Tools and guidelines to monitor and track progress made in Botswana's NDC – Energy sector

ICAT Initiative for Climate Action Transparency

Initiative for Climate Action Transparency - ICAT

Report on tools and guidelines to monitor and track progress made in implementing and achieving Botswana's NDC – Energy sector

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Acronyms

BDQAF	Botswana Data Quality Assessment Framework
BERA	Botswana Energy Regulation Authority
BITRI	Botswana Institute for Technology Research and Innovation

BPC	Botswana Power Corporation
CO_2	Carbon dioxide
CO_2 eq.	Carbon dioxide equivalence
CH_4	Methane
DoE	Department of Energy
INDCs	Intended Nationally Determined Contributions
Kt	Kiloton
Kg	Kilograms
LED	Light Emitting Diode
NDC	Nationally Determined Contributions
GHGs	Greenhouse Gases
Gg	Giga gram
GoB	Government of Botswana
ETF	Enhanced Transparency Framework
MIH	Ministry of Infrastructure and Housing Development
MRV	Monitoring Reporting and Verification
MPG	Modalities, Procedures and Guidelines
MJ	Mega Joules
MW	Mega Watt
N_2O	Nitrous oxide
TJ	Tera Joules
UNFCCC	United National Framework Convention of Climate change
WUC	Water Utilities Corporation

Introduction

Nationally Determined Contributions (NDCs) are at the heart of the Paris Agreement to achieve the global target of limiting greenhouse gas emissions below a level that dangerously interferes with the climate (UNFCCC, 2019). As per Paris agreement Article 4, 7, 9, 10, 11 and 13, each party must communicate its NDCs with the necessary information for clarity and transparency. Furthermore, it is required that NDCs are communicated every five years (UNFCCC, 2020). Importantly, each party could update its NDC target at any time, based on its ambitions (UNFCCC, 2020). Given the importance of NDCs in achieving the global GHG emission reduction target, tracking a party's NDC efforts is paramount. Consequently, Paris Agreement, Article 13, stresses that each party shall regularly provide information necessary to track progress made in implementing and achieving its NDCs. Emphatically, this calls for the development of tracking tools to monitor party members' NDC targets and policy efforts.

The Government of Botswana (GoB) communicated its Intended Nationally Determined Contributions (INDC) as per decision i/CP. 19 and 1/CP.20 in 2015, which were adopted in 2016. The Paris Agreement required parties to submit the next round of updated NDCs in 2020. The GoB has submitted its updated NDC to UNFCCC in 2021. The NDC covers both mitigation and adaptation sectors. The mitigation targets focus on the energy sector, representing approximately 15 mitigation measures.

This report presents the NDC energy sector mitigation tracking tools. The tracking tools were developed following the Modalities, Procedures, and Guidelines (MPGs) for the transparency framework (UNFCCC, 2018). These tools will be used by implementing entities whose portfolio entails energy mitigation. The tracking tools will collect all the necessary information to track the government mitigation efforts and the resultant GHG emissions in line with the targets set in the NDC. As per the MPGs, the tracking tools cover all aspects of the NDCs being:

- Mitigation measures,
- Financial support received
- Capacity-building support received
- Technological transfers received
- Policy and measures

Specific tracking tools have been developed for each of the ten mitigation measures covering the energy sector to ensure transparency and ease of mitigation tracking.

Objectives

The main objective of the assignment is to report on information necessary to track progress made in implementing and achieving Botswana's NDC. Consequently, this involved the development of the tracking tools which constitute identifying the indicators and parameters to estimate the GHG emission reduction. The tracking tools constitute active excel sheets with equations to calculate the GHG emissions reductions.

Methods and approaches

The primary method employed to develop the NDC tracking tools was desk review. The entry point was the review of the Botswana's updated NDC to identify the proposed mitigation measures for the energy sector. Based on the updated NDC review, all the energy mitigation measures were identified. Further desk review was undertaken on the UNFCCC Enhanced Transparency Framework (ETF), the MPG for the ETF and the Handbook on measurement, reporting and verification. Another important document that formed the bases for the development of the NDC tracking tools was the 2006 IPCC Guidelines for National GHG inventory. The 2006 IPCC guidelines for National GHG

inventory provided the equations which were used for the development of the active excel spreadsheet. Consequently, the 2006 IPCC guideline was used in conformity to the MPG which stipulated that each Party shall use methods from the IPCC guidelines. Thus, the existing IPCC and UNFCCC documents mainly the 2006 IPCC guidelines, the MPGs and handbook on MRV amongst others guided the development of the NDC tracking tools. All the equations used were derived from the 2006 IPCC guidelines and the emission factors are consistent with those used for Botswana's GHG emission inventory. Further work was undertaken on the available NDC tracking tools that have been submitted and ICAT documentation on NDC tracking tools. Another critical document that was accessed and reviewed specifically for the identification of the indicators, data needs for tracking the NDCs mitigation measures was the ISPRA (2021). This document list proposed indicators for domestic MRV purposes and tracking progress of NDCs. However, it stresses that country need to develop their indicators based on national mitigation measures, circumstances, and data availability.

Botswana Nationally Determined Contributions

Botswana's Intended Nationally Determined Contributions were submitted in 2015 and adopted in 2016. Using the business-as-usual model, which assumed constant population growth and economic growth from the baseline, the GHG emissions were projected to increase to 18,434.1 Gg by 2030 without the mitigation measures. The reported GHGs included carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). GHG emissions were projected using the low GHG emission pathways, which assumes moderate penetration of renewable energies, energy-efficient and ecosystems-based approaches and improved veldt fire management. Based on the assumptions, the GHG emissions reduction was estimated at 2,607.77 Gg for the year 2030 using 2010 as a base year. Based on the estimated GHG emission reduction the country intended to achieve an overall GHG emissions reduction of 15%, taking 2010.

Under decision 4/CMA. 1 para 7 of the Paris Agreement, parties are required to have updated their NDC by 2020 (UNFCCC, 2020). Accordingly, GoB updated its NDC with a GHG emission reduction target of 4,528.8 Kt CO_2eq. for the year 2030 taking 2010 as the base year. The updated GHG emission reduction target constitutes an unconditional emission reduction of 3,375.8 Kt CO_2eq and a conditional target of 1,153 kt CO_2eq by 2030. Almost all the proposed mitigation measures emanate from the energy sector, as depicted in Table 1 and Table 2 below.

Name measure	**2030 annual emission reductions**
	($ktCO_2e$/year)
Solar PV IPP	486
1000 MW solar PV program	2,024
Wind power	680
Modern biogas plants	118
Solar rooftops (RC&I)	8
Solar water pumping	8
Building retrofits (RC&I)	17

Solar geysers	6.1
Solar and LED streetlights	3.7
Building retrofits (gov't)	17
Solar rooftops, (gov't)	8
total emission reduction for unconditional	***3,375.8***

Table 1: Energy mitigation measures and estimated emission reduction targets. Source: HEAT GmbH (2021)

Source: HEAT GmbH (2021)

Name measure	**2030 annual emission reductions**
	($ktCO_2e$/year)
Sustainable Renewables Risk Mitigation Initiative (SRMI)	0[1]
Concentrated solar power	1,153
Total emission reduction for conditional	***>1,153***
Total, mitigation	**>4,528.8**

Table 2: Conditional mitigation measures and estimated emission reduction targets. Source: HEAT GmbH (2021)

Source: HEAT GmbH (2021)

Based on these energy mitigation measures and their target emission reductions by 2030, the tracking tools for each mitigation measure were developed. The data source and collection methods are discussed under tracking tools and the steps in estimating the GHG emission reductions.

Modalities, Procedures, and Guidelines for the Transparency Frameworks

The MPG guided the development of the NDC tracking tools for the transparency framework for action and support as per Paris Agreement Article 13. The MPG gives necessary elaborative information to enhance tracking the parties'

[1] This is conservative, as some of the investments may lead to emission reductions. The exact amount of such emission reductions is hard to quantify. In addition, SRMI paves the way for future investments that will lead to emission reductions. Such emission reductions have been allocated to the future investments.

efforts in achieving their updated NDC. The MPG states that parties must identify the indicator(s) for each NDC proposed mitigation measure (UNFCCC, undated). The indicator can be either quantitative or qualitative (UNFCCC, undated). Examples of the indicator as listed under the MPG include:

- Net GHG emissions and removals,
- Percentage reduction of GHG intensity,
- Relevant qualitative indicators for a specific policy or measure,
- Mitigation co-benefits of adaptation actions and/or economic diversification plans or other (e.g., hectares of reforestation, percentage of renewable energy use or production, carbon neutrality, the share of non-fossil fuel in primary energy consumption and non-GHG related indicators)

NDCs are implemented from 2020 to 2030; it is thus imperative that they are tracked on an annual basis and that reporting is completed every two years as per the EFT. The MPG explicitly indicated that countries must provide the reference point for each indicator used for tracking progress of NDC implementation. The Glasgow Climate Change Conference reaffirmed the ETF as per Paris Agreement Article 13. The conference adopted the tabular formats for the reporting of the information necessary to track progress made in implementing and achieving NDC targets. The common tabular formats covered information for tracking the NDCs, information on financial, technology development and transfer and capacity-building support provided and mobilized, as well as support needed and received.

For the tracking of the GHG emissions and their reduction, the Glasgow Conference devised three tabular format constituting:

- Structured summary: Description of selected indicators
- Structured summary: Definitions needed to understand NDC
- Structured summary: Methodologies and accounting approaches – consistency with Article 4, paragraphs 13 and 14 of the Paris Agreement and with decision 4/CMA.1: these tabular format summaries the methodologies and accounting and seeks to establish consistency with the IPCC guidelines on GHG inventory.
- Structured summary: Tracking progress made in implementing and achieving the NDC under Article 4 of the Paris Agreement: this tabular format constitute the indicators, quantifies annual anthropogenic emissions by sources and removals by sinks covered by its NDC, annual quantity of mitigation outcomes, total quantitative corresponding adjustments used to calculate the emissions balance, assessment of the achievement of the Party's NDC under Article 4 of the Paris Agreement
- Summary of greenhouse gas emissions and removals in accordance with the common reporting table 10 emission trends – summary

Consequently, the development of the NDC tracking tools hinged exclusively on the 2006 IPCC guidelines on GHG inventories and the developed and adopted tabular format by the Glasgow Climate Change Conference. Importantly, The EFT manual also guided the development of the NDC tracking tools.

In summary, the development of the tracking tools ensured that the following aspects were taken on board:

- Measurable indicators in common units and percentages.
- Baseline or reference point for accounting.
- Estimating the current mitigation capacity and their emission reduction.
- Use of 2006 IPCCC guidelines

Tracking tools for the NDC energy sector

The tracking tools have been developed for the mitigation, international finance, and policy measures as per the EFT manual and MPG. The tracking tools were developed for the 11 identified mitigation measures. Though the NDC should be reported every two years as per the Paris Agreement, it is recommended that the tools be used annually to track the mitigation measures at the national level. This will ensure accuracy and enhance transparency at the national level rather than collect data after five years.

Tracking tools for mitigation measures

Thirteen (13) mitigation measures (have been identified covering both the conditional and unconditional for the energy sector (table 1 and 2). The tracking tools are developed for each mitigation measure. Data requirements and collection methods are also discussed for each mitigation measure. Most importantly, verifying and ensuring transparency is necessary for mitigation measures such as the number of plants (biogas plants, streetlights, etc.) and their capacities (cubic meters, wattage) are collected and reported. This will enhance transparency and quality assurance issues and make it easier for verification purposes.

Solar PV independent power producers

Solar PV independent power producers (IPP) is one energy mitigation measure that aims to increase the share of renewable energy in the energy supply mix. It is targeting large-scale energy producers. The solar PV IPP mitigation indicators are the renewable electricity in Tera joules (TJ) and the emission reduction in kt CO_2 eq. As per the updated NDC, the emission reduction from Solar IPP is 486 Kt CO_2 eq.

The data requirement for tracking this mitigation measure is the number of IPP for the baseline and the current (the year of data collection), and the capacity of the PV systems. These data will be obtained from Botswana Power Corporation (BPC), Botswana Energy Regulation Authority (BERA) and Department of Energy (DoE). BERA is responsible for issuing all the permits for the production of electricity in the country and hence have all the information on the number of IPP and the capacity of their plants. The IPP will be using the BPC distribution networks to sell solar-generated electricity. This will involve the installation of meters for the BPC to account for IPP electricity. Thus, the electricity from the meters will be used to track this mitigation measure from the baseline to the current year of accounting. The indicator will be renewable energy generated in TJ.

To estimate the GHG emissions reduction from the solar PV IPP, it is important to give a brief background on electricity production in the country. Electricity is generated from thermal (charcoal-fired) power stations, and the diesel-powered generators owned and operated by BPC. The thermal power stations have a capacity of 732 MW, which constitutes two plants: Morupule B (600 MW) and Morupule A (132 MW), respectively. The diesel-powered generators are in Orapa and Matshelagabedi, with a total capacity of 160 MW (GoB, 2020). Electricity production from diesel-powered generators constitutes approximately 7.9 % of the national electricity production (Statistics Botswana, 2020). Lastly, solar electricity contribution to the national electricity presents an insignificant estimated at 1.3 MhW (Statistics Botswana, 2020).

Subsequently, solar PV from the IPP as a mitigation could have an impact on electricity generated from both sources. It is therefore important that consultation is undertaken with BPC to determine which source of electricity generation (Coal or diesel) has been affected by solar PV IPP. If both sources of electricity generation (coal and diesel) have been affected by solar IPP, it is vital to estimate the determine percentage of the solar electricity that has replaced coal and diesel electricity e.g., 75% of the generated IPP solar replaced coal electricity and 25% of the solar generated replaced diesel electricity.

Based on the renewable electricity generated, the avoided GHG emissions will be estimated using the 2006 IPCCC guidelines for National GHG inventories equations. The reported GHG emissions as per the updated NDC will be CO_2, CH_4 and N_2O, converted to ktCO_2eq. The 2006 IPCC equations for both coal and diesel fuel that were used in the development of the tracking tools as shown below:

$$Emission_{CO2} = Coal\ consumption * Emission\ factor_{CO2,coal}$$

Equation 1: CO_2 emission from coal combustion

$$Emission_{CH4} = Coal\ consumption * Emission\ factor_{CH4,coal} * Conversion\ factor_{CH4\ to\ CO2}$$

Equation 2: CH_4 emission from coal combustion

$$Emission_{N2O} = coal\ consumption * Emission\ factor_{N2O,coal} * Conversion\ factor_{N2O\ to\ CO2}$$

Equation 3: N_2O emission from coal combustion

$$Emission_{CO2,diesel} = diesel\ consumption_{diesel} * emission\ factor_{CO2,diesel}$$

Equation 4: CO_2 emissions from diesel consumption for electricity generation

$$Emission_{CH4} = diesel\ consumption * Emission\ factor_{CH4,diesel} * Conversion\ factor_{CH4\ to\ CO2}$$

Equation 5: CH_4 emission from diesel consumption for electricity generation

$$Emission_{N2O} = diesel\ consumption * Emission\ factor_{N2O,diesel} * Conversion\ factor_{N2O\ to\ CO2}$$

Equation 6: N_2O emission from diesel consumption for electricity generation

Table 3 depicts the tracking tool for the solar IPP and its impact on GHG emissions from both coal and diesel electricity generated. It is recommended that the data is collected annually for ease of tracking the IPP.

Date:		
Name of Department:		
Name of the person:		
Contact:		
Type of mitigation measure:	**Solar PV Independent Power producer**	
Variable	Unit	Quantity
Indicator	TJ renewable electricity	
Target capacity by 2030	TJ renewable electricity	a
Target emission reduction by 2030	$KtCO_2$ eq	b = 486
Baseline No of IPP	Unitless	c
Current No of IPP	Unitless	d
Baseline capacity per IPP	MW	e
Current capacity per IPP	MW	f
Baseline capacity	MW	g
Current capacity	MW	h
Net change in capacity	MW	i = h-g

% Of current capacity to target	%	j = (h/a)*100
Baseline renewable electricity generated	TJ	k
Current renewable electricity generated	TJ	l
Net renewable electricity generated	TJ	m = (l-k)
% Of renewable electricity generated	%	n = (l/national)*100
% Of solar generated that replaced coal electricity	%	o
CO_2 emission factor from coal consumption	Kg CO_2/TJ	p = 94,000
CH_4 emission factor from coal consumption	Kg CH_4/TJ	q = 1
N_2O emission factor from coal consumption	KG N_2O/TJ	r = 1.5
CH_4 to CO_2eq conversion	Unitless	s = 28
N_2O to CO_2eq conversion factor	Unitless	t = 265
CO_2 emission reduction from coal electricity	Kt	u = (l*o*p)/1,000,000
CH_4 emissions reduction in CO_2eq from coal electr.	Kt	v = (l*o*q*s)/1,000,000
N_2O emission reduction in CO_2eq from coal electr.	Kt	w = (l*o*r*t)/1,000,000
GHG emission reduction from coal electr	Kt CO_2 eq	x =(t+u+v)
% Of solar generated that replace diesel electricity	%	y
CO2 emission factor from diesel consumption	Kg CO2/TJ	z = 70 800
CH4 emission factor from diesel consumption	Kg CH4/TJ	aa = 3
N2O emissions factor from diesel consumption	Kg N2O/TJ	ab = 0.6
CO2 emissions reduction from diesel electr.	Kt	ac = (l*y*z)/1,000,000
CH4 emission reduction in CO2 eq from diesel electr.	Kt	ad = (l*y*aa*s)/1,000,000
NO2 emission reduction in CO2 eq from diesel electr	Kt	ae = (l*y*ab*t)/1,000,000
GHG emission reduction from diesel	Kt	af = (ac+ad+ae)
Total GHG emission reduction	Kt	ag = (x+af)
GHG emission reduction to target	%	y = (ag/b)*100

Table 3: Tracking took for the solar IPP.

1000 MW Solar PV programme/solar concentration plan

To increase the renewable energy contribution to the national energy production, the GoB aims to implement solar PV systems of 1000 MW. The indicators for this mitigation initiative will be similar to the solar PV IPP mitigation, which are renewable electricity produced TJ and the GHG emission reduction in Kt CO_2eq. The emission reduction from the 1000 MW solar PV programme is 2,024 Kt CO_2eq.

The data requirements for tracking this mitigation measure include PV systems' capacity for the baseline, the current (the year of data collection) in WM and the renewable-generated electricity in TJ. These data will be obtained from Botswana Power Corporation (BPC), Botswana Energy Regulation Authority (BERA) and Department of Energy (DoE).

The renewable electricity generated will be obtained from the operator being BPC. The data gathered will compute capacity changes over time (baseline and the current year) and the renewable electricity generated.

Similarly, the 1000 MW solar PV programme could affect both the electricity produced from coal and diesel fuels. It is therefore vital that consultation is undertaken with BPC and BERA to determine the percentage of solar generated that replace coal and diesel electricity. Table 4 depicts the tracking tools for this initiative for coal and diesel fuels consumptions and their respective GHG emissions reductions based on equations 1 to 6.

Date		
Name of Department		
Name of the person		
Contact		
Type of mitigation measure	**1000 MW solar PV programme**	
Variable	Unit	Quantity
Indicator	TJ renewable energy	
Target capacity by 2030	MW	a = 1000
Target emission reduction by 2030	Kt CO_2 eq	b = 2,024
Baseline capacity	MW	c
Current capacity	MW	d
Change in capacity	MW	e
% of current capacity to target	%	f =(d/a)*100
Baseline solar electricity generated	TJ	g
Current solar electricity generated	TJ	h
Net electricity generated	TJ	i = (h-g)
% of solar electricity generated to national	%	j=(h/national)

% of solar that replaced coal electricity	%	k
CO_2 emission factor from coal consumption	Kg CO_2/TJ	l = 94,000
CH_4 emission factor from coal consumption	Kg CH_4/TJ	m = 1
N_2O emission factor from coal consumption	Kg/N_2O/TJ	n = 1.5
CH_4 to CO_2eq conversion	unitless	o = 28
N_2O to CO_2eq conversion factor	unitless	p = 265
CO_2 emission reduction	Kt	q = (h*k*l)/1,000,000
CH_4 emissions reduction in CO_2eq	Kt	r = (h*K*m*o)/1,000,000
N_2O emission reduction in CO_2eq	Kt	s = (h*k*n*p)/1,000,000
GHG emission reduction from coal electr.	Kt CO_2 eq	t = (p+q+r)
% of solar that replace diesel electricity	%	u
CO_2 emission factor from diesel consumption	Kg CO_2/TJ	v = 70,800
CH_4 emission factor from diesel consumption	Kg CH_4/TJ	w = 3
N_2O emissions factor from diesel consumption	Kg N_2O/TJ	x = 0.6
CO_2 emissions reduction from diesel electr	Kt	y = (h*u*v)/1,000,000
CH_4 emission reduction in CO_2 eq from diesel elec	Kt	z = (h*u*w*o)/1,000,000
N_2O emission reduction in CO_2 eq from diesel elec	Kt	aa = (h*u*x*p)/1,000,000
GHG emission reduction from diesel	Kt	ab = (y+z+aa)
Total GHG emission reduction (coal + diesel)	Kt	ac = (t+ab)
GHG emission reduction to target	%	u = (ac/b)*100

Table 4: Tracking tools for 1000 MW solar PV programme for coal fuel.

Wind power renewable energy

This mitigation measure is aimed at generating renewable electricity from wind. The indicators are renewable electricity in TJ and GHG emission reduction in ktCO_2eq. The projected target emission reduction by 2030 is 680 ktCO_2eq. The GHGs to be reported are CO_2, CH_4 and N_2O. Data requirements for tracking this mitigation measure are the number of wind turbines for the baseline and current years, turbine capacity in MW and windspeed. This will enable the estimation of electricity generation. The electricity generated will be obtained from the measuring meters connected to the national electricity grid system.

The total renewable electricity generated from wind power mitigation will be used to derive the GHG emissions reduction from coal power plants and diesel generators. Equations 1 to 6 from the 2006 IPCCC guideline are used to estimate the avoided GHG emission from coal thermal power stations and diesel generators. Consequently, it is

vital that consultation is undertaken with BPC to determine the reduced electricity generations from coal and diesel as a result of wind power mitigation. Based on the estimated electricity generation from coal and diesel, Table 5 should be used to track GHG emissions reduction from coal and diesel electricity generations.

Date		
Name of Department		
Name of the person		
Contact		
Type of mitigation measure	**Wind power**	
Measurement unit	Unit	Quantity
Indicator	TJ renewable electricity	
Target capacity by 2030	TJ renewable electricity	a
Target emission reduction by 2030	Kt CO_2 eq	b= 680
baseline No of wind turbines	unitless	c
current No of Wind turbines	unitless	d
capacity per wind turbine	MW	e
baseline capacity	MW	f = (c*e)
Current capacity	MW	g =(d*e)
Net change in capacity	MW	h =(g-f)
% of current capacity to target	%	i =(g/a)*100
Baseline electricity generated	TJ	j
Current electricity generated	TJ	k
Net electricity generated	TJ	l = k-j
% of electricity generated to national	%	m = (k/national)*100
% of wind that replaced coal generated electricity	%	n
CO_2 emission factor from coal consumption	Kg CO_2/TJ	o = 9,4000
CH_4 emission factor from coal consumption	Kg CH_4/TJ	p = 1
N_2O emission factor from coal consumption	KG/N_2O/TJ	q = 1.5

CH_4 to CO_2eq conversion	unitless	r = 28
N_2O to CO_2eq conversion factor	unitless	s = 265
CO_2 emission reduction	Kt	t = (k*n*o)/1,000,00
CH_4 emissions reduction in CO_2eq	Kt	u = (k*n*p*r)/1,000,000
N_2O emission reduction in CO_2 eq	Kt	v = (k*n*q*s)/1,000,000
GHG emission reduction from coal electr	Kt CO_2eq	w = (t+u+v)
% of wind electricity that replace diesel electricity	%	x
CO_2 emission factor from diesel consumption	Kg CO_2/TJ	y = 70,800
CH_4 emission factor from diesel consumption	Kg CH_4/TJ	z = 3
N_2O emissions factor from diesel consumption	Kg N_2O/TJ	aa = 0.6
CO_2 emissions reduction from diesel electr	Kt	ab = (k*x*y)/1,000,000
CH_4 emission reduction in CO_2 eq from diesel elec	Kt	ac = (k*x*z*r)/1,000,000
N_2O emission reduction in CO_2 eq from diesel elec	Kt	ad = (k*x*aa*s)/1,000,000
GHG emission reduction from diesel electricity	Kt	ae = (ab+ac+ad)
Total GHG emission reduction (coal + diesel)	Kt CO_2 eq	af = (w+ae)
GHG emission reduction to target	%	X = (af/b)*100

Table 5: Tracking tools for wind-powered renewable energy.

Biogas plant mitigation measure

The mitigation measure covers the households and commercial sector. The commercial sector comprises poultry farms, abattoirs (Botswana Meat Commission) and hotels. This project has been initiated by United Nations Development Programme (UNDP) in partnership with GoB, represented by Botswana Institute for Technology and Innovation (BITRI) and the DoE. The biogas plants initiative has co-benefits, including avoiding rangeland degradation and the health of women and children.

The indicators for the initiative are renewable energy production in TJ, GHG emission reduction in Kt CO_2eq and improved rangeland ecosystems which is qualitative.

The tracking for the biogas plant initiative will include estimating the number of biogas plants by sector (household, commercial etc.), their capacities and the daily amount of stockfeed into the biogas. The number of biogas plants by sector (households, commercial) will be obtained from the DoE and Statistics Botswana surveys.

As the biogas initiative is targeting household and commercial, the impacts for the two sectors on the energy consumption by type will be different. The household biogas initiative will have an impact on wood consumption whilst on the commercial sector, the impacts will be reduced electricity from either coal or diesel sources. Furthermore, for the two sectors, biogas results in avoided methane emissions as the captured methane is used for cooking and heating . The equations for estimating GHG emission from fuelwood are depicted in the equations 7 to 9 below. The unit for wood consumption is in TJ and emission factors in Kg/TJ. These equations are further

expanded in the tracking tools (table 9,10 and 11).

$$Emission_{CO2} = wood\ consumption * Emission\ factor_{CO2,wood}$$

Equation 7: CO_2 emission from wood combustion

$$Emission_{CH4} = wood\ consumption * Emission\ factor_{CH4,wood} * Conversion\ factor_{CH4\ to\ CO2}$$

Equation 8: CH_4 emission from wood combustion

$$Emission_{N2O} = wood\ consumption * Emission\ factor_{N2O,wood} * Conversion\ factor_{N2O\ to\ CO2}$$

Equation 9: N_2O emission from wood combustion

Table 6 and 7, below is the tracking tools for the domestic and commercial biogas plants. As indicated the commercial biogas will replace either coal or diesel electricity generation. For the commercial sector it is necessary to estimate which type of electricity source (coal or diesel) will be replaced by methane energy. The results obtained should be combined and reported under the biogas plant mitigation initiative.

Date		
Name of Department		
Name of the person		
Contact		
Type of mitigation measure	**biogas plant**	
Measurement unit	Unit	Quantity
Indicator	TJ renewable energy	
Avoided deforestation	Ha	
Target capacity by 2030	TJ renewable energy	a
Target emission reduction by 2030	Kt CO_2eq	b = 118
Baseline No of biogas plants	unitless	c
Current No of biogas plants	unitless	d
Average unit capacity	m^3	e
Baseline capacity	m^3	f = (c*e)
Current capacity	m^3	g = d*e
Net change in capacity	m^3	h = (g-f)
% of current capacity to target	%	i = (g/a)*100
stockfeed per biogas plant per day	Kg	j

Methane production per kg feedstock (e.g cow dung)	Kg	k = 0.25 kg
baseline methane production	Kg	l = (j*k*c)*365
current methane production	kg	m = (g*j*d)*365
methane energy density	kg/MJ	n = 52.75
Baseline energy generated	TJ	o =(l*n)/1,000,000
Current energy generated	TJ	p = (m*n)/1,000,000
Net energy generated	TJ	q = (p-o)
% of energy generated from methane to national	%	r = (o/national)*100
CH_4 to CO_2 eq conversion	Unitless	s = 28
CH_4 emissions reduction in CO_2 eq	Kt CO_2eq	t =(m*s)/1,000,000
CO_2 emission factor from fuelwood	Kg CO_2/TJ	u = 112,000
CH_4 emission factor from fuel wood	Kg CH_4/TJ	v = 30
N_2O emission factor from fuelwood	KG N_2O/TJ	w = 4
CH_4 to CO_2eq conversion	unitless	x = 28
N_2O to CO_2eq conversion factor	unitless	y = 265
CO_2 emission reduction	Kt	z = (p*u)/1,000,000
CH_4 emissions reduction in CO_2 eq	Kt	aa = (p*v*x)/1,000,000
N_2O emission reduction in CO_2 eq	Kt	ab = (p*w*y)/1,000,00
total GHG emission reduction	Kt CO_2 eq	ac = (t+z+aa+ab)
GHG emission reduction to target	%	ad=(ac/b)*100

Table 6: Tracking tool for domestic biogas plant and emission reduction.

For the commercial sector, the biogas will replace electricity as a source of heat and cooking whilst BMC it will be used for generation of electricity. It is therefore necessary to determine which source of electricity (coal or diesel) will be replaced by energy from methane. This should thus involve consultation with BPC. In the event that both types of electricity generation will be replaced in proportion by methane, then the percentage should be worked out and table 7 should be used to estimate the GHG emission reductions.

Date Name of Department Name of the person

Contact		
Type of mitigation measure	biogas plant	
Measurement unit	Unit	Quantity
Indicator	TJ renewable energy	
Target capacity by 2030	TJ renewable energy	a
Target emission reduction by 2030	Kt CO_2 eq	b = 118
baseline No of biogas plants	unitless	c
Current No of biogas plants	unitless	d
average unit capacity	M^3	e
Baseline capacity	m^3	f =(c*e)
Current capacity	m^3	g = (d*e)
Net change in capacity	m^3	h = (g-f)
% of current capacity to target	%	i = (g/a)*100
stockfeed per biogas plant per day	kg	j
methane production per kg of feedstock (e.g cow dung)	kg	k = 0.25
baseline methane production	kg	l = (c*j*k)*365
current methane production	kg	m = (d*j*k)*365
Net change in methane production	kg	n = (m-l)
methane energy density	kg/MJ	o = 52.75
Baseline energy generated	TJ	p = (l*o)/1,000,000
Current energy generated	TJ	q = (m*o)/1,000,000
Net energy generated	TJ	r = (q-p)
% of energy generated from methane to national	%	s = (q/national)*100
CH_4 to CO_2 eq conversion	kt	t = 28
CH_4 emissions reduction in CO_2 eq	Kt CO_2 eq	u = (m*t)/1,000,000
% of methane energy that replace coal electricity	%	v

Emission factor for CO_2 from coal consumption	Kg CO_2/TJ	w = 94,000
Emission factor for CH_4 from coal consumption	Kg CH_4/TJ	x = 1
Emission factor for N_2O from coal consumption	KG/N_2O/TJ	y = 1.5
CH_4 to CO_2 eq conversion	unitless	z = 28
N_2O to CO_2 eq conversion factor	unitless	aa = 265
CO_2 emission reduction	Kt	ab = (q*w*v)/1,000,000
CH_4 emissions reduction in CO_2 eq	Kt	ac = (q*x*z*v)/1,000,000
N_2O emission reduction in CO_2 eq	Kt	ad = (q*y*aa*v)/1,000,000
GHG emission reduction from coal electricity	Kt CO_2 eq	ae = (ab+ac+ad+u)
% of methane energy that replace diesel electricit	%	af
Emission factor for CO_2 from diesel consumption	Kg CO_2/TJ	ag = 70,800
Emission factor for CH_4 from diesel consumption	Kg CH_4/TJ	ah = 3
Emission factor for N_2O from diesel consumption	Kg N_2O/TJ	ai = 0.6
CO_2 emission reduction	Kt	aj = (q*af*ag)/1,000,000
CH_4 emissions reduction in CO_2 eq	Kt	ak = (q*af*ah*z)/1,000,000
N_2O emission reduction in CO_2 eq	Kt	al = (q*af*ai*aa)/1,000,000
GHG emission from diesel electricity	Kt CO_2 eq	am = (aj+ak+al)
Total GHG emissions reduction (coal + diesel)	Kt CO_2 eq	an = (ae+am)
GHG emission reduction to target	%	ao = (an/b)*100

Table 7: Tracking tool for commercial biogas plant and emission reduction.

Solar rooftop mitigation initiative

Solar rooftop is a solar renewable energy project where consumers will install grid-tied solar systems with the capacity of up to 35 kilowatts (kW) and 1 MW for residential, Commercial and industrial (RC&I), respectively. The indicators for this mitigation are renewable electricity generation in TJ and the GHG emissions reduction in Kt CO_2 eq. The data necessary for tracking the solar rooftop mitigation include the number of solar rooftops for both residential, commercial and industrial, and the capacity of the solar rooftops per unit. These variables will be collected from the DoE, BPC and Botswana Statistics. For transparency, it is necessary to track the number of participants (domestic and commercial) and the solar PV systems capacities for both the baseline and the current.

Another information will be the amount of renewable electricity generated by the residential, commercial and industrial sectors. As the initiative will involve the sale of electricity and hence metering, the electricity generated will be obtained from BPC. Based on the electricity generated, the GHG emission reduction will be estimated from avoided coal and diesel electricity generation using equations 1 to 6. Similar to the other mitigation initiatives, it is

necessary to determine which electricity sources (coal or diesel) will be affected by the solar rooftop programme. Thus, consultation should be undertaken with BPC to identify the fuel source that will be affected. If all the electricity generation sources will be affected, it is important to apportion the total solar electricity generated to the two sources e.g., 75% to coal electricity generation and 25% to diesel electricity generation.

On the basis of the outcomes from consultation with BPC on percentage allocation of renewable electricity to coal and or diesel, Table 8 will be used to track the solar rooftop mitigation measure and GHG emissions reduction from (coal or diesel).

Date		
Name of Department		
Name of the person		
Contact		
Type of mitigation measure	**Solar rooftops**	
Measurement unit	Unit	Quantity
Indicator	TJ renewable energy	
Target capacity by 2030	TJ Renewable energy	a
Target emission reduction by 2030	KtCO2 eq	b = 8
baseline No of solar rooftops	unitless	c
Current No of solar rooftop	unitless	d
Baseline average capacity of solar rooftop per unit	MW	E
Current average capacity of solar rooftop per unit	MW	F
Baseline total capacity	MW	g = (c*e)
Current total capacity	MW	h = (d*f)
Net change in capacity	MW	i = (h-g)
% of current capacity to target	%	j = (h/a)*100
Baseline electricity generated	TJ	k
Current electricity generated	TJ	l
Net electricity generated	TJ	m = (l-k)
% of electricity generated to national	%	n = (l/national)*100

% of solar electricity generated that replace coal	%	o
CO_2 emission factor from coal consumption	Kg CO_2/TJ	p = 94,000
CH_4 emission factor from coal consumption	Kg CH_4/TJ	q = 1
N_2O emission factor from coal consumption	KG/N_2O/TJ	r = 1.5
CH_4 to CO_2 eq conversion	unitless	s = 28
N_2O to CO_2 eq conversion factor	unitless	t = 265
CO_2 emission reduction	Kt	u = (l*o*p)/1,000,000
CH_4 emissions reduction in CO_2 eq	Kt	v = (l*o*q*s)/1,000,000
N_2O emission reduction in CO_2 eq	Kt	w = (l*o*r*t)/1,000,000
GHG emission reduction from coal	Kt CO2 eq	x = (u+v+w)
% of solar electricity generated that replace diesel	%	y
CO_2 emission factor from diesel consumption	Kg CO_2/TJ	z = 70,800
CH_4 emission factor from diesel consumption	Kg CH_4/TJ	aa = 3
N_2O emission factor from diesel consumption	Kg N_2O/TJ	ab = 0.6
CO_2 emission reduction	Kt	ac = (l*y*z)/1,000,000
CH_4 emissions reduction in CO_2 eq	Kt	ad = (l*y*aa*s)/1,000,000
N_2O emission reduction in CO_2 eq	Kt	ae = (l*y*ab*t)/1,000,000
GHG emission reduction from diesel	Kt	af = (ac+ad+ae)
Total GHG emission reduction (Coal + diesel)	Kt CO2 eq	ag = (x+af)
GHG emission reduction to target	%	ah = (ag/b)*100

Table 8: Tracking tool for solar rooftop mitigation.

Solar water pump

The mitigation initiative is targeted at the Water Utilities Corporation (WUC) and the agricultural sector, mainly livestock groundwater abstraction. It will involve the replacement of diesel-powered borehole pumps for groundwater abstraction with solar water pumps. The indicators for the initiatives are the number of solar boreholes and the GHG emissions reduction in Kt CO_2eq. The data that is vital for tracking and estimating the GHGs emissions are the number of solar water boreholes pumps, for the baseline and the current, diesel consumption per borehole for the livestock farmers and WUC boreholes. The data will be used to estimate the avoided diesel consumption and the resultant energy in TJ, which is necessary for estimating the GHG emission. It is important that the data is collected separately for the farmers and the WUC, as their diesel consumption per borehole differs significantly.

Data sources will be Botswana Statistics on livestock sector diesel consumption surveys, Departments of Animal production under Ministry of Agriculture and Food security and WUC expenditure on boreholes.

The GHG emissions reduction are estimated from the equations 4 to 6 for the diesel consumption.

Table 9 depicts the tracking tools for this mitigation measure. Once again, it is necessary to collect the data annually to ensure reliability.

Date Name of Department Name of the person Contact		
Type of mitigation measure	**Solar water pump**	
Measurement unit	Unit	Quantity
Indicators (diesel consumption)	l	
Target capacity by 2030	borehole numbers	a
Target emission reduction by 2030	$KtCO_2$ eq	b = 8
Baseline No of solar boreholes	unitless	c
Current No of solar boreholes	unitless	d
Net change in solar boreholes	unitless	e
% of solar boreholes to target	%	f
average diesel consumption per borehole annually	l	g
baseline annual avoided diesel consumption	l	h =(c*g)
current annual avoided diesel consumption	l	i = (d*g)
diesel energy density	MJ/l	j = 36.00
energy produced from the avoided diesel consumption	TJ	k = (i*j)/1,000,000
CO_2 emission factor from diesel consumption	Kg CO_2/TJ	l = 70,800
CH_4 emission factor from diesel consumption	Kg CH_4/TJ	m = 3
N_2O emission factor from diesel consumption	Kg N_2O/TJ	n = 0.6
CH_4 to CO_2eq conversion	unitless	o = 28

N_2O to CO_2eq conversion factor	unitless	p = 265
CO_2 emission reduction	Kt	q = (k*l)/1,000,000
CH_4 emissions reduction in CO_2eq	Kt	r = (k*m*o)/1,000,00
N_2O emission reduction in CO_2eq	Kt	s = (k*n*p)/1,000,000
Total GHG emission reduction	Kt CO2 eq	t = (q+r+s)
GHG emission reduction to target	%	u = (t/b)*100

Table 9: Tracking tool for Solar water pumps.

Building retrofits mitigation measure for Government and commercial sectors

Building retrofits is an energy-saving initiative. Three indicators are vital to track this mitigation measure: the number of buildings retrofitted for energy efficiency, the energy saved in TJ, and the GHG emissions in Kt CO_2eq. As per the MPG, these variables will be tracked from the baseline and the current year of reporting.

The variables to be collected for tracking building retrofits include the number of buildings retrofitted for the baseline and current years and the electricity consumption before and after retrofitting. This will enable estimation of the energy saving in TJ per building. Total energy savings for the baseline and current is the summation of energy savings for all the retrofitted buildings.

The data will be collected from the Department of Building and Engineering Services under the Ministry of Infrastructure and Housing Development (MIH), the private sector, Business Botswana and the BERA.

The data will be available from BPC and the retrofitted building owners or occupants for energy consumption and savings. The collected data will be used to derive the total energy savings in TJ and GHG emissions reduction corresponding to the energy savings.

Equations 1 to 3 will be used to compute the GHG emissions reduction based on the energy savings. As there are two sources of electricity generation (coal and diesel) it is necessary to determine which source of electricity generation will be affected by building retrofit. Table 10 depicts the tracking tools for the building retrofits mitigations for both the coal and diesel sources. The tracking tools should be used to calculate and track mitigation for the domestic, commercial and government buildings separately, and the results combined for NDC reporting. It is advisable to track the progress and efforts annually.

Date Name of Department Name of the person Contact		
Type of mitigation measure	**building retrofits**	
Measurement unit	Unit	Quantity
Indicator	TJ of saved energy	
Target capacity by 2030	TJ of saved energy	a

Target emission reduction by 2030	Kt CO_2eq	b = 17
baseline number of building retrofitted	unitless	c
current number of buildings retrofitted	unitless	d
baseline electricity consumption prior to retrofitting per building	TJ	e
current electricity consumption after retrofitting per building	TJ	f
electricity saving per building retrofitted	TJ	g = (f-e)
Baseline total electricity saving	TJ	h = (c*g)
Current total electricity savings	TJ	i = (d*g)
% of saved electricity that replaced coal electricity	%	j
CO_2 emission factor from coal consumption	Kg CO_2/TJ	k = 94,000
CH_4 emission factor from coal consumption	Kg CH_4/TJ	l = 1
N_2O emission factor from coal consumption	K_G N_2O/TJ	m = 1.5
CH_4 to CO_2eq conversion	unitless	n = 28
N_2O to CO_2eq conversion factor	unitless	o = 265
CO_2 emission reduction	Kt	p = (i*j*k)/1,000,00
CH_4 emissions reduction in CO_2eq	Kt	q = (i*j*l*n)/1,000,000
N_2O emission reduction in CO_2eq	Kt	r =(i*j*m*o)/1,000,000
GHG emission reduction from coal electricity	Kt CO_2 eq	s = (p+q+r)
% of saved electricity that replaced diesel electricity	%	t
CO_2 emission factor from diesel consumption	Kg CO_2/TJ	u = 70,800
CH_4 emission factor from diesel consumption	Kg CH_4/TJ	v = 3
N_2O emission factor from diesel consumption	Kg N_2O/TJ	w = 0.6
CO_2 emission reduction	Kt	y = (i*t*u)/1,000,000
CH_4 emissions reduction in CO_2eq	Kt	z = (i*t*v*n)/1,000,000
N2O emissions reduction in CO2 eq	Kt	aa = (i*t*w*o)/1,000,000
GHG emissions reduction from diesel	KT	ab = (y+z+aa)

Total GHG emission reduction (coal + diesel)	Kt CO_2 eq	ac = (s+ab)
GHG emission reduction to target	%	t = (ac/b)*100

Table 10: Tracking tool for building retrofits mitigation.

Solar geysers mitigation measure

This initiative involves the replacement of electric water heaters (geysers) with solar ones. The indicators for this mitigation are energy saved in TJ and the GHG emissions reductions in Kt CO2 eq. The variables that will be required to track the indicators are:

- Number of households, government and council, houses with solar geysers,
- Institutional accommodations houses with solar geysers (boarding schools, tertiary and training schools),
- Average wattage of electric water heaters,
- The number of hours the electric heaters are switched.

These variables will be used to compute annual energy consumption per geyser in TJ and the corresponding energy saving by switching to solar geysers. The information will be obtained from BPC, Department of Building and Engineering Services under the MIH and Botswana Statistics surveys on solar appliance utilisation.

Since there are two source of electricity generation in the country (coal and diesel) it is necessary to determine which source of electricity generated will be saved. Based on the outcome from the consultations with BPC, table 11 should be used to track the mitigation implementations and the GHG emissions. This tracking tool should be used annually to track the solar geysers mitigation measure and the results reported on a 2-year period as per the EFT.

Date		
Name of Department		
Name of the person		
Contact		
Type of mitigation measure	**Solar geysers**	
Measurement unit	Unit	Quantity
Indicator	TJ energy saved	
Target capacity by 2030	TJ energy saved	a
Target emission reduction by 2030	Kt CO_2eq	b = 6.1
Baseline number of solar geyser	unitless	c
Current number of solar geyser	unitless	d
Net change in solar geysers	unitless	e
average wattage of electricity water heaters (geyser)	kwh	f

average hours an electricity geyser is switched on	h	g
Annual energy consumption per unit	kwh	h= (f*g)*365
total energy saved	TJ	i = (d*h)*0.0000036
% Of the total energy saved that replace coal electricity	%	j
CO_2 emission factor from coal consumption	Kg CO_2/TJ	k = 94,000
CH_4 emission factor from coal consumption	Kg CH_4/TJ	l = 1
N_2O emission factor from coal consumption	Kg N_2O/TJ	m = 1.5
CH_4 to CO_2eq conversion	unitless	n = 28
N_2O to CO_2eq conversion factor	unitless	o = 265
CO_2 emission reduction	Kt	p = (i*j*k)/1,000,000
CH_4 emissions reduction in CO_2eq	Kt	q = (i*j*l*n)/1,000,000
N_2O emission reduction in CO_2eq	Kt	r = (i*j*m*o)/1,000,000
GHG emission reduction from coal	Kt CO_2eq	s = (p+q+r)
% Of total energy saved that replace diesel electricity	%	t
CO_2 emission factor from diesel consumption	Kg CO_2/TJ	u = 70,800
CH_4 emission factor from diesel consumption	Kg CH_4/TJ	v = 3
N_2O emission factor from diesel consumption	Kg N_2O/TJ	w = 0.6
CO_2 emission reduction	Kt	x =(i*t*u)/1,000,000
CH_4 emissions reduction in CO_2eq	Kt	y = (i*t*v*n)/1,000,000
N_2O emission reduction in CO_2eq	Kt	z = (i*t*w*o)/1,000,000
GHG emission reduction from diesel electricity	Kt CO_2 eq	aa = (x+y+z)
Total GHG emissions reduction (Coal + diesel)	Kt CO_2 eq	ab = (s+aa)
GHG emission reduction to target	%	ac = (ab/b)*100

Table 11: Tracking tool for solar geysers mitigation.

Solar and LED streetlights

This is another solar appliance initiative that is aimed at saving energy. The indicators from this mitigation initiative are energy saving in TJ and the GHG emission reduction in Kt CO_2eq. The variables essential for tracking the solar and LED streetlights are the number of national solar and streetlights with LED. Additional data required are the

current bulb wattage of streetlights connected to the national electricity grid systems and the number of hours the streetlights are switched on. This will enable estimation of the energy consumption per streetlight and the resultant energy saving by switching to solar streetlights.

Additional data that will be needed will be the number of streetlights fitted with the light-emitting diode (LED) bulbs and the energy saving of the LED bulbs. These data sources will be obtained from BITRI and district councils. Councils are responsible for maintaining the streetlights throughout the country, while BITRI is involved in developing and installing solar streetlights in the country.

The collected data will estimate the energy saving in TJ and the resultant GHG emission reduction in Kt CO_2eq based on Equations 1 to 3. Similarly, it will be necessary to determine which electricity source (coal or diesel will be reduced by the solar streetlights. Table 12 will be used to tracking the solar and LED streetlight and their resultant GHG emissions reduction. It is also advised that the tracking should be done annually to ensure accuracy.

Date		
Name of Department		
Name of the person		
Contact		
Type of mitigation measure	Solar and LED streetlight	
Measurement unit	Unit	Quantity
Indicator	TJ electricity saved	
Target number of solar streetlight by 2030	unitless	a
Target emission reduction by 2030	Kt CO_2eq	b = 3.7
Baseline number of solar streetlights	unitless	c
Current number of solar streetlights	unitless	d
Net change in number of streetlights	unitless	e = (d-c)
% Change in solar streetlights	%	f = (e/c)*100
% Of solar streetlight to target	%	g = (d/a)*100
streetlight incandescent bulb wattage	w	h = 1,000
number of hours operational per day	hr	i = 10
number of streetlights with LED	unitless	j
wattage of LED	w	k = 100
energy saving by LED streetlight	w	l = 900

energy saving from solar streetlight	TJ	m = (d*h*i*365)*0.0000036
energy saving from LED streetlight	TJ	n = (j*l*i*365)*0.000036
total energy saving	TJ	o = (m+n)
% Of solar saved that replace coal electricity	%	p
CO_2 emission factor from coal consumption	Kg CO_2/TJ	q = 94,000
CH_4 emission factor from coal consumption	Kg CH_4/TJ	r = 1
N_2O emission factor from coal combustion	Kg N_2O/TJ	s = 1.5
CH_4 to CO_2eq conversion	unitless	t = 28
N_2O to CO_2eq conversion factor	unitless	u = 265
CO_2 emission reduction	Kt	v = (o*p*q)/1,000,000
CH_4 emissions reduction in CO_2 eq	Kt	w = (o*p*r*t)/1,000,000
N_2O emission reduction in CO_2 eq	Kt	x = (o*p*s*u)/1,000,000
GHG emission reduction from coal electricity	Kt CO_2eq	y = (v+w+x)
% Of solar energy that replace diesel electricity	%	z
CO_2 emission factor from diesel consumption	Kg CO_2/TJ	aa = 70,800
CH_4 emission factor from diesel consumption	Kg CH_4/TJ	ab = 3
N_2O emission factor from diesel consumption	Kg N_2O/TJ	ac = 0.6
CO_2 emission reduction	Kt	ad = (o*z*aa)/1,000,000
CH_4 emissions reduction in CO_2 eq	Kt	ae = (o*z*ab*t)/1,000,000
N_2O emission reduction in CO_2 eq	Kt	af = (o*z*ac*u)/1,000,000
GHG emission reduction from diesel electricity	Kt CO_2 eq	ag = ((ad+ae+af)
Total GHG emission reduction (coal+ diesel)	Kt CO_2 eq	ah = (y+ag)
GHG emission reduction to target	%	z = (ah/b)*100

Table 12: Tracking tool for solar and LED streetlight.

Concentrated solar power

This mitigation measure is similar to the 1000 MW Solar PV Programme. It is a conditional mitigation measure. The indicators are renewable energy in TJ and GHG emissions reduction in Kt CO_2eq. Table 13 is the tracking tool for the concentrated solar power, the variables, and equations for estimating the indicators. Equations 1 to 3 will estimate

GHG emissions following the 2006 IPCCC guidelines for National GHG inventories emissions. The data source for tracking this mitigation measure will be DoE and BPC.

Date		
Name of Department		
Name of the person		
Contact		
Type of mitigation measure	**Concentrated solar power**	
Measurement unit	Unit	Quantity
Indicator	TJ renewable energy	
Target capacity by 2030	MW	a
Target emission reduction by 2030	Kt CO_2eq	b = 1,153
Baseline capacity	MW	c
Current capacity	MW	d
Change in capacity	MW	e
% Of current capacity to target	%	f
Baseline electricity generated	TJ	g
Current electricity generated	TJ	h
Net electricity generated	TJ	i
% Of solar electricity generated to thermal	%	j =(h/national)*100
% Of solar electricity that replaced coal electricity	%	k
CO_2 emission factor from coal consumption	Kg CO_2/TJ	l = 94,000
CH_4 emission factor from coal consumption	Kg CH_4/TJ	m = 1
N_2O emission factor from coal consumption	Kg/N_2O/TJ	n = 1.5
CH_4 to CO_2eq conversion	unitless	o = 28
N_2O to CO_2eq conversion factor	unitless	p = 265
CO_2 emission reduction	Kt	q = (h*k*l)/1,000,000

CH_4 emissions reduction in CO_2eq	Kt	r = (h*k*m*o)/1,000,000
N_2O emission reduction in CO_2eq	Kt	s = (h*K*n*p)/1,000,000
GHG emission reduction from coal electricity	Kt CO_2 eq	t = (p+q+r)
% Of solar electricity that replaced diesel electricity	%	u
CO_2 emission factor from diesel consumption	Kg CO_2/TJ	v = 70,800
CH_4 emission factor from diesel consumption	Kg CH_4/TJ	w = 3
N_2O emission factor from diesel consumption	Kg/N_2O/TJ	x = 0.6
CO_2 emission reduction	Kt	y = (h*u*v)/1,000,000
CH_4 emissions reduction in CO_2eq	Kt	z = (h*u*w*o)/1,000,000
N_2O emission reduction in CO_2eq	Kt	aa = (h*u*x*p)/1,000,000
GHG emission reduction from diesel electricity	Kt CO_2 eq	Aa = (ty+a+aa)
Total GHG emission reduction (coal+ diesel)	Kt CO_2 eq	ab = (t+aa)
GHG emission reduction to target	%	t = (ab/b)*100

Table 13: Tracking tool for concentrated solar power.

Tracking tools for finance and technology transfers

Paris Agreement Articles 9, 10, and 11 state that the developing countries shall provide information on financial, technology transfer and capacity-building support needed and received (UNFCCC, 2020). The tracking tools for the financial resources and technology transfers have been prepared based on the MPG. Table 14 depicts the tracking tools for the financial support received for the implementation of NDCs. As different departments may receive financial support for the energy mitigation, it is advised that this tracking tool be used by all departments implementing the energy mitigation. The financial resources received by the different line ministries and their respective departments should be totalled each year for ease of reporting.

The GHG emission reduction impacts of the financial resources received should be estimated using Table 3 to 12 depending on the mitigation measure.

Date		
Recipient/implementing entity		
Name of the person		
Source of funding		
Amount	US$	BWP

Year of funding received						
Expected time frame						
Financial instrument	Grant	Concessional loan	Non-concessional loan	Equity	Guarantee	Insurance
Status	Committed			Received		
Type of mitigation activity funded	Technological transfers		Capacity building		Mitigation measure	
	Planned		Ongoing		Completed	
Status of activity						
The capacity of the mitigation measure (TJ)						
GHG emission reduction (potential) of the fund						

Table 14: Tracking tools for the financial support received.

Tracking tools for technology transfers

Technological transfer is imperative to reducing global emissions. Article 10, paragraph 4 is specifically focused on the technology transfer framework. The purpose of the technology transfer framework is to provide overall guidance on promoting and facilitating enhanced action on technology development and transfer to support the implementation of the Paris Agreement (UNFCCC, 2017). The Paris Agreement's technological transfer framework focuses on the following areas (UNFCCC, 2017):

- Innovation
- Implementation
- Enabling environment and capacity building
- Collaboration and stakeholder engagement
- Support

According to the MPGs, technology transfer must be tracked and reported under the EFT. Similarly, the Technological Transfer Framework emphasises developing a system for monitoring and tracking of actions and activities undertaken and support received by the Technology Mechanism to implement the technology framework (UNFCCC, 2017). Thus, Table 15 depicts the tracking tools based on the MPG guidelines for technological transfers. Like financial support, the relevant recipients must use the tracking tool annually to ensure that all the technology received is recorded.

The GHG emission reduction arising from technological transfer received should be estimated using Table 3 to 12 depending on the type of mitigation measure.

Date				
Name of ministry				
Recipient/implementing entity				
Name of the person				
Type of technology received				
Entity donor				
Title of activity, project or programme				
Time frame				
Status of activity	Planned	Ongoing	Completed	
Capacity of the mitigation measure (TJ)				
GHG emission reduction (potential) of the fund				

Table 15: Tracking tool for technological transfer received.

Capacity building tracking tool

Capacity building is another crucial aspect that will enable the implementation of NDC mitigation activities. Mitigation measures such as retrofitting, concentrated solar power and solar appliances will require the capacity building of various stakeholders. Similarly, the capacity-building initiatives need to be tracked and reported under the EFT as per the MPG. Table 16 depicts the tracking tools for the capacity building undertaken to enable the implementation of the NDC.

Name of the recipient entity				
Name of implementing entity				
Type of capacity development	Short course	Long term course	Online	On job training
Status of activity	planned	ongoing	completed	
Number of participants trained				
List of stakeholders trained				
results from capacity building on mitigation				

implementation	

Table 16: Tracking tools for capacity building.

Tracking tool for policies and measures

Policies and legal frameworks are an important component of the NDC. The policy creates an enabling environment to enhance and facilitate the implementation of the NDC. Similarly, as noted in the Technological transfer frameworks, the policy is paramount to technological transfers and innovation. Policy efforts and their impacts on GHG emission reduction are also to be reported as per the MPGs. Table 17 depicts the tracking tools for the policy and measure that the GoB will implement to achieve its NDC target.

The GHG emission reduction of technological transfer received should be estimated using Table 3 to 12 depending on the mitigation measure.

Date		
Implementing entity		
Name of person		
Name policy		
Type of instrument	Legal	Financial
Status	Planned	Implemented
Year of implementation		
Description of the policy		
Objective of policy/measure		
Target mitigation area		
Policy results (mitigation project)		
GHG emission reduction		

Table 17: Tracking tools for policy and measures

Data quality

The Paris Agreement highlights that data quality is imperative for transparency. Effectively, it stresses that the presentation of clear and understandable data and information will contribute significantly to the EFT and ensure transparency (UNFCCC, 2020). According to the MPGs, each party should provide a detailed description of the

quality assurance/quality control (QA/QC) plan following the IPCC guidelines (UNFCCC, undated).

Statistics Botswana has developed a Botswana Data Quality Assessment Framework (BDQAF), which guides its data quality and control protocols. The BDQAF has been developed following the UN Fundamental Principles of Official Statistics. Two principles that underpin the BDQAF are accountability and transparency. The BDQAF is based on the underlying principle that the agency must present information according to scientific standards on the sources, methods, and procedures of the statistics (UNECE, undated).

It is thus imperative that the data collection for the developed tracking tools uses the BDQAF, which follows the international UN standards. Consequently, it is fundamental that through institutional arrangements, Statistics Botswana should include the data requirements for the NDC tracking as one of their priority areas. Consequently, Statistics Botswana has been collecting some of the data for the mitigation measures such as solar boreholes, biogas digester and solar appliance. In order to ensure that Statistics Botswana extent data collection to cover the data indicated in the tracking tools, it is critical that Memorandum of Agreement/understanding is signed between Department of Meteorological Services (DMS) and Statistics Botswana. The Memorandum of Agreement/understanding should also emphasis on QA/QC as per IPCC.

Monitoring and Evaluation

Monitoring and evaluation (M&E) of the tracking is fundamental for the effectiveness of tracking the country's NDC efforts. M&E must be undertaken primarily to determine the relevancy of the tracking tools, their user friendliness, and data availability for their implementation. Before their adoption and full-scale use, these tracking tools should be tested and evaluated for their structural robustness. That is, the equations developed must be tested to determine their structural and content validity. This will involve the collection of data and tracking the mitigation measures.

In addition, it is also important that their data requirements for the tracking tools are also evaluated in terms of availability and cost-effectiveness. Based on the outcomes from the evaluation exercise, the tracking tools should either be adopted or modified.

Furthermore, tracking tools are dynamic and generally evolve and as new information emerge. It is therefore important that these tracking tools should be evaluated on an annual basis to determine aspects that are obsolete or not relevant.

Moreover, it is critical that the M&E informs the NDC implementation progress. There is thus a need to development a monitoring and evaluation framework where the data collected from the tracking tools is used to monitor the NDC implementation progress. The tracking tools have variables such as target capacity by 2030, current capacity, and % of current capacity to target which are necessary to track the NDC implementation. Thus, the information should be used for M&E of the NDC implementation progress and inform the decision makers. This information should feed into the next round of NDC review.

Recommendations

The following recommendations are made to ensure effective tracking of the NDC mitigation efforts for both mitigation measures, policy efforts, financial resources, and capacity building:

- The tracking tools should be used annually to track the country's NDC efforts. This will significantly improve data reliability and enhance transparency on reporting of the country's NDC.
- For the mitigation measures that use instruments such as feed-in-tariffs wind turbines, it is highly recommended that monthly readings are taken to calculate rather than estimate energy production.
- For mitigation measures that cover a wide range of stakeholders (household, commercial and

public/government), the tracking tools should be used for each group as the scale of operations could be different. For instance, the average feedstock for biogas will be different between households, commercial, and government. After estimating the mitigation reduction for each group, the results should be combined for reporting purposes.

- Statistics Botswana is tasked with collection, processing, analysis, dissemination and archiving of statistical information across the economy covering all major sectors. Thus, it is the lead data provider for mitigation measures. Therefore, it is important that Statistics Botswana is engaged at early stages on the data requirements for the tracking tools to ensure data availability.
- It is also important that other stakeholders such as BITRI (solar streetlights), DoE (biogas), councils (solar streetlights), Ministry of Infrastructure and Housing Development (retrofitting and solar appliances) and the Department of Animal Production (solar boreholes) are also included at an initial stage to expedite data and information exchange platforms.
- QA/QC forms are an essential part of the Paris Agreement regarding the transparency framework. Statistics Botswana has a well-established data quality control framework named the Botswana Data Quality Assessment Framework (BDQAF). It is recommended that this framework be adopted for the tracking tools' data.
- It is critical that the Memorandum of Agreements/understanding between parastatals such as Statistics Botswana, Business Botswana, etc are signed to enhance and facilitate their participation in the NDC tracking particularly regarding data collection and exchange amongst the stakeholders.
- There are existing barriers and gaps that have been identified such as limited knowledge on the country's NDC and EFT, lack of institutional capacity, lack of data and gaps. In order to close these existing barriers and create an enabling environment for reporting the NDC as per the EFT, an institutional and policy framework roadmap for the country has been developed. The roadmap identifies strategic activities for implementation to close the existing gaps and remove barriers. Thus, the need for its implementation cannot be overemphasised.

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