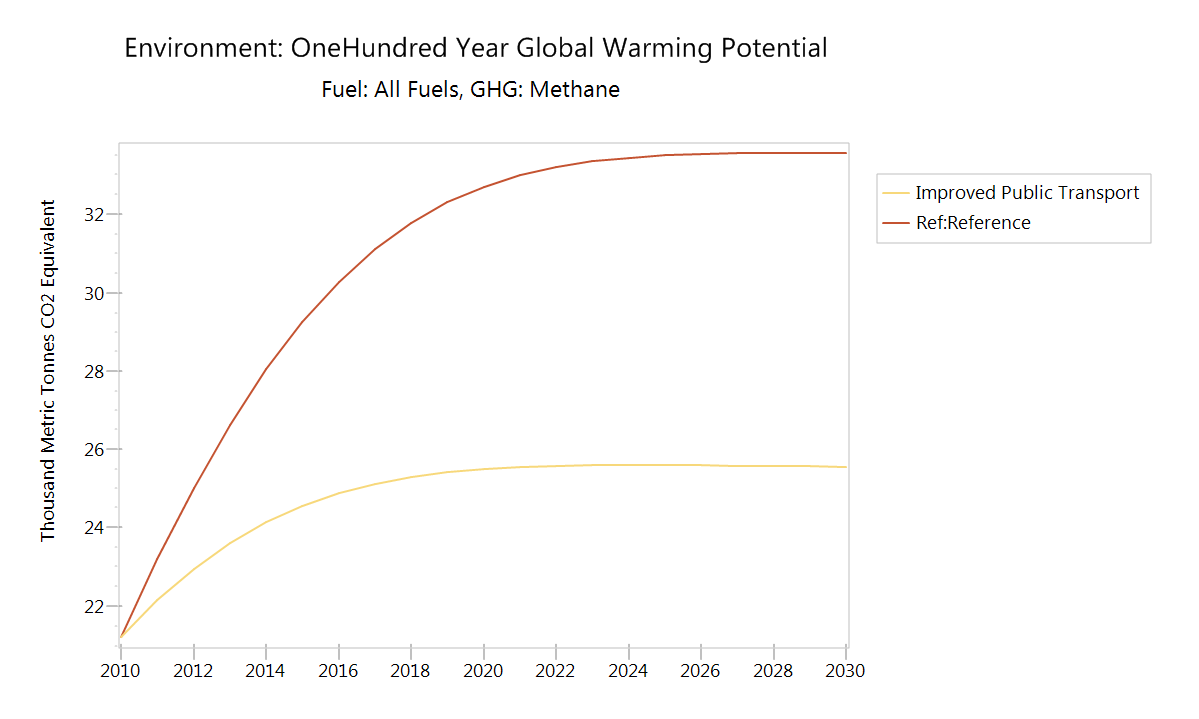


Figure 15: Projected CH4 emission for the transport sector

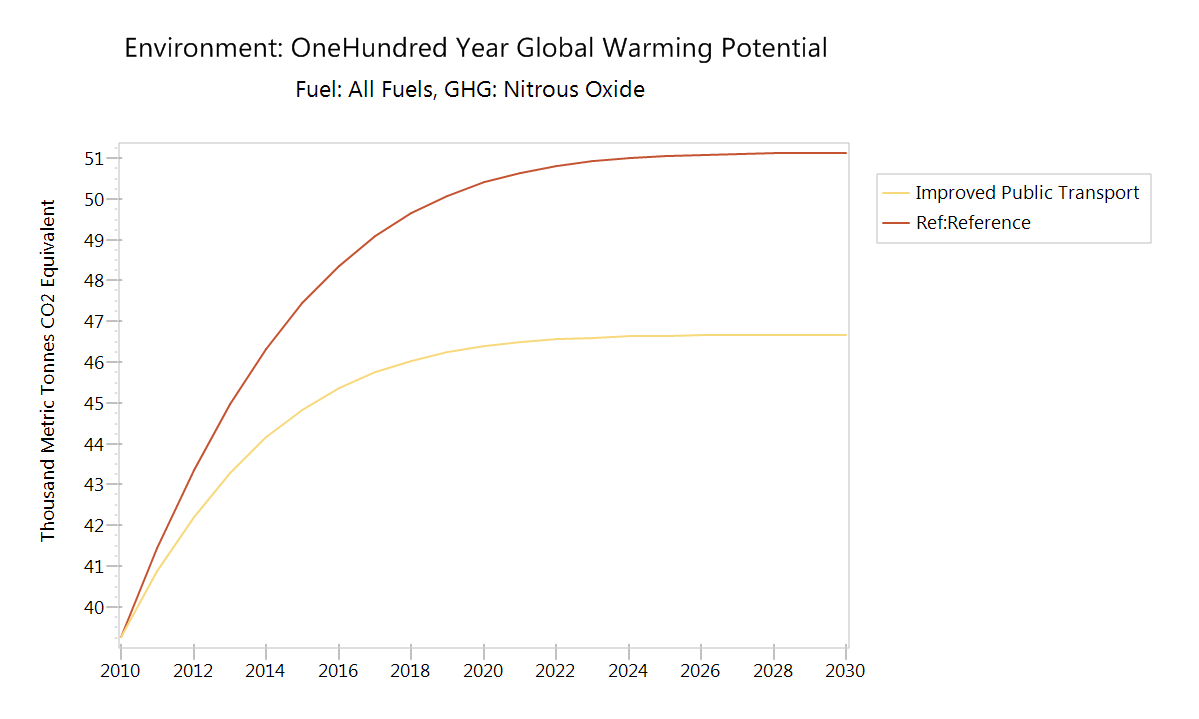


Figure 16: Projected N2O emission for the transport sector

### Co-benefits

The benefits associated with the implementation of this proposed mitigation action include:

* Revenue generated from operations
* Saving made by the general public (reduced mileage and petrol costs)
* Increased productivity due to early arrival at work
* Reduced road accidents in the cities
* Reduced GHGs and vehicle emissions
* Improved urban air quality
* Reduced incidents of diseases associated with improved urban air quality

### Cost estimates

It is estimated that the initial investment costs will be in the region of BWP 2 billion. Based on a 15 year period, the NPV for the mitigation action is assessed to be BWP89 million and therefore the project financially viable.

### Barriers to use of public transport

The following are some of the barriers that have been identified to discourage member of public to use public transport**:**

* Inefficient public transport system: public transport in the country is highly inefficient in terms of time management and this generally encourages the public to use their private vehicles.
* Comfortability of the systems: currently public transport in the cities and large villages use mini-buses as opposed to buses. This results in overcrowding in the mini-buses and reduces their comfortability. In addition, the mini-buses are generally old and condition appalling.
* Subsidies on petroleum products: petroleum products (diesel and petrol) are cheaper in the country compared to South Africa where they are imported from due to subsidies. The effect of subsidies is that it reduces the cost of using private vehicles. This encourages the public to use their private vehicles excessively.
* Low costs of use private vehicles: in addition to low cost of petroleum products, the registration and vehicles tax in the country are generally lower to non-existent in the country. This encourages high rate of ownership.

### Policy instruments

The recommended policy instruments, to optimise the operations of the mitigation actions are:

* Introducing tax on petroleum products.
* Introduce parking fees and control parking on empty spaces.

In addition, it is also proposed that the current public transport sector be improved by replacing mini-buses with buses, construct bus lanes and improve reliability of the buses.

### Proposed funding options

It is proposed that the initial investment costs will be funded by the international funding organisations while operational costs will be funded by revenue generated from the mitigation actions operations.

### Proposed implementation activities

Implementation of improved transport sector will involve the following activities:

* Develop and submit proposal for international funding for improved transport system
* Design of transport infrastructure in the urban areas
* Construction of the transport infrastructure that have been designed
* Purchase of buses to replace mini-buses
* Removal petroleum product subsidies
* Design petroleum product taxes and implement

## Electricity transformation

Botswana Energy Statistics of 2008 indicates that the country’s energy resource base is dominated by coal resources which are estimated at 212 billion tonnes, almost double those of its neighbour, South Africa, which are estimated at 121 billion tonnes. Currently, coal consumption is only around one million tonnes per annum of which more than half is used for electricity generation by BPC. Another factor that makes the country to be highly reliant on coal fired power plants to produce electricity is that currently, solar power plants are generally expensive to invest in. Despite these inhibiting factors the country has built a 1.3 MW Photovoltaic (PV) Solar Power Plant which has been connected to the national grid.

### Solar power plants

This is one of the feasible and viable mitigation actions. According to the draft Energy Policy, the proposed goal for renewable sources of energy is to maximise their potential in meeting the socio-economic needs of the country. Moreover, GoB has set a target to increase the use of renewable energy to 25% by 2030. Through the amendment of the Electricity Supply Act in 2007, Independent Power Producers (IPPs) are now permitted to participate in the sector.

Solar power plants have zero emission and thus have the potential to significantly reduce the GHGs emissions over time. Currently, the country is planning to construct two (2) 50 MW solar power plants to supply the mines in the country and also supply the economy with surplus. The two (2) 50 MW solar power plants would produce approximately 328.5 MWh which translated into avoided GHGs of approximately 1000 Gg CO2 eq. emissions for CO2 and 236 Gg CO2 eq for Nitrous oxide annually respectively.

### Co-benefits

The co-benefits from solar power plant which are quantifiable include the following:

* Power generation.
* Avoided costs of using coal as a feedstock, this avoided costs are reflected in the market price of electricity.
* Avoided environmental impacts and health impacts from emissions.
* Avoided environmental impacts associated with water required in coal fired power station and water depletion.
* Employment creation.

### Cost estimates

The investment cost of this mitigation action is estimated in the region of BWP150 billion with a negative NPV over a 10 years period. Therefore financially this project is not viable while economically it could be viable.

### Barrier to investing in solar power plants

The following as some of the barriers to invest in the renewable energy in the country:

* High investment costs: solar plants are generally characterised by exorbitantly high initial investment and are long term investment. This discourages the private sector to investment in the sector.
* Lack of guarantee on loans: high investment costs and lack of guarantors act jointly to discourage potential financiers from giving loans to investors.
* Subsidies on substitutes: A low cost of fossil based electricity generally lowers the attractiveness of investing in solar generated power. The financial viability of solar based power becomes non-competitive due to the low market price of the energy.
* Low investment cost on substitutes: in addition to existence of subsidies, the initial investment costs of coal fired power station are generally lower and this automatically attracts potential investors to invest in substitutes.

### Policy instruments

The following policy instruments are recommended for this mitigation action:

* Removal of subsidies on electricity generated from coal
* Introduce Feed In Tariffs for renewable energy
* Increase tax on electricity generated from coal to internalise the externalities

### Proposed funding options

It is proposed that initial investment be funded by the international financiers (World Bank, African Bank, GEF etc.) while the operational costs should be met from revenue generated from REFIT.

### Proposed activities for mitigation action implementation

The following are the planned activities that will enable implementation of solar power station:

* Development and submission of funding proposal for solar power station
* Identification and acquisition of land for construction of the solar power station
* Development of the strategy for FeedIn tariff
* Removal of subsidies on coal based electricity
* Introduction of subsidises for solar generated electricity

## Waste sector

### Methane capture

Energy provision is generally about innovating around and exploiting the country’s indigenous and locally generated raw materials. Thus methane capture is another innovative feasible and highly viable mitigation measure as all landfills constructed in the country require construction of gas capture systems to avoid landfill gas build-up and potential explosion of the landfills. Based on the IPCCC waste model, and assuming a 0.5 fraction recovered methane, figure 15 depicts Methane emission from the landfills in CO2 eq. 100 year GWP.

Figure 17: Methane emissions under capture scenario

### Co-benefits

The benefits of the LFG facility in addition to the avoided cost of climate change include:

* Bio-electricity power generation.
* Revenue generated from sale of methane as a fuel for the vehicle or cooking gas.
* Employment creation: This mitigation measure will create employment opportunities for the local communities.

### Cost estimates

The LFG facility is financially viable at a discount rate of 5% with NPV of approximately BWP 350 million with an initial cost of approximately BWP 70 million.

### Policy instruments

Policy instrument proposed for this NAMA is the Introduction of Renewable Feed In Tariffs (REFIT). REFIT is a mechanism that can be used for the deployment of renewable technologies such as biogas, landfill gas, solar, wind etc. as well as allow multiple developers to fast track a number of projects.

### Proposed funding options

Funding options proposed for this NAMA include international funders and operational costs to be funded by revenue generated from the sale of cooking gas.

### Proposed activities for mitigation action implementation

The following are the planned activities that will enable implementation of landfill Gas facility:

* Development and submission of proposal for international funding
* Identification of partnership to manage the gas facility
* Construction of LFG facility

## Land use change and forestry

This is the major GHG emitter in the country which contributes approximately 90% of the national emission. The most contributing factor to Land use change and forestry is deforestation mainly from veldt fire which contributes approximately 50% of the land use change and forestry. Therefore, the feasible mitigation measures include improved fire management in the country to reduce the veldt fires and pasture management to reduce deforestation and improved access to rural electrification and lastly, enhance natural reforestation of the degraded rangelands. Based on the ALU mitigation scenario for deforestation rate and adopting a 30% deforested area cleared for mitigation, figure depicts GHG emission reductions up to 2030.

Figure 18: Emission reduction from improved land use management

### Co-benefits

The benefits of improved land use management which entails veldt fire management include:

* Avoided land degradation and increase ecosystems functions and services: improving land use management as noted would reduce environmental degradation and thus increase the ability of the ecosystems to support economic activities such as improved agricultural productivity
* Increased wildlife population: improved land use management and reduced veldt fire would also enhance wildlife population and hence contribute to tourism sectors in the country
* Reduced vulnerability of the rural communities to climatic variability such as drought: improved land use management reduce environmental degradation and this increases the ecosystem stability and resiliency to weather pattern and thus able to support economic activities even during drought period. Consequently, the livestock mortality is reduced relative to less managed rangelands

### Policy instruments

The following as some of the proposed policy instruments for improved land use management to reduce deforestation and land degradation:

* Introduction carrying capacity quotas and livestock tax on exceeded numbers
* Review existing charges for fire veldt and introduce optimal charges that would discourage torching
* Introduce adequate allowances for voluntary community fire-fighting exercises

### Proposed funding options

Funding options proposed for this NAMA include international funding and local funding. It is proposed equipment for fire management and surveillance would be internationally funded while fire breakers and maintenance operational costs will be domestically funded.

### Proposed activities for mitigation action implementation

The following are the planned activities that will facilitate improved land use management and reduced deforestation in the country:

* identification of the additional fire breakers to be constructed
* development of the management plans for the maintenance
* acquire fire surveillance system and equipment
* construct fire stations at areas prone/susceptible to veldt fires such as chobe, Ngamiland Central district (Nata areas)
* develop a land use plan with emphasis on agro-ecological zoning
* develop an agricultural policy encourage afforestation (fruit trees) within the ploughing fields

## Prioritised summary table of Mitigation Action

Table below summarises the NAMA proposal for the country based on the identified actions and their potential impacts. The mitigations are prioritised based on the easiness of implementation and cost effectiveness and the operational status of the project.

Table 1: Prioritised summary of NAMA proposal

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Mitigation Action** | **Status** | **Specific Objectives** | **Description**  **Type of action** | **Coordination and Management** | **Estimated Emissions Reduction Potential** | **Co benefits** | **Recommended facilitation policy** | **Type of Support anticipated** | **Cost of preparation and implementation** |
| Switch to energy efficient lighting | On-going | To reduce electricity consumption by 25% and 50% for CFLs and LEDs respectively | Replacing incandescent light bulbs with efficient CFLs and LEDs at household and commercial level | BPC  DoE  DMS | 5% reduction in GHG emissions | Electricity saving; Avoided pollution from reduced electricity demand | Tax Put an inefficient appliances (incandescent bulbs) | Government | Average of P200 million per annum to 2030 |
| Introduction of efficient refrigeration | On-going | To reduce demand for electricity | Reduce electricity demand at household levels by limiting the demand for electricity and corresponding GHG emissions | BPC  DoE  DMS | 0.5% of GHGs emission from electricity generation. | Electricity saving; Avoided pollution from reduced electricity demand | Tax inefficient refrigeration | Government | Average BWP 50 millio per annum |
| Introduction of solar geysers | On-going | To replace conventional geysers with solar geysers | Reduce electricity demand at household and institutional sector | DoE  DMS | Will contribute 87.7 Gg of CO2 eq. emission reductions | Improved environmental quality  Increase the country energy security  Reduce energy supply deficits | Introduce subsidies on solar equipment | Domestically funded | Average of 1716 million per annum to 2030 |
| Introduction of solar electrical appliances | On-going | To switch from diesel powered pumps to solar electrical pumps | Major users of the fossil fuels mainly diesel is groundwater pumping by both the state owned parastatals and private cattle owners | WUC  MoA  DoE | 10 Gg CO2 eq. emission reduction | Reduction of use of fossil fuels | Introduce subsidies on solar equipment | Government and external funding | P50 million annually |
| Replacement of electric streetlights with solar streetlights | On-going | To replace electricity powered street lights with Solar street lamps | Replacement of electric streetlights with solar streetlights especially in the big town and cities | DoE  Local councils  BITRI | 38 Gg CO2 eq. emission reduction | Reduction of use of fossil fuels | Introduce subsidies on solar equipment | Government and external funding | P230 million annually |
| Improved land use management | On-going | To improve fire management hence reducing the veldt fires and pasture management. To reduce deforestation and improved access to rural electrification. To enhance natural reforestation of the degraded rangelands. | Identification of additional fire breakers to be constructed.  Development of management plans.  Acquire fire surveillance system and equipment.  Construct fire stations at areas prone to veldt fires.  Introduce agro-ecological zoning.  Encourage afforestation. | MoA  MLGL | 16000 Gg CO2 eq. emission reduction | Avoided land degradation and increase ecosystems functions and services.  Increased wildlife population.  Reduced vulnerability of rural communities to climatic variability. | Introduction of carrying capacity quotas and livestock tax on exceeded numbers.  introduce optimal charges that discourage torching.  Introduce adequate allowances for voluntary community fire-fighting exercises. | International funding and local funding | Difficult to estimate given time constraints |
| Exploitation of landfill gas | Proposed | To capture methane from landfills | Construction of LFG facility at selected landfills in the country which can be used to generate use the electricity or captured gas for domestic use | DWMPC | Reduce GHG emissions by 2% from energy sector | Revenue generated from sale of methane as a fuel for the vehicle or as cooking gas | Increase energy self-reliance  Reduce country import bill from energy imports  Employment creation | Government and external funding | P70 million |
| Bio-electricity generation | Proposed | To capture methane from sewerage ponds and generate electricity | Construction of the shed for bio-generator, installation of the pipe system to transport methane from digesters to generators | DWMPC | Reduced emission by approximately 73 Gg CO2 eq. per year | Revenue generation from waste sector, increase energy security and reduction of emission | Introduce Feed In Tariffs for renewable energy | External funding | P8 million |
| Introduction of efficient transport system | Planned | To encourage the general public to use public transport and reduce GHGs emissions fro the transport sector | The high use of private vehicles as opposed to public transportation. has fuelled the demand for private vehicles | DTRS | Emissions reduction of 1350 Gg of CO2 eq. | Reduce traffic congestion  Improve ambient air quality  Reduce consumption of petroleum and reduce import bill | Introduce tax on petroleum products  Introduce parking fees and control parking on empty spaces | External funding | P2 billion |
| Development of solar power plants | Planned | To produce 328.5 MWh of electricity from (2) 50 MW solar power plants | Construction of two 50 MW solar power plants to supply the mines and economy in the country is on the cards | DoE | 761 Gg CO2 eq., which translates into 9% emissions reduction | Improve energy self-sufficient and reduce imports  Improved ambient air quality  Improve health of the communities in the proximity of the power plants | Removal of subsidies on Coal Electricity  Introduce Feed In Tariffs for renewable energy | Government and external funding | P165 Billion |
| **Based on these mitigation actions, total GHGs emissions reduction for the country is projected at 15% by 2030 based on 2010 as the baseline year** | | | | | | | | | 167 billion |

## Low GHG emission

Based on the NAMA proposal, it is projected that the country would achieve reduced GHG emissions in the region of approximately 15% taking the year 2010 as the base year. Figure 16 depicts GHG emission under BAU and mitigation measures.

Figure 19: Low GHG emissions for the country over time

# Financing barriers to climate investment in Botswana

Implementation of mitigation actions would require significant revenue from both domestic and international sources. For instance, construction of the 100 MW solar power plant would require approximately BWP160 billion. Consequently, this is a challenge particularly for the developing countries which have competing developmental needs coupled with significantly limited financial resources. It is therefore imperative that adequate resources are put in place to remove financial barriers that exist as a way of enhancing easy flow of investment into NAMAs with emphasis on international investment. However, in order to strategically remove the existing factors that inhibit financing of the mitigation actions, it is important that a comprehensive assessment of the existing barriers is undertaken. Thus, this section attempts to undertake a holistic analysis of the existing barriers that inhibit private investing in climate change mitigation action. It is important to note that in some instances, the identified barriers act jointly to compound the problem of creating barriers for investment in climate mitigation projects. Below is a description of the identified barriers to financial flow into mitigation measure:

* **High investment costs and long term investment nature of the climate Mitigation projects**

Most of the mitigation projects that have the potential to significantly reduce the GHG emissions in the country are high investments costs projects with long duration to break-even and start to realise positive return on investment (Berliner et al., 2013). For instance two (2) 50 MW solar power station and improved public transport will cost approximately BWP 160 billion and BWP 20 billion as initial investment costs respectively. For developing countries with multiple socio-economic challenges, the high investment costs become a hindrance to invest in these mitigation projects. Additionally, even the potential investors are discouraged from investing in these climate mitigation projects. Other factors such as political stability and country risk compound to this problem. Linked to the high initial costs is lack of guarantee for climate change loans from the governments and other lenders due to the existing high risk of project failure.

* **Existing subsidies on substitutes of the climate mitigation projects**

Another factor that creates barriers to financing and investing in climate mitigation projects is that most of them have competing alternatives/substitutes which are generally relatively cheap to implement. Additionally, these substitutes are highly subsidised both directly and indirectly by the government. The effect of subsidies is to lower the cost of investment for the substitutes to the extent that prices/charged by the providers becomes extremely lower. Incidentally, this results in mitigation projects which have high investment costs to be non-viable projects as the on-going markets prices results in loss over time. Consequently, economic analysis of the mitigation action results in non-viability based on the market price for the alternatives which effectively creates barriers to the investors. Non-viability of the projects based on lower market prices of the alternatives inhibit private investors to invest in these projects as their ultimate motive is profit maximisation. It is important to note that the high investment and long term nature of these projects to break-even and the existing subsidies on substitutes jointly act to create barriers for investing in these mitigation projects in the country. Projects that are highly affected by subsidies include Solar Power Plants, Private versus Public Transport sector, solar geysers and solar pumps at the cattle post. Therefore, if subsidies are removed on petroleum products, this would incentivise the public to demand the use public transport which would create an enabling environment for improved public transport system.

* **Existence of externalities and public good nature of environment**

In addition to existing subsidies, existence of externalities and public good nature of the environment create barriers for investing in climate mitigation projects. Externalities ensure that the producers of environmentally dirty projects such as coal fired electricity generation and private vehicle users do not integrate their cost of operation in economic decision making. Evidently, this results in producers charging lower electricity prices which out-competes and edges out the solar electricity projects out of the market. It is therefore critical that externalities are internalised to allow investment in the environmentally friendly projects such as improved public transport, solar appliances such as solar geysers, solar street lights etc.

* **Competing developmental priorities and limited resources**

Developing countries have various competing developmental needs coupled with limited financial resources. Therefore issues such as health, access to water, education and poverty take precedence over climate mitigation actions. Consequently, this creates sombre barriers particularly for domestic financing of the mitigation actions. For instance, it is highly unlikely that the developing countries would give priority to solar generated energy over coal fired electric generation, water and health issues due to the high investment costs. Subsequently, the developing country would optimally allocate the scarce financial resources amongst the various competing demand. Automatically, relative cheap projects which would meet the demands will be selected as opposed to expensive projects.

* **Stiff Competition for available climate change funds and lack of personnel to develop climate change projects**

Climate mitigation action are legible for international financing/funding mainly from Green Climate Fund (hereinafter GCF), Less Developing Country Funds (hereinafter LDCF), Deutsche Gesellschaft fur Internationale Zusammenarbeit (hereinafter GIZ) and Global Environmental Fund (hereinafter GEF) amongst others. One of the barriers of accessing funding from the available global/international financing is stiff competition amongst the legible parties. Additionally, there is a limit on the number of the projects that can be funded within a defined time frame. This result in some of submitted proposals not accepted. For other countries such as Botswana, other factors that create barriers on accessing funding is lack of skilled personnel to develop proposal for financing. Incidentally, the requirement for application for funding is tedious and demands trained skill manpower. It is therefore imperative that countries invest in training skilled manpower to facilitate the development of the proposal.

* **Lack of enabling and conducive environment for operation of the mitigation action**

In order for climate mitigation action to be profitable and attract financial flow both domestically and internationally, there is a need to create an enabling and conducive environment for their operations. This enabling environment is created through legal framework in the form of financial incentives such as tax exemptions, internalisation of externalities amongst others. Consequently, lack of enabling and conducive environment ensure that environmentally clean projects such as public transport are exposed to unfair competition resulting in them being out-competed by dirty projects. For instance, there is sombre lack of policy framework that encourages investment in climate mitigation projects. In the country, there are no existing policy guideline on appliance standards in terms of energy consumption and sources of energy at the national level. Additionally, there are policies on increasing the share of renewable energy to total energy supply mix are there but conducive environment that would facilitate their implementation is lacking. This thus results in lack of guidelines and creates a vacuum which discourages potential investors to invest in climate mitigation projects.

* **Political instability and country risk and lack of loan guarantee**

Another factor that inhibits investing in climate change projects in the developing countries including Botswana, is political stability and country risks. As highlighted, climate mitigation projects are highly expensive and are long terms investment. This factor has been identified as a barrier to financing climate mitigation projects. In addition to high initial investment costs, investors are generally sceptical and risk averse in investing in the developing countries due to political instabilities and country risks. The political risk is generally compounded by lack of guarantee for climate change project investment loans. Specifically to Botswana, its dependence on diamond as the main source of revenue could possible creates country risk due to its vulnerability to international diamond market fluctuations. Thus, political instability and country risk are some of the factor that acts as barriers for financing climate change projects (Berliner et al., 2013).

* **Absence of economies of scale in the country**

One of the factors that inhibit adequate investment/funding in climate mitigation projects is lack of economies of scale for most of the climate mitigation projects (Berliner, 2013) particularly in countries with small population such as Botswana. Incidentally, projects in the country are generally small scale coupled with high investment and transaction costs. The small population of the country thus dictates that small projects which have high investment and transition costs are implemented which inevitably results in low production output and high average cost per unit. Incidentally, the high average cost does not decline over time as production is already curtailed by small production hence diseconomies of scale. This thus creates a barrier to enter into climate mitigation measure as the products become continuously expensive and lowers demand over time.

As demonstrated, there are various factors (political, social, economic and geographical) that inhibit the financial flow into climate mitigation projects in the country. The highlighted factors in main instance act jointly to create barriers to entry. It is therefore critical that efforts are made to remove most of them to create a conducive environment for climate mitigation projects. For other barriers such as lack of economies of scale, they can be resolved by providing guarantors and also subsidising the climate projects.

Table 3 summaries some of the barriers that impede investing on mitigation actions in the country.

Table 3: Summary of barriers to investing in climate change projects

|  |  |
| --- | --- |
| **Barriers to climate change financing** | **Factor that create barriers** |
| High investment cost and long term investment | * Lack of technology * Lack of existing infrastructure * Lack of skilled manpower |
| Existing subsidies on climate mitigation project substitutes | * Government policies |
| Existence of the externalities | * Public good nature of the environment * Missing markets * Government policies |
| Limited resources and competing developmental needs | * Developing nature of the country |
| Stiff competition and lack of trained personnel to develop climate mitigation proposals | * Lack of training plans amongst relevant institutions |
| Lack of enable and conducive environment for operation of climate mitigation projects | * Lack of energy policy and appliance guidelines on energy consumption standards |
| Political instability risk | * Location of the country in an African continent |
| Absence of economies of scale for most climate projects | * Small population size of the country |

# Policy and economic instruments for NAMAs functioning

Optimal implementation and operations of the climate mitigation actions would require that a conducive and enabling environment is created. Simply, this would involve policy instrument implementation which will spontaneously remove the identified barriers to financing climate mitigation projects. These instruments include taxes, subsidies, grants, concessional loans and guarantees. Below is a highlight of the instruments and policies that are proposed for implementation in the country to ensure that optimal conditions for climate mitigation projects are created.

* **Removal of subsidies on Coal Power Electricity Generation**

This has been identified as one of the factors that create barriers to financial flow into climate projects. Additionally, subsidies exacerbate the gap between private and social costs which invariably worsen external/environmental costs that are borne by the society. Incidentally, subsidies further lower the market prices for coal generated electricity which makes it impossible for solar power electricity to be a viable project in the country. Thus, removal of subsidies and internalising the existing externalities would hike the price of electricity to allow the solar electricity projects to be viable and competitive. Currently, the price of electricity is significantly lower and thus discourages investment in solar projects.

* **Introduce Feed In Tariffs for renewable energy**

A Renewable Feed In Tariff (hereinafter REFIT) is a policy instrument used by Governments to encourage and promote the local growth of electricity generation from renewable energy (hereinafter RE) resources for input into the national grid. REFITs bind utilities such as BPC to purchase electricity produced from renewable energy resources at profitable cost-reflective prices. This ensures that those who produce electricity from renewable sources have a guaranteed market and a reasonable rate of return for the electricity they produce. A REFIT is a strong policy instrument that ensures that RE is a sound long-term investment for companies, industries and individuals.

* **Introduce subsidies on solar electricity**

The initial investment in the solar project is relatively high compared to the coal based power generation. However, the environmental costs of solar energy are insignificantly lower to non-existence compared to the counterparts. Therefore, it is imperative that subsidies are introduced to encourage high investment in solar projects. There are various forms of subsidies that can be allocated to the solar electricity as follows:

1. Tax exemption on solar investment
2. Zero interest loan on solar investment
3. Part payment by the government on solar electricity tariffs

* **Introduce tax on petroleum products**

The transport sector is one of the major GHGs emitter in the country through consumption of the petroleum products (petrol and diesel). One of the factors that results in the transport sector to be a major GHGs emitter is the use of private vehicles. Factors that encourage the excessive use of private vehicles as opposed to public transport include lower cost of petroleum products, the unattractiveness of the public transport which encompasses lack of public transport facility, roads, reliability of the public transport. Thus, introduction of tax and removal of the subsidies on petroleum products would deter excessive use of private vehicles. Petroleum products in the country are relatively cheaper compared to South Africa where it is imported from. In comparison, one (1) litre of petrol costs approximately an equivalence of P13 while in Botswana it costs P8. In addition to introducing tax and removal of subsidies, it is critical that the government invest intensively on public transport and transform the sector to comparative standard as developed countries. This will involve replacement mini-buses with buses and introduce public bus lanes to enhance reliability and efficiency.

* **Introduce parking fees and control parking on empty spaces**

The objective of the climate change mitigation action on the transport sector is to discourage the excessive use of the private vehicles which would automatically reduce GHGs emissions over time. Therefore, introducing parking fees in addition to other incentives such as introducing tax on petroleum products and improving public transport sector facility would incentivise the use of public transport utilisation.

* **Introduce subsidies on solar appliances mainly solar geysers etc**

Currently solar appliances such as solar geysers and solar panels are excessively expensive relative to the counterparts. For instance, solar geyser costs in the range of between P10,000.00 to P20,000.00 while conventional geysers cost around P2000.00 per unit. Therefore, this act as a disincentive for the public to purchase the solar appliances which would reduce the demand for coal based electricity production. It is therefore recommended that subsidies on solar appliances be introduced which would reduce demand for coal-based electricity production.

* **Introduce tax exemption on house sales that have solar appliances**

Introduction of tax exemption on house sales that are environmentally friendly, would act as an incentive for the public to invest in solar appliances. The rational for introducing tax exemption is generally based on the fact that individuals who have constructed environmentally friendly houses have internalised the externalities. Hence, there is a need to refund the expenses they incurred by exempting them from paying tax from house sale. In addition, it is also recommended that council rates for environmental friendly houses be lowered as an incentive to invest in solar appliances.

* **Introduce government to guarantee climate mitigation projects**

Lack of guarantor for the climate mitigation projects is one of the barriers to finance climate mitigation projects. It is therefore important that the government considers being a guarantor for the climate mitigation projects. This would encourage foreign direct investment in climate related projects by reducing the country risks that have been identified as barriers to climate change.

Table 4 below summarises the proposed policy instruments that would create a conducive environment for financing mitigation projects.

Table 4: Summary of policy instruments for investing in climate mitigation projects

|  |  |
| --- | --- |
| Policy instrument | Its impact |
| Removal of subsidies on coal power electrical generation | * Increase the market price of electricity for solar electricity to be competitive and viable * Internalise the externalities associated with coal fired electricity and reflect the true cost of producing coal fired electricity |
| Introduce REFIT | * Encourages and promotes electricity generation from renewable energy resources * Ensures that producers of electricity from renewable sources have a guaranteed market and a reasonable rate of return * Ensures that RE is a sound long-term investment for investors * Encourages foreign direct investment |
| Introduce subsidies on solar electricity | * Reflect the benefits associated with solar electricity * Lower the unit cost of solar electricity to increase demand |
| Introduce tax on petroleum products | * Increase the cost of using private vehicle * Discourage individual to use large engine vehicles |
| Introduce parking fees and control parking on empty spaces | * Increase the cost of using private vehicles |
| Introduce subsidies on solar appliances | * Encourage use of solar appliance mainly solar geysers |
| Tax exemptions on environmentally friendly houses | * Encourage individual to invest in solar energy and environmentally friendly houses |
| Government as guarantor on climate loans | * Reduce country risks for foreign direct investment |

# Monitoring, Reporting and Verification

Parties to the UNFCCC have agreed that the NAMA proposals must be accompanied by Monitoring, Reporting and Verification (hereinafter MRV) section. Thus, this is an important component of the NAMAs as it facilitates trust, transparency and facilitates decision making. Consequently, the ultimate goal of MRV is to ensure that intended emission reduction targets are attained through continuously improving on implementation of the mitigation measures and their effectiveness. According to GIZ (2014) the key purposes of the MRV are as follows:

* To ensure and enhance transparency, accuracy and comparability of information with regard to climate change in order to identify good practice and also allow for international benchmarking,
* To track both progress and the impacts of the mitigation measures that have been identified by the partner countries
* To assess the impacts of policy instruments on the functioning of the identified and implemented mitigation measure
* To track international support flow into implementation of the mitigation measures
* To improve access to the international public and private financial support

Thus, the purpose of the section is to develop the MRV for emission, mitigation measures implementation and international support. The outputs of the section are templates which will be employed to monitor, report and verify emissions; NAMAs and international support. Additionally, the output of the section is a monitoring plan which details instructions to the emitters on how-to collect and analyse the data for monitoring purposes. They entail the following parameters: aspects to be monitored, frequency of monitoring, instruments for data collection and responsible agent for monitoring and structure for reporting.

## MRV for emissions

MRV for emissions entail data collection on GHGs emission by sector for purposes of determining the performance of the parties in attaining their emission reduction targets. Scope of the MRV emissions can be undertaken at four levels being:

* National
* Sub-national
* Sectorial, and;
* Facility levels.

For this assignment, the MRV for emission is developed at the sectoral level and the results harmonised at the national level.

MRV comprises of two aspects being monitoring plan and the development of the template which are instruments for monitoring, reporting and verification. The next section, thus discusses the monitoring plan for MRV section. MRV is a cycle as depicted in Figure 20 below. It involves monitoring which entail data collection through measuring, data analysis, reporting of the results and verifying the results through sampling and spot- check.

QA/C Framework

Data collection Central point

CSO

Data collecting agencies

Data analysis

Agencies

QA/C analysis framework

DMS

Local reporting

DMS verification

International reporting UNFCCC

Feedback & correction

Feedback & clarity

Monitoring

Reporting and Verification ( local & International.

Figure 20: MRV processes for GHG emissions

## Monitoring plan

Central to the success of the MRV is a robust and sound monitoring plan. A monitoring plan guides the monitoring processes for GHG emissions. The plan details, methods of measurement or quantification for the GHG for the various sectors, instruments to be used for data collection, parameters to be collected and monitored, frequency of data collection, and analyses of the results. In the main, a monitoring plan gives guidelines on monitoring processes for GHGs emissions.

The monitoring approach for the country is developed based on the concept of cost-effective while at the same time emphasising on accuracy in GHGs emissions measuring. Therefore, point sources which are generally the highest emitters should be monitored accurately to ensure that GHGs emissions in the country are not underestimated. Therefore, measurement based approach (hereinafter MBA) is recommended for high emitters such as industrial production and energy transformation sources while for low emitters such as mobile sources calculation based approach (hereinafter CBA) is recommended.

Monitoring for the GHGs emissions should be done at the sectoral level and this should be compiled to produce national GHG emissions inventories.

## Sector for GHG monitoring

It is recommended that GHG monitoring should be undertaken for the major emitters being: Energy (include transport, waste), Land use change, Agriculture and industrial processes. The energy sector should be categorised into stationary and mobile sources where the stationary source include electricity transformation such as Coal fired power plants and household energy demands. The mobile source includes the transportation sectors (road, air, rail and water). The agricultural sector should be categorised into crop production (fertiliser utilisation) and livestock sectors where emission is generally through enteric fermentation. The industrial sector should cover the processing sectors mainly cement production and smelters.

## Parameters to be monitored

For all the economic sectors of the country, the three major GHGs being CO2, CH4 and N2O should be monitored. The three GHGs must be converted to CO2 eq. 100 years Global Warming Potential (hereafter GWP) based on the IPCCC guidelines for converting GHGs. The parameters to be collected for monitoring should include GHG emissions in Giga grams (hereinafter Gg), activity data on the following:

* Consumption of all fuel fossil by type (coal, petroleum products) in appropriate units such as litres and tonnes
* Fuel-wood in tonnes
* Fertilisers in tonnes
* Amount of waste deposited at the landfills also known as managed waste in tonnes and percentage of carbon/biogradable
* Land use and land cover changes from grassland, dryland forests to ploughing field and settlements
* Number of livestock by type and age (cattle, sheep, goats, etc)
* Number of vehicles by type and activity (private, commercial and freight)
* Number of boats, trains etc by engine size
* Scale of industrial processes mainly cement and smelters in tons

The data collected should be used for measuring/estimating the GHGs emissions and subsequently for tracking (monitoring) the GHGs emissions over a defined time scale. Additionally, the information will also be used by the Verifier for verification purposes.

## Methods of data collected

Data collection methods vary significantly by sector depending on various factors such as cost-effectiveness, point and non-points sources and number of emitters. Therefore, these factors determine the appropriate method for GHGs emissions data collection. Generally, there are three (3) main types of data collection methods being. Below is the description of the recommended methods, approaches and equations for collecting data for the GHGs for the respective sectors. These methods are based on the IPCCC guidelines and regulation for GHGs inventory.

**Energy sector**

Energy sector is one of the major GHG emitters in the country and it comprises of stationary and mobile sources. For the stationary sources mainly electricity transformation/generation from coal fired power stations, it is recommended that MBA should be used for collecting data. The instruments that are recommended are the flow meters. On the other hand, for the mobile source (non-point sources) mainly transport sector, Calculation Based Approaches should be employed. Total fuel consumption must be estimated based on the fuel imports by type. The activity data must be multiplied by the country default emissions to determine the GHG emission by fuel type.

**Waste sector**

As landfills are categorised as point source, it is thus recommended that the flow meters be installed for collection of GHG emission data.

**Agriculture sector**

The sector emits GHGs from land use change and livestock sector, CBA is recommended as a method for data collection. Activity data should be obtained from the Land Surveys and livestock census conducted by Ministry of Agriculture and Central Statistics Office (hereinafter CSO).

**Industrial processes**

These activities are point-sources, it is thus appropriate to employ the MBA for monitoring purposes. Therefore, it is recommended that the flow meters be installed at the point source to measure the emissions.

Table 4 below depicts a summary of the recommended data collection methods for the various sectors.

Table 4: Emissions estimation approaches

|  |  |
| --- | --- |
| sector | Methods |
| 1. Energy |  |
| * 1. Mobile | CBA |
| * 1. Stationary | MBA |
| 1. Waste | MBA |
| 1. Agriculture | CBA |
| 1. Industrial process | MBA |

## Frequency of data collection

For all the identified economic sectors, it is recommended that data should be collected on bi-ennial basis for monitoring purposes.

## Responsible agents

The various economic sectors would require multiple players for data collection and analysis. Below is a list of the economic sectors and the responsible agents for data collection and monitoring.

Table 5: Responsible agents for monitoring GHG emissions

|  |  |
| --- | --- |
| **Sector** | **Responsible agent** |
| Energy (stationary) | BPC |
| Households | DOE |
| Transport | DTRS |
| Waste | DWMPC |
| Land use change | MOA, DFRR |
| Industrial processes | BCL and Cement Sector |

Table 6 summarises the monitoring plan for the GHGs emissions monitoring for the country.

Table 6: Monitoring plan for GHG emissions

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sectors** | **GHG to be monitored** | **Parameters** | **Method of measurement** | **Instruments** | **Method of analysis** | **Responsible agents** |
| Energy | CO2, CH4, N2O | emissions, energy demand, consumption of fossil fuel, activity data | measurement based approach and calculation based approaches | Flow meters | statistical analysis | DOE, BPC |
| Waste | CO2, CH4, N2O | emissions, waste generation, percentage of carbon content in waste, percentage of managed waste to landfills | measurement based approach and calculation based approaches | Flow meters | statistical analysis | DWMPC |
| Agriculture | CO2, CH4, N2O | land use change, soil carbon content, fertiliser utilisation, number of livestock and growth rates | calculation based approaches | Non | statistical analysis | MOA |
| Land use change | CO2, CH4, N2O | land use change, emission factors | calculation based approaches | Non | statistical analysis | DLS |
| Industrial processes | CO2, CH4, N2O | scale of operation for selected industries (cements and copper nickel smelter) | measurement based approach | Flow meters | statistical analysis | Private sector |

## Monitoring framework

Having defined the monitoring plan, it is critical that a GHGs monitoring template is developed which will be employed and adopted by the country. Typically, a monitoring framework template is an active excel spread-sheet that can be implemented by the monitors who are also defined as responsible agents. The monitoring framework is divided between monitoring for activities that require measuring and those that involve calculation based approaches.

### Monitoring for measurement based approach

Activities that require measurement based approach should use table 7 monitoring template to monitor GHGs emissions over time.

Table 7: Monitoring template for Measurement based approach sectors

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sector** | | |  | | | |
| **Name of authority** | | |  | | | |
| **Name of responsible official** | | |  | | | |
| **Date of data collection** | | |  | | | |
| **GHG** | **previous reading (a)** | **current reading (b)** | | **actual emissions (b-a)** | **baseline emission** | **GHG emission threshold target** |
| CO2 |  |  | |  |  |  |
| CH4 |  |  | |  |  |  |
| N2O |  |  | |  |  |  |
| Remarks | | | | | | |
|

The results obtained above should be crossed checked based on calculation based approach using table 8 below.

Table 8: Calculation Based Approach for cross checking measurement based approach

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Scale of production** | | | | |
| **Current production** | **Previous production** | **Input in production (a)** | **Emission factor (b)** | **Total emissions (a\*b)** |
|  |  |  | CO2 |  |
|  |  |  | CH4 |  |
|  |  |  | N2O |  |
| Remarks | | | | |

### Monitoring for calculation based approach

As highlighted some emissions sources particularly non-point sources would require CBA to estimate and monitor sectoral and national emissions. Calculation based estimation require activity data and emission factors to enable quantification of the emissions. Templates below should be used to estimate emissions from the various sectors.

Table 9: Fuelwood Monitoring template

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Date** | | |  | | | | | | | |
| **Name of authority** | | |  | | | | | | | |
| **Name of responsible official** | | |  | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |  |
| HH number | HH connected to National Grid | HH not connected to Grid | % of connected HH using f/wood | average f/wood consumption by connected HH | average f/wood by HH not connected | % of institutions using f/Wood | Average f/wood consumption per capita at institution | Total f/wood consumption | f/wood emission factor | GHG emission (Gg CO2 eq.) |
|  |  |  |  |  |  |  |  |  | CO2 |  |
|  |  |  |  |  |  |  |  |  | CH4 |  |
|  |  |  |  |  |  |  |  |  | N2O |  |
| Baseline emission | | | | | | | | | |  |
| Emission reduction target | | | | | | | | | |  |
| Remarks |  | | | | | | | | | |

Table 10: Monitoring template for transport

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Date** | |  | | | | | | | |
| **Name of authority** | |  | | | | | | | |
| **Name of official** | |  | | | | | | | |
|  | |  |  |  |  |  |  |  |  |
| Total Vehicle numbers | Number of vehicles using diesel | Number of vehicles using petrol | Average mileage diesel | Average mileage petrol | Total fuel used diesel | Total fuel used Petrol | Diesel emission factors | Petrol emissions factors | Total emissions |
|  |  |  |  |  |  |  | CO2 factor | CO2 factor |  |
|  |  |  |  |  |  |  | N2O factor | N2O factor |  |
|  |  |  |  |  |  |  | CH4 factor | CH4 factor |  |
| Baseline | | | | | | | | |  |
| Emission reduction target | | | | | | | | |  |
| Remarks | | | | | | | | | |

Table 11: Monitoring template for land use change

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Date** | |  | | | | | | |
| **Name of authority** | |  | | | | | | |
| **Name of official** | | |  | | | | | |
|  |  | |  |  |  |  |  |  |
| grassland Savannah coverage (h) | grassland converted to arable (h) | | grassland converted to pastoral | grassland converted to settlements | emission factor arable | emission factor pastoral | emission factor settlement | total emissions |
|  |  | |  |  | CO2 | CO2 | CO2 |  |
|  |  | |  |  | CH4 | CH4 | CH4 |  |
| Baseline |  | |  |  | N2O | N2O | N2O |  |
| Emission reduction targets | | | | | | | |  |
| Remarks | | | | | | | |  |

Table 12: Monitoring template for fertilisers

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Date** |  | | | | |
| **Name of Authority** |  | | | | |
| **Name of Official** |  | | | | |
|  |  |  |  |  |  |
| Type of fertiliser | Quantity ordered | Quantity used by commercial | Quantity used by subsistence | Emission factors | Total emissions |
|  |  |  |  | CO2 |  |
|  |  |  |  | CH4 |  |
|  |  |  |  | N2O |  |
| Baseline |  | | | | |
| Emission reduction target |  | | | | |
| Remarks |  | | | | |

## Reporting

Reporting is another important component of the MRV and it entails production of GHGs emissions reports that comprehensively depicts GHGs emission dynamics. The report structure must entail the following information: data collection methods, data analysis methods, emissions estimated and measured for all the GHGs (CO2, CH4, N2O). The report should be a maximum of 4 pages. The report must be compiled by the authorities responsible such as DOE, DFRR; BPC, DTRS and DWMPC. The compiled report must be submitted to the DMS. Table 13 depicts the proposed GHGs emissions reporting standards for the country.

Table 13: Proposed Reporting Structure for GHG emissions

|  |  |
| --- | --- |
| **Reporting institution** | **Enter name of authority** |
| Sector category | Enter name of sector and specify e.g. energy mobile sector |
| GHGs reporting | Enter gases monitored |
| Methods of data collection | Describe methods of data collection used |
| Methods of data analysis | Statistical analysis |
| Results on GHGs emissions | Brief description of the results by way of numbers and figures |
| Conclusions on GHGs emissions and targets | Brief description of the findings and compare them to baseline and emission reduction targets |

## Verification

Verification is an important component of the MRV as it enables independent analysis of the GHG emissions. This thus enhances transparency and reliability of the results. Verification can be undertaken at both domestic and international levels. At the domestic level, it is recommended that the DMS should take the responsibility of being a domestic verifier. For international verification purposes, DMS should engage a UNFCCC expert to verify the compiled GHGs emissions. As the funders are the affected stakeholders, it is recommended that the funder(s) select an independent verifier for the assessment.

### Techniques for Verification

Verification techniques include internal quality checks, inventory inter-comparison, comparison of intensity indicators, comparison with atmospheric concentrations and source measurements, and modelling studies. In all cases, comparisons of the systems for which data are available and the processes of data acquisition should be considered along with the results of the studies. These techniques, and their applicability at the national and international level, are discussed below. Additionally, other methods are inclusive of evaluation of emissions estimates and trends, as part of the UNFCCC review of emissions inventories. Another approach entails an evaluation of aggregate inventories on a global or regional basis, with the objective of providing further scientific insight. The following activities must be undertaken for verification purposes of the GHGs emission at both the national and international levels.

**Compliance to Monitoring plan**

It is important that the verifier assesses the extent to which the monitoring plan has adhered to collecting GHGs emissions data. This can be done through inspecting the monitoring templates to determine the extent to which they have been applied and populated. Therefore, all the templates that were used by the responsible authority should be availed to the verifier.

**Instruments calibration check**

As it has been highlighted under data collection, some sectors would require MBA while other will require CBA methods. For those sectors which require measurement instruments, the verifier should access the instruments and check the calibration based on the manufacturers specifications. The instruments must be checked in terms of reliability and accuracy. It is recommended that another instrument should be used to corroborate the results.

**Check data collected**

Another procedure for verifying the results obtained is to check the data that has been used in the GHGs inventory. The data should be checked for consistency mainly in terms of out-layers and extreme values. This should be corroborated with socio-economic activities such as economic growth, population growth and climatic data. This verification exercise should give the verifier a clear picture of the data used in terms of accuracy and reliability. It is recommended that trendlines should be used to check the data and all abnormal fluctuations should be explained and corroborated.

**Analyse the calculations**

The verifier must access all the spreadsheets that have been used in calculating the GHGs emissions and checked for mathematical errors and consistencies. All emission factors and activity data should be checked by the verifier. It is critical that the emission factors are consistent with the IPCCC guidelines. Therefore the verifier must cross-check with IPCCC guidelines.

**Verification report**

Based on the results from the verification exercise, the verifier must compile a report detailing their findings on monitoring plan compliance, instruments measurement accuracy, quality of data collected and used for GHG inventory, precision and accuracy in data analysis and calculations, amongst other things. It is recommended that the report should be a maximum of 5 pages.

## MRV for NAMAs

Similar to monitoring GHG, it is also vital that MRV for NAMAs be undertaken. Monitoring for NAMAs entails tracking implementation progress of the mitigation actions, their impacts on GHGs emissions, and associated co-benefits. Essentially, it is critical that a scorecard be used to track (monitor) the implementation progress and impacts of the mitigation project on GHGs emissions over time.

## MRV for NAMAs Monitoring plan

In order to undertake a comprehensive monitoring for the mitigation measure progress and their impact, it is fundamental that a monitoring plan be prepared. Correspondingly, to the monitoring plan for the GHGs emissions, the plan details parameters to be collected, responsible agent, frequency of monitoring, methods of data collection and analysis. Table 14 depicts the monitoring plan for the NAMAs MRV.

Table 14: Monitoring plan for NAMAs

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sectors** | **Mitigation measure** | **Parameters** | **Method of monitoring** | **Instruments** | **Method of analysis** | **Responsible agents** |
| Energy | Efficient lighting | * percentage penetration of CFL and LED * percentage of number of household replacing incandescent bulbs with CFLs and LED | Household survey | Questionnaire | Statistical analysis | BPC |
| Efficient refrigeration | * percentage penetration of efficient fridges * percentage of household replacing less efficient fridges with efficient ones | Household survey | Questionnaire | Statistical analysis | BPC |
| Increase share of renewable energy | * Percentage share of renewable solar electricity to coal fired electricity generation | MBA | Flow meters | Statistical analysis | BPC |
| Improved use of public transport | * Replacement of mini-buses with buses * Number of households using public transport * Reduced petroleum imports * Introduction of bus lanes | Transport and infrastructural survey | Questionnaire | Statistical analysis | DRTS |
| Waste | Capture of LFG | * Landfill gas captured | MBA | Flow meters | Statistical analysis | DWMPC |

Monitoring for NAMAs involve tracking implementation progress, performance of the mitigation measures in terms of reducing GHGs emissions to the targets and also evaluating the co-benefits of the mitigation measures. The convenient method to monitor the mitigation measure is the implementation scorecard. Table 15 depicts the scorecard for monitoring mitigation measures that should be used by the responsible agent for monitoring.

Table 15: Proposed scorecard for monitoring NAMAs

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Name of mitigation measure** | |  | | | |
|  | preparation stage (1) | developmental stage (2) | completed (3) | submitted for funding (4) | |
| **Development of proposal for funding** |  |  |  |  | |
|  | Rejected (0) | conditional approved (1) | Approved (2) | Funds disbursed (3) | |
| **Status of submitted proposal** |  |  |  |  | |
|  | preparation stage (1) | construction of infrastructure (2) | constructed at advanced stage (3) | construction completed (4) | operational phase (5) |
| **Implementation of mitigation measure** |  |  |  |  |  |
|  | no change in emissions (0) | Below target (1) | At target (2) | Above target (3) | |
| **Impacts of the mitigation on emission** |  |  |  |  | |
| Description of all mitigation co-benefits | | | | | |
|  | | | | | |
|  | | | | | |
| Co-benefits performance | No co-benefit (0) | Below target (1) | At target (2) | Above target (3) | |
| Co-benefits 1 |  |  |  |  | |
| Co-benefit 2 |  |  |  |  | |

## NAMAs Reporting

Similarly to the GHGs emissions, NAMAs implementation should be reported. The report structure for the NAMAs must include: proposed mitigation measure by sector, implementation process, impact of the implemented measure on GHGs emissions, co-benefits over time. The report should be a maximum of 5 pages and should be compiled by the implementation authorities such as BPC, DOE, DTRS and DWMPC. The compiled report must be submitted to the DMS. Table 16 depicts the proposed GHGs emissions reporting standards for the country.

Table 16: Proposed Reporting Structure for Mitigation Actions

|  |  |
| --- | --- |
| **Reporting institution** | **Enter name of authority** |
| Sector category | Enter name of sector and specify e.g. energy mobile sector |
| Mitigation measure reported | Enter gases monitored |
| Implementation status of the mitigation | Describe the state at which the mitigation measure is at (preparation, being implemented, operation etc) |
| Impact of the mitigation on GHG | Describe the impacts of the mitigation measure on GHG emissions and compare with the projects emission reduction target |
| Co-benefits | List all possible co-benefits and describe them and where possible quantify them |

## Verification of the mitigation actions

It is proposed that verification for the NAMA implementation be undertaken at both domestic and international v. Consequently, verification should be done by an independent agent and it is recommended that DMS should be responsible for verification of the mitigation measures. Verification should be done on annual basis for effective monitoring of implementation of mitigation and at the same time avoid implementation lapses and regressions. Implementation audits must be undertaken to verify the results from the implementation scorecard. The verifier from DMS should physically visit the sites of operation and inspect facility. For operational facilities, flow meters must be used to verify outputs for solar power plants and Landfill facility. For transportation sector, annual survey should be conducted to determine public transportation utilisation. Additionally, fuel consumption should also be used to establish the linkage between public transport and reduction in petroleum products use. Table 16 should be used by the verifying agent based on audits for consistence with the findings from the monitoring stage of the NAMAs. Where there are inconsistencies, the verifier must highlight and seek clarify from the monitoring institutions.

## MRV for international assistance

Mitigation measures that fall under NAMAs can either be domestically or internationally financed depending on the country’s financial ability and readiness. Additional to being legible to international financing/funding, developing countries are also legible to international technological transfer. Thus, as much as MRV is undertaken for GHGs emissions and for mitigation measures, it is also imperative that international flows (finance and technical assistance) are monitored, reported and verified. This will ensure that international aid for mitigating GHGs emissions are tracked for transparency and accountability. Monitoring for international flow should be the responsibility of DMS and all proposals for international assistance should be routed through DMS. Monitoring for international assistance (financial and technical) should be monitored by sector based on table 17 below.

Table 17: monitoring framework for international assistance

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sector** | **Financial assistance** | | | | | | |  |
| **Energy** |  | **Proposal submitted** | | **Approvals** | **Amount** | | **Amount disbursed** | **Source of funding/country** |
| efficient lighting |  | |  |  | |  |  |
| Refrigeration |  | |  |  | |  |  |
| solar power plant |  | |  |  | |  |  |
| solar geysers |  | |  |  | |  |  |
| transport |  | |  |  | |  |  |
| Waste | landfill gas facility |  | |  |  | |  |  |
|  | Technical Assistance | | | | | | |  |
|  |  | Technical transfer | Type | | | Number of personnel trained | | Source of assistance |
| Energy | efficient lighting |  |  | | |  | |  |
| refrigeration |  |  | | |  | |  |
| solar power plant |  |  | | |  | |  |
| solar geyser |  |  | | |  | |  |
| transport |  |  | | |  | |  |
| Waste | landfill gas facility |  |  | | |  | |  |

## Reporting

It is proposed that reporting on international assistance flow (financial and technological) should be the responsibility of DMS which is the liaison/contact departments for climate change. Thus, based on the findings from the monitoring template as depicted in table 18, a report of a maximum of 5 pages should be produced detailing key aspects as in table 18 below.

Table 18: Reporting structure for International assistance for NAMAs

|  |  |
| --- | --- |
| Reporting institution | Enter name of authority |
| Source of funding by sector | Describe source of funding for each sector |
| Amount by source | Describe amount of funding per sector |
| Total amount of funding | Calculate total amount of funds received |
| Technological transfer by sector | Describe technological transfer by source and sector |
| Skill transfer by sector | Describe training undertaken by sector in terms of numbers |
| Source of technological transfer | Describe source of technological transfer per year |

## Verification for technical assistance

Verification should be done by international verifiers appointed by UNFCCC. It is recommended that financial and skills audit be conducted to verify the reported results on technical assistance. The verification should immediately follow the monitoring results. The verifier must have access to all financial accounts for the auditing purposes.

# Conclusions

The report details the feasible and cost-effective mitigation actions that GoB can implement without necessarily impeding economic growth and development. In fact, the identified mitigation actions have a positive net return on investment over a defined time period. The proposed mitigation actions include energy efficiency with specific focus on efficient lighting, efficient appliances such as refrigeration, switch to solar appliances mainly solar geysers, increase share of renewable energy, improved public transport system and the landfill gas capture. It is projected that implementation of this projects would potentially reduce the country total GHGs emissions by 15% by year 2030 based on 2010 base baseline. This emission reduction is based on the country generating its electricity with no imports.

In order for the emission reduction target to be achieved, there is a need to have an enabling and conducive environment for the mitigation actions to work optimally. This would entail implementation of instruments such as removal of subsidies on coal based electricity generation, removal of subsidies on petroleum products, introduction of REFIT and subsidies on solar electricity generation.

It is also important that MRV is undertaken for GHGs emissions, mitigation projects implementation and international assistances in terms of financial flows and technical skill transfers.

# Recommendations

Based on the findings of the assignment, the following recommendations are made for implementations:

Based on the findings of the assignment, the following recommendations are made for implementations:

* Implement the identified policy instruments to create a conducive environment for operation of the mitigation actions.
* Improve public transport by replacing mini-buses with buses, develop public transport infrastructures to encourage use of public transport.
* It is also critical that methane from LFG is exploited. The co-benefits of this project would be to reduce the import bill on Liquid Petroleum Gas (hereinafter LPG) and also create employment opportunities for the locals.
* Government guarantees high investment climate mitigation projects to encourage foreign and local direct investment into these projects.

# References

Berliner, J., Gruning C., Kempa, K., Menzel, C., Moslener, U (2013). Addressing the barriers to climate investment. Frankfust. School – UNEP Collaborating Centre for Climate & Sustainable Energy Finance.

Government of Botswana (2010). Draft Energy Policy of December, 2010. Government of Botswana, Gaborone, Botswana

Government of Botswana (2008). Statistical bulletin. Government of Botswana, Gaborone, Botswana

Hinostroza, M. 2011. Measuring, Reporting and Verifying- A primer on MRV for Nationally Appropriate Mitigation Action. UNEP Riso Centre. Energy, Climate and Sustainable Development. National Laboratory for Sustainable Energy. Technical University of Denmark. 400 Roskilde DenmarkIPCCC (2007). IPCCC Good Practise Guidance and Uncertainty Management in National Greenhouse Gas inventory. Metz, B., Davidson, R.O,. Bosch, R. P., Dave, R and Meyer, A. L (ed). Cambridge University Press. Cambridge, United Kingdom and New York, NY, USA

Michaelowa, A. (2001) Mitigation versus adaptation: The political economy of competition between climate policy strategies and the consequences for developing countries. Hamburg: Hamburgisches Welt-Wirtschafts-Archiv.