



Ministry of Tourism and Environment
Republic of Maldives

Methodology Report for Estimation of Mitigation Actions

Consultancy Service for Tracking Mitigation Actions

CBIT Maldives

Capacity Building for Improved Transparency
of Climate Change Mitigation and Adaptation
Actions in the Maldives



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CBIT MALDIVES

Capacity Strengthening for Improved Transparency of
Climate Change Mitigation and Adaptation Actions in the
Maldives Project





Ministry of Tourism and Environment

Capacity Strengthening for Improved
Transparency of Climate Change
Mitigation and Adaptation Actions in the
Maldives Project (CBIT Maldives)



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Consultant:



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Executive Summary

The Government of Maldives aims to enhance its national transparency system in alignment with the enhanced transparency framework (ETF) through the capacity– building Initiative for Transparency (CBIT) Maldives project. This project titled Consultancy Service for Tracking Mitigation Actions is part of the larger CBIT Maldives project. The project focuses on improving the tracking of mitigation actions to support the preparation of GHG inventories, monitor progress toward Nationally Determined Contributions (NDCs), and track climate finance effectively.

In February 2025, Maldives submitted its third NDC, focusing on mitigation in the energy, transport, and waste sectors, and adaptation aiming to reduce 1.52 million tonne of CO₂ equivalent, conditional on international support. The monitoring and verification methodology outlined in this report will support the Government to track progress made in achieving its NDC target.

Based on the mitigation measures identified in the NDC report, stakeholder consultations were conducted by the project team to understand the mitigation actions currently being implemented in Maldives. The preliminary list of stakeholder consultations was validated by the Ministry of Tourism and Environment. To ensure broad participation and flexibility, a hybrid consultation approach—combining in-person and virtual meetings—was adopted. A standard questionnaire was developed to guide these discussions, collect consistent information and identify data gaps. Consultations were carried out with stakeholders from FENAKA, STELCO, Energy and Waste Department of Ministry of Tourism and Environment (MoTE), and, Utility Regulatory Authority (URA).

Based on the insights gathered from stakeholder consultations; detailed methodologies were developed for tracking mitigation actions under four sectors along with identification of key indicators.

Summary of the indicators and key data required for estimation of the mitigations for the different sectors is presented next.

Sectors	Indicator	Scenarios	Additional data if available will be beneficial
Renewable Energy Projects	<ul style="list-style-type: none"> Annual Electricity Generation (kWh/year) for the RE system Installed capacity (kW_p) 	<ul style="list-style-type: none"> Renewable energy replacing grid electricity Renewable energy replacing diesel generator (DG) electricity 	<ul style="list-style-type: none"> Capacity utilization factor Grid emission factor SEGR of the Diesel Generator
Energy Efficiency Projects:	<ul style="list-style-type: none"> Import data for the appliance along with Hakathari label rating of the respective appliance (Air conditioners, Washing Machines, Refrigerators) 	<ul style="list-style-type: none"> Reduction in energy generation – Grid Electricity Reduction in energy generation – Diesel Generator Electricity 	<ul style="list-style-type: none"> Hakathari label data Details of capacities for appliances Grid emission factor SEGR of the Diesel Generator
Waste-to-Energy Projects:	<ul style="list-style-type: none"> Annual quantity of waste processed by the WtE plant. 	<ul style="list-style-type: none"> Reduction in energy generation – Grid Electricity Reduction in energy generation – Diesel Generator Electricity 	<ul style="list-style-type: none"> Energy generation from WtE plant Avoided / reduced methane emissions from landfill Grid emission factor SEGR of the Diesel Generator
Transport Sector Projects:	<ul style="list-style-type: none"> Number EV sold (based upon vehicle types) Specific energy consumption (km/kWh) for EV Number HV sold 	<ul style="list-style-type: none"> Fuel consumption reduction and increased grid electricity consumption Fuel 	<ul style="list-style-type: none"> Range of the EV / battery capacity (kWh) Fuel economy for new HV Grid emission factor

Sectors	Indicator	Scenarios	Additional data if available will be beneficial
	(based upon vehicle types) <ul style="list-style-type: none"> Specific fuel consumption (km/liter) for HV 	consumption reduction and increased electricity from DG <ul style="list-style-type: none"> Fuel consumption reduction and increased electricity from 	<ul style="list-style-type: none"> SEGR of the Diesel Generator

Chapter 1: Introduction

1.1. Project overview

Tracking mitigation actions is critical for strengthening Maldives' institutional capacity to meet its climate commitments under the Paris Agreement. Through Capacity– building Initiative for Transparency (CBIT) Maldives project, the Government aims to enhance its national transparency system in alignment with the enhanced transparency framework (ETF). This involves systematizing data collection, improving data quality and developing indicators and methodologies. This tracking of mitigation actions would enable Maldives to better prepare GHG inventories, measure progress made in achieving national determined contribution (NDC) target and track climate finance in an integrated and consistent manner.

The broader objective of the CBIT Maldives project is as follows:

- Develop standardized methodologies for estimating key mitigation indicators, aligned with national and international climate reporting frameworks.
- Design & implement emissions estimation tool to quantify reductions from mitigation actions, ensuring compatibility with national data systems & reporting requirements.
- Formulate clear and practical guidelines for reporting GHG estimations to ensure consistency, transparency, and accuracy in mitigation reporting.
- Develop an integrated tool for tracking and reporting mitigation actions, enabling real– time monitoring, data integration, and streamlined reporting processes.
- This assignment aims to strengthen the Maldives' capacity to track NDC implementation in the energy and waste sectors. It involves developing tools, methodologies, and sector– specific mitigation indicators. Guidelines will be prepared for estimating mitigation indicators, archiving data, and validating tracking methods.

The activities covered under the CBIT Maldives project will support evidence– based decision making to ensure timely submissions of biennial transparency reports (BTRs) to the United Nations framework convention on climate change (UNFCCC), through accountability and transparency of climate action. Tracking mitigation actions will also serves two key purposes.

1. To verify the progress of mitigation activities and the effectiveness of implementation arrangements in line with established policies and strategies.
2. To help in evaluate if the intended outcomes or impacts are being achieved within the specified timeframe and allocated budget.

To initiate the assignment and develop a robust methodology for tracking mitigation actions, it is essential to assess the current projects and activities undertaken by relevant departments and stakeholders. As part of this process, the project team conducted a comprehensive review and analysis of the latest BTR, NDC report submitted by the Maldives to the UNFCCC.

1.2. Review of latest NDC and BTR

During February 2025, Maldives submitted its third NDC under the Paris Agreement, reaffirming its commitment to both mitigation and adaptation actions. BTR was submitted during the month of November 2024. The mitigation component focuses primarily on the energy (including transport) and waste sectors, aligning with national priorities and international obligations. Under the NDC, the proposed mitigation actions in these sectors aim to reduce 1.52 million tonne of CO₂ equivalent, conditional upon the availability of international finance, technology transfer, and capacity– building support. A summary of the key actions and activities outlined in the NDC for the energy, transport, and waste sectors are presented in the following section¹–

Scaling Up Renewable Energy (RE):

Meet 33% of electricity needs from renewable energy sources. **Enhancing Energy Efficiency:**

- Expand the standard labelling program and gradually implement its mandatory phase..
- Enhance and upgrade electricity grids to reduce energy loss in power generation facilities nationwide..
- **Waste Management:** Develop and operationalize three regional waste management systems in the Maldives.
- Expand composting programs across the Maldives to promote waste-to resource recovery..
- Remediation of the two largest dumpsites and establish island waste and resource management centers throughout the country..

Transitioning to More Efficient Transport:

- Introduce national vehicle emissions standards..
- Expand public transport networks throughout the entire country.

Introduce incentives to promote electric (EV) and hybrid vehicles. The NDC provides high level mitigation actions and the BTR provides details of the various mitigation actions being

¹ <https://unfccc.int/sites/default/files/2025-02/Maldives%E2%80%99Third%20Nationally%20Determined%20Contribution.pdf>

implemented within Maldives along with the amount of emission reduction achieved through few of the Solar PV installation projects.

The details of ongoing mitigation initiatives are presented in annexure 1.

Chapter 2: Stakeholder Consultation and Key inference

2.1. Stakeholders mapping

To initiate the activities, the project team began by identifying and mapping key stakeholders through secondary research. This preliminary list was subsequently validated in coordination with the Ministry of Environment to ensure its relevance and completeness.

A key insight from the desk research was the need for targeted stakeholder consultations to gather detailed information on the mitigation actions currently being implemented in the Maldives. These consultations aimed to understand the types of data being monitored and the methodologies used for tracking emission reductions.

The project team worked closely with the Ministry and relevant stakeholders to schedule the consultations. A hybrid approach, combining both in– person and virtual meetings, was adopted to ensure broad participation and flexibility.

To facilitate structured and consistent input, a standard questionnaire was developed. This questionnaire was shared during the consultations to guide discussions, collect information on ongoing mitigation actions, and identify potential data gaps. This approach ensured that the consultations were aligned with national priorities, reflected on– the– ground realities, and addressed existing data limitations.

Ultimately, the consultations aimed to integrate stakeholder perspectives into the broader mitigation planning and reporting framework, thereby strengthening the Maldives’ institutional capacity for effective climate action. The names of stakeholders and consultation dates are provided in table 1.

Table 1: Stakeholder Consultation Schedule

Stakeholders	Consultation date
1. FENAKA	05 th Feb 2025
2. STELCO	12 th Feb 2025
3. Climate Change Department, Ministry of Tourism and Environment	20 th Feb 2025
4. Waste Department, Ministry of Tourism and Environment	25 th Feb 2025
5. Utility Regulatory Authority (URA)	26 th Feb 2025
6. Waste Management Corporation Limited (WAMCO)	04 th Mar 2025

2.2. Inference from Stakeholder Consultations

The summary of the key insights gathered from the different stakeholder consultations are:

- There is significant challenges related to data collection and transparency. One of the primary issue is the **lack of a standardized template or uniform methodology used for data collection and different project information is tracked by different stakeholders.**
- Another significant challenge is that the stakeholders have limited or lack the dedicated technical staff and resources needed to capture the accurate data required for the mitigation actions. In many instances, **proxy data is used in absence of actual, verifiable data**, which affects the accuracy and reliability of emission reduction estimates, leading to high uncertainty. This reliance on assumptions or estimated values instead of real-time or measured data introduces a high degree of uncertainty in reporting outcomes.
- Projects are handled by different government entities at different stages of execution. In absence of common reporting formats for mitigation actions, information has to be collected from different departments. For example, for a Solar PV system installation project, project execution cost, technology used, gender related information at the project installation phase might be available with one government entity while information related to the quantity of electricity generated by Solar PV, reduction in diesel consumption etc. might be maintained by the commissioning and maintaining entity.
- Private sector is not mandated to submit the data and reports of projects such as Solar PV installations, installing the EE appliances, etc. In absence of the data from private sector, the overall GHG emission reductions levels may not be fully captured and reported.

Chapter 3: Methodology for Tracking Emissions Reductions

The project team gained valuable insights through secondary research and stakeholder consultations. The key issue identified was the lack of a standardized format for data collection. This inconsistency affects the accuracy, transparency, and reliability of emission-related data. To effectively assess emission reductions and monitor progress toward national targets, framework shall be developed to capture accurate data from different stakeholders. This requires developing a standardized data collection framework that includes both public and private sector input.

A review of the tracking methodologies that include emission reduction achieved is essentially the difference in emissions in the baseline scenario and post implementation scenario. In essence, baseline scenario represents the amount of GHG emissions being generated before the project was implemented whereas post implementation scenario refers to the real, measured or estimated amount of greenhouse gas emissions produced after the implementation of a project or activity.

The project team evaluated different options and scenarios for accurately capturing data related to mitigation actions (under each of the segment – energy efficiency, renewable energy, transport, and waste). GHG emission reduction is the primary objective that must be assessed for all mitigation efforts. Various parameters and datasets can be used to evaluate GHG reductions, each offering different levels of accuracy.

In-depth deliberations were carried out with key stakeholders to narrow down the most relevant indicators from a wide array of options and scenarios. These indicators were finalized for each sector, taking into account the regional context, as well as the availability and feasibility of accurately monitoring each parameter. Finalized indicators shall be used to evaluate mitigation measures through a well-defined methodological framework. This systematic and comprehensive approach will enable the Maldives to identify mitigation measures using the best available data from both public and private sectors.

The GHG emission reduction methodology has been developed for the four sectors of mitigation actions currently being implemented in the country; renewable energy projects, energy efficiency projects, transport, and waste to energy projects.

3.1. Renewable energy projects: Methodology for evaluating GHG mitigation

The first step in a renewable energy project is to classify the type of renewable energy (RE) project being implemented. There are three types of renewable projects that are most commonly implemented in the Small Island Developing States (SIDS). Different type of the RE project are categorized under the following categories: –

- **Solar Energy Projects**
 - I. Rooftop Solar
 - II. Ground– Mounted Solar
 - III. Floating Solar
- **Wind Energy Projects**
 - I. Onshore Wind
 - II. Ground– Mounted Wind
- **Marine Energy Projects**
 - I. Tidal Energy
 - II. Wave Energy
 - III. Other Ocean– Based Energy Solutions

To effectively identify and quantify the mitigation impact of RE projects, it is essential to evaluate the associated reduction in GHG emissions. These projects contribute to emission reductions by displacing fossil fuel– based energy sources. For example, solar or wind installations can reduce reliance on grid electricity or diesel consumed by Diesel Gensets (DG sets). Therefore, a critical first step in estimating GHG reductions is to determine the type of fossil– based system being replaced.



Accurate estimation of energy generation from RE systems is key to calculating emission reductions. Ideally, this data should be captured through energy meters installed at project sites. However, in practice, only a limited number of RE installations are equipped with such meters (largely projects managed by STELCO and FENEKA). Periodic calibration of these meters is also challenging, which can lead to lower accuracy in reporting.

Identification of the key indicator for RE

Given these limitations, a more practical and reliable approach is to use the installed capacity of the RE system as a key indicator for energy generation. Installed capacity data is generally well documented and readily available across private sector projects. During stakeholder consultations, it was agreed that this parameter would serve as a primary indicator for evaluating RE projects. For public projects and other IDA funded initiatives, energy monitoring is typically an integral part of the project design to evaluate energy generation. As a result, for such projects, the annual electricity generation can be tracked and used as an indicator. Thus, the **two major indicators** for tracking RE projects GHG mitigation are as follows:

- **Annual electricity generation (kWh/year)**
- **Installed capacity (kW_p)**

Assumptions

Once the data of installed capacity is available, to estimate the annual energy generation, we need to use Maldives specific CUFs (capacity utilization factor). The CUFs vary depending on the type of RE technology (e.g., solar, wind, tidal, etc.) and location. It represents the ratio of actual energy generated to the maximum possible generation over a given period. Data for the CUF can be taken from global sources such as IRENA², other WB and UN reports. This systematic approach combining installed capacity with CUF assumptions provides a consistent and scalable method for estimating energy generation and, by extension, GHG emission reductions.

Another important data for estimating GHG reduction is the quantity of diesel saved. In absence of monitoring electricity generation and diesel consumption of the diesel generators, we are proposing to use the Specific Energy Generation Ratio (SEGR) for diesel generators as 3.9 kWh per litre of diesel. Estimation of the based on STELCO data and explained in annexure 2.

The grid emission factor can be calculated using the annual data published by FENEKA and STELCO. The grid emission factor will be calculated based on total diesel consumption and total electricity fed into grid by the two entities. Sample calculation for STELCO is provided in annexure 2.

² [Maldives IRENA report Renewable Energy Statistics 2024](#) – CUF can be calculated from the data in this report

Identifying the different Scenarios

To evaluate mitigation actions effectively, two possible scenarios have been identified. These scenarios are highly essential for enhancing the accuracy GHG reduction estimation. Considering the different baseline energy generation contexts, the following scenarios have been outlined:

- a. **Scenario 1:** Renewable energy replacing grid electricity
- b. **Scenario 2:** Renewable energy replacing diesel generator (DG) electricity

Based upon the parameters detailed out above, the following methodology is proposed for the mitigation actions under the different scenarios.

Indicator: Annual Electricity Generation from Renewable Energy Plant (kWh/year)

Scenario 1: RE is replacing Grid electricity

- **Step 1:** Annual energy generation from RE project (kWh/year) is available
- **Step 2:** Estimated of GHG reduction = RE energy generation (kWh/year) × Grid emission factor

Scenario 2: RE is replacing Diesel Generator electricity, but baseline diesel consumption is not monitored

- **Step 1:** Calculate the SEGR of the Diesel Generator or use 3.9 kWh/L
- **Step 2:** Diesel saved due to renewable energy plant (L) = SEGR × Annual Electricity Generation from Renewable Energy Plant
- **Step 3:** Estimated GHG reduction = Diesel saved (L) × IPCC Default factor for diesel³

Indicator: Installed Capacity of Renewable Energy Plant (kW_p)

Scenario 1: RE is replacing Grid electricity

- **Step 1:** Check CUF for RE project (or use default CUF) and calculate annual electricity generation.

Annual electricity generation = RE Plant capacity (kW) × 8760 (hr/year) × CUF

- **Step 2:** Estimated GHG reduction = RE energy generation × Grid emission factor

³ This shall include Total GHG emission reduction (kg CO_{2e}) = Emission reduction (kg CO₂) + Equivalent emission reduction from methane and translated to CO_{2e} equivalent + Equivalent emission reduction from N₂O and translated to CO_{2e} equivalent as per IPCC guidelines. IPCC Guidelines for National Greenhouse Gas Inventories: Volume 2: Energy, Chapter 2: Stationary Combustion, Chapter 3: Mobile Combustion can be referred.

Scenario 2: RE is replacing Diesel Generator electricity, but baseline diesel consumption is not monitored

- **Step 1:** Check CUF for RE project (or use default CUF) and calculate annual electricity generation.
- Annual electricity generation = RE Plant capacity (kW) × 8760 (hr/year) × CUF
- **Step 2:** Calculate the SEGR of the Diesel Generator or use 3.9 kWh/L
- **Step 3:** Diesel saved due to Renewable energy plant (L) = SEGR × Annual Electricity Generation from Renewable Energy Project
- **Step 4:** Estimated GHG reduction = Diesel saved (L) × IPCC Default diesel emission factor

3.2. Energy Efficiency Projects: Methodology for evaluating GHG mitigation

The first step in EE is to classify the type of EE project being implemented. EE projects in Maldives can broadly be categorized in two type – Standards & Labelling (Hakathari Program) and other Energy Efficient equipment / appliances. During the consultations, it was discussed that other energy– efficient equipment and appliances form only a minimal part of the total mitigation measures. The baseline data is not available for most of these other Energy Efficient equipment and appliances; therefore, they are not included in the mitigation strategy. Among EE projects, the focus is on Hakathari program, and its details are as follows:

Hakathari Program (In Maldives three appliances are covered under the program)

- a. Air conditioners
- b. Washing Machines
- c. Refrigerators

To effectively identify & quantify the mitigation impact of EE projects, it is essential to evaluate associated GHG emissions reduction. These projects reduce energy consumption for the same operation, which in turn lowers the need for energy generated from fossil fuels.

For example, if EE equipment reduces energy consumption and the energy drawn from the grid, it results in lowering the overall GHG emissions from the grid. If the energy supply was from a DG, the reduction leads to diesel savings and consequently, lower GHG emissions. Therefore, it is critical to identify if the EE project is reducing grid electricity or DG electricity.



Accurate estimation of energy savings from EE projects is key to calculating emission reductions. Ideally, this data should be captured through energy meters installed at project sites. However, in practice, installing dedicated energy meters for individual equipment or appliances being replaced is commercially unviable in Maldives' context.

Identification of the key indicator for EE

To evaluate the impact GHG reduction of EE projects, several potential indicators have been identified. These include energy conservation (kWh/year), Hakathari label level (1,2,3,4,5), and other parameters, details of the parameters are presented next for each of the appliance.

- Air conditioners: Btu/h, Cooling Seasonal Performance Factor, annual operating hours
- Refrigerators: Adjusted volume, Annual energy consumption
- Washing machine: Rated capacity of the washing machine in kg, Energy consumption per cycle, number of operating cycles per year.

Import data⁴ related to the number of Hakathari labeled appliances sales by rating can be sourced from different departments (import data from customs, Hakathari labels ID from Ministry of Environment). Import data and energy efficiency label data can be used to estimate the energy savings for the different appliance categories. Based on feedback received during the consultations, the finalized approach is from among several options for evaluating energy savings. The following **indicator** was finalized for the appliance and equipment under Hakathari label program.

- **Import data for the appliance along with Hakathari label rating of the respective appliance**

Assumptions

Capturing baseline data for appliances being replaced by Hakathari– labeled models is quite challenging, as detailed information on the older equipment is often unavailable. To address this, it is proposed to consider the minimum Hakathari label rating as the baseline energy consumption. Energy savings can then be estimated by comparing the energy consumption of the new EE equipment with that of a lowest–rated appliance in the category, based on

⁴ In absence of single source for sales data, it is being assumed that import is equal to sales. As the inventory of present year and previous year is expected to offset each other.

standard performance benchmarks.

It is important to estimate the annual operating hours of the appliance. For air conditioners are assumed to operate for an average of 4380 hours per year⁵⁵. For washing machines, an annual usage of 220 cycles can be assumed for calculating the mitigation actions⁵⁶.

Another important data point for estimating GHG reduction is the SEGR for diesel– based electricity generators, or the grid emission factor when electricity is drawn from the grid. The details for these parameters are outlined under the assumptions in section – 3.1, similar approach can be used for the EEP.

Identifying the different Scenarios

Additionally, to evaluate mitigation actions effectively, two possible scenarios have been identified for Maldives. These scenarios are highly essential for enhancing the accuracy of GHG reduction estimation. The following scenarios have been outlined:

- a. **Scenario 1:** *Reduction in energy generation – Grid Electricity*
- b. **Scenario 2:** *Reduction in energy generation – Diesel Generator Electricity*

Based upon the parameters detailed out above, the following methodology is proposed for the mitigation actions under the different scenarios.

Indicator: Appliance wise data for the sales respective Hakathari label rating of the appliance

Evaluating energy saving from the EE appliances is presented below (the first three steps are common for both scenarios).

- **Step 1:** Annual energy saving from EE appliance (kWh/year) for each label = Baseline energy consumption – Energy consumption of the EE appliance
- **Step 2:** Calculating the import of the appliance from the custom department (sales / year) for each label and each appliance category
- **Step 3:** Estimated energy saving (kWh/year) = Annual Energy consumption calculated in Step 1 × Number of the import for the same EE appliance

Scenario 1: EEP leading to reduction in energy generation – Grid Electricity

- **Step 4:** Estimated GHG reduction = Energy saving per year due to Hakathari appliance's (Energy saving calculated in Step 3) × Grid emission factor

⁵⁵ [Guide on Minimum Energy Performance Standard for Air Conditioner](#)

⁵⁶ [Impact Assessment of EE Measures](#)

Scenario 2: EEP leading to reduction in energy generation – Diesel Generator Electricity

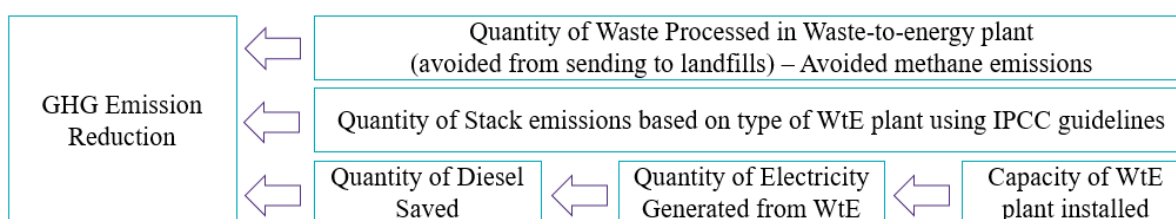
- **Step 4:** Calculate the SEGR of the Diesel Generator or use 3.9 kWh/L
- **Step 5:** Diesel saved due to Renewable energy plant (L) = SEGR × Energy saving per year due to Hakathari appliance's (Energy saving calculated in Step 3)
- **Step 6:** Estimated GHG reduction = Diesel saved (L) × IPCC Default diesel emission factor

3.3. Waste to Energy Projects: Methodology for evaluating GHG mitigation

Primarily, it is important to identify the type of waste-to-energy (WtE) project. These may include incinerators, gasifiers, or refuse-derived fuel-based systems.

To accurately assess the mitigation impact of WtE projects, we must evaluate the reduction in GHG emissions. Key factors to consider include:

- **Energy generation (A):** WtE projects will generate electrical energy, reducing dependence on fossil fuel-based power generation. Reduction in the grid electricity / diesel saving can be converted to GHG reduction.
- **Waste Diversion and avoided landfill emissions (B):** WtE plant will use the waste, thus reducing the quantity of the waste going to landfills. Over time, landfill waste degrades and emits methane (greenhouse gas), in case open / controlled burning is done then emission from degradation of waste before burning and emissions from burning results in emissions. By using the waste in the WtE project will help in reducing the methane emissions from landfills / burning of waste.
- **Emission from combustion of waste (C):** WtE plant burns waste, which results in additional GHG emissions.



To monitor the overall impact, all three aspects must be carefully evaluated. Overall impact of the GHG reduction = A + B – C (as describe above).

Identification of the key indicator for WtE

To evaluate the GHG reduction impact of WtE projects, several potential indicators have been

identified. These include energy generation from the WtE plant, categorization of the waste, stack emissions from the WtE plant, change in the waste parameters, collection efficiency, and estimation of the degradation factors.

Based on feedback received during the consultations, the following **indicator** was finalized from among several options for evaluating energy savings.

▪ **Annual quantity of waste used in the WtE plant**

Assumptions

Energy Savings: The reduction in emissions from energy generation can be estimated by comparing the energy produced by the WtE plant with the emissions from DG sets or grid electricity that would otherwise be used. (Using the data from STELCO and FENEKA data).

Avoided Methane Emissions: This data can be calculated using assumptions, composition of waste can be sourced from World Bank or IPCC reports (IPCC 2006 Volume 5 Chapter 2, Average WB MSW characterization – 2019).

Stack Emissions: This data varies with the type of WtE technology used for processing and generating energy in WtE plants. In the absence of plant-specific data, emission factors can be taken from the IPCC guidelines for stationary combustion can be applied. (IPCC 2006 Volume 5 Chapter 5)

Another important data point for estimating GHG reduction is the SEGR for diesel-based electricity generators, or the grid emission factor when electricity is drawn from the grid. The details for these parameters are outlined under the assumptions in section-3.1, similar approach can be used for the WtE.

Identifying the different Scenarios

Additionally, to evaluate mitigation actions effectively, two possible scenarios have been identified for Maldives. These scenarios are highly essential for enhancing the accuracy GHG reduction estimation. The following scenarios have been outlined:

- c. **Scenario 1:** *Reduction in energy generation – Grid Electricity*
- d. **Scenario 2:** *Reduction in energy generation – Diesel Generator Electricity*

Based upon the parameters detailed out above, the following methodology is proposed for the mitigation actions under the different scenarios.

Indicator: Quantity of the waste used in the WtE plant

Evaluating the GHG reduction and energy generation from WtE plant. The first four steps are common to both scenarios.

- **Step 1:** Quantify the waste used in the WtE plant (tonne/year)
- **Step 2:** GHG reduction due to avoided methane emissions from landfill (tonne CO₂/year) **(B)** = Quantity of waste (tonne/ year) × Methane emission factor (tonne of methane per tonne of waste) × Conversion factor of methane⁷ to CO₂
- **Step 3:** GHG reduction generated from waste combustions (tonne CO₂/year) **(C)** = Quantity of waste (tonne/ year) × Stack emission data taken from IPCC guidelines⁸
- **Step 4:** Energy generation from WtE plant **(A)** = Data taken from the energy meter installed at plant (reducing the auxiliary energy consumption by the WtE plant)

Scenario 1: Reduction in energy generation – Grid Electricity

- **Step 5:** Use the grid emission factor for the Maldives (CO₂/kWh)
- **Step 6:** Estimated GHG reduction = Grid emission factor × Energy generation (A) + GHG emissions avoided (B) – GHG emissions from stack / combustion of waste (C)

Scenario 2: Reduction in energy generation – Diesel Generator Electricity

- **Step 5:** Calculate the SEGR of the Diesel Generator or use 3.9 kWh/L⁹
- **Step 6:** Diesel saved (L) due to Energy generation from WtE plant = SEGR × Energy generation from WtE plant
- **Step 7:** Estimate GHG reduction = [Diesel saved (L) × IPCC Default diesel emission factor] (A) + GHG emissions avoided (B) – GHG emissions from stack/combustion of waste (C).

3.4. Transport sector Projects: Methodology for evaluating GHG mitigation

The first step is to identify the type of mitigation project being implemented in transport. Mitigation actions in this sector typically involve replacing conventional internal combustion engines (ICE) vehicles with electric vehicle (EV) or hybrid vehicle (HV).

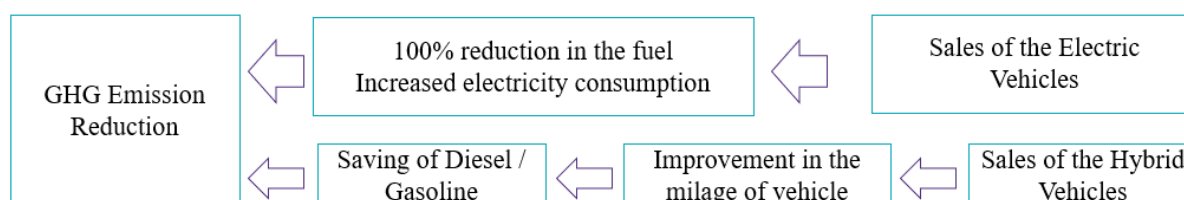
This transition leads to a reduction in fossil fuel consumption (gasoline and diesel), thereby decreasing tailpipe emissions from ICE vehicles (Emission A). However, it also results in

⁷ IPCC 2006 Volume 5 Chapter 2, Average WB MSW characterization – 2019

⁸ IPCC 2006 Volume 5 Chapter 5

⁹ Details presented in section above sections.

increased electricity demand in the transport sector. This additional electricity consumption may lead to higher emissions from power generation (Emission B), depending on the primary energy source for the generation of the electricity. But leads to overall GHG emissions reduction.



Identification of the key indicator for EE

To evaluate the impact GHG reduction of in the transport sector it is important to monitor the sales of EV and hybrid vehicles. The key **indicators** for tracking mitigation actions for the transport sector are:

- **Number EV sold (based upon vehicle types) & specific energy consumption (km/kWh)**
- **Number HV sold (based upon vehicle types) & specific fuel consumption (km/liter)**

All data related to the sales of EV / HV under different class and vehicle types (urban buses, motorcycles, heavy– duty vehicles, light commercial vehicles, and passenger cars) needs to be captured. This information can be obtained from the Customs Department (import data) or the Transport department (sales/vehicle registration data).

Assumptions

Data for the fuel economy of the different vehicle types (km/liter) is required along with the annual distance traveled by each vehicle class (km/year) to evaluate the baseline fuel consumption. This data can be taken from the BTR report¹⁰.

Additionally, GHG emissions from fuel consumption can be calculated using the IPCC guidelines to quantify the GHG emission (kg CO₂ / unit of gasoline or diesel).

Another important data point for estimating GHG reduction is the SEGR for diesel-based electricity generators, or the grid emission factor when electricity is drawn from the grid. The details of these parameters are outlined under the assumptions in section-3.1, a similar approach can be used for the transport sector.

¹⁰ <https://unfccc.int/sites/default/files/resource/MDV-BTR%201-Nov2024.pdf>

Identifying the different Scenarios

To evaluate mitigation actions effectively, three possible scenarios have been identified for Maldives. These scenarios are highly essential for enhancing the accuracy GHG reduction estimation. The following scenarios have been outlined for the EVs¹¹:

- a. *Scenario 1: Fuel consumption reduction and increased grid electricity consumption*
- b. *Scenario 2: Fuel consumption reduction and increased electricity from DG*
- c. *Scenario 3: Fuel consumption reduction and electricity from dedicated RE*

Note in case Scenario 3 is opted (preferably it might be linked to roof top solar at the housing / commercial facility, or other RE source), kindly ensure same RE power project is not captured under any other mitigation measures.

Based upon the parameters detailed out above, the following methodology is proposed for the mitigation actions under the different scenarios.

Indicator: Number of the different type of the EV sold

Evaluating the baseline GHG emission (A) and additional electricity required. The steps 1 to 4 are common for all three scenarios.

- **Step 1:** Capture the sales of the EV sold under each vehicle type
- **Step 2:** Fuel consumption for each vehicle type (liters/year) = Annual distance travelled (km) × Fuel economy (l/km)
- **Step 3:** Baseline GHG emissions (tonne of CO₂) = Quantity of the fuel used × emission factor as per IPCC¹²
- **Step 4:** Additional annual electricity required for pure EV = Range of the EV / battery capacity (kWh) × Annual distance travelled (km) based upon the vehicle type

Scenario 1: Fuel consumption reduction and increased grid electricity consumption

- **Step 5:** Estimated of GHG reduction = Baseline GHG emissions – Grid emission factor × Additional annual electricity required for pure EV

Scenario 2: Fuel consumption reduction and increased electricity from DG

- **Step 5:** Calculate the SEGR of the Diesel Generator use 3.9 kWh/L
- **Step 6:** Additional Diesel required (L) to generate electricity = Additional annual electricity

¹¹ Fuel saving for the HV (no additional electricity required)

¹² Microsoft Word - V2_Ch3_Mobile_Combustion_Final.doc (IPCC Guidelines for National Greenhouse Gas Inventories – Volume 2: Chapter 3 – Mobile Combustion)

required for pure EV × SEGR (Step 5')

- **Step 7:** Estimated GHG reduction = Baselines GHG emission from ICE vehicle (calculated in step 3) – Additional diesel required (L) × IPCC Default emission factor for diesel

Scenario 3: Fuel consumption reduction and electricity from dedicated RE

- **Step 5:** Emission from the RE electricity is considered zero¹³.
- **Step 6:** Estimated GHG reduction = Baseline GHG emissions

Indicator: Number Hybrid Vehicles sold (based upon vehicle types)

Evaluating the baseline GHG emission (A) and GHG reduction after replacement with new HV

- **Step 1:** Capture the sales of the vehicles under each Vehicle Types
- **Step 2:** Annual fuel consumption in baseline scenario¹⁴ (liters/year) = {Annual distance travelled (km) × Fuel economy (l/km)}
- **Step 3:** Annual fuel required in mitigation scenario (liters/year) = {Annual distance travelled (km) × Fuel economy for new HV (l/km)¹⁵}
- **Step 4:** Annual fuel saving (units/year) = Annual fuel consumption in baseline scenario – Annual fuel required in mitigation scenario
- **Step 5:** Calculate the baseline GHG emissions = Annual fuel Saving (units/year) × emission factor for the fuel (Gasoline / Diesel) as per IPCC¹⁶

¹³ Ensure this RE is not factored in any other mitigation measure, if RE is captured in the migration measure in RE, then evaluated based upon the scenario 1 & 2

¹⁴ Two types of the fuel can be saved gasoline or diesel based upon the vehicle fuel type

¹⁵ In case the fuel economy of HV is not available, consider improvement in fuel economy by 30%

¹⁶ Microsoft Word - V2_Ch3_Mobile_Combustion_Final.doc (IPCC Guidelines for National Greenhouse Gas Inventories – Volume 2: Chapter 3 – Mobile Combustion)

Annexures

Annexure 1: Details of ongoing mitigation initiative

1. Renewable Energy Projects (Solar PV)

Maldives has made significant investments in solar PV systems to reduce reliance on fossil fuels and achieve energy security.

Table 2: Solar PV Mitigation Initiatives

Initiatives	Description
1. Resort PV installation	Maldivian resorts formulate, invest, develop, and implement to cater to their resort demands. This mitigation action is solely undertaken by private sector through their self-interest and voluntary in nature.
2. Net Metering Program	This is an enabling framework that aims to promote investment and ownership of renewable energy to households and businesses. This allows these entities to generate renewable energy (particularly solar) and feed excess electricity into the grid.
3. Home Solar/ Magey Solar Program	It aims to further solarization in residential areas.
4. Project for Clean Energy Promotion in Malé initiative	This project aims to install 740 kW of solar PV in Malé to promote renewable energy. This project was funded through JICA.
5. Clean Energy for Climate Mitigation Project	Deployed 558 kWp of PV with automated monitoring systems for grid stability.
6. POISED (Preparing Outer Islands for Sustainable Energy Development)	One of the largest solar projects (29 MW), focusing on inhabited islands.
7. ASPIRE (Accelerating Sustainable Private Investments in Renewable Energy)	Aims to scale up solar PV with private sector participation.
8. ASCENT (Accelerating Sustainable Clean Energy Investments for Net Zero Transition)	Plans a 50 MW solar PV rollout to enhance national power generation.

Initiatives	Description
9. ASSURE (Accelerating Sustainable System Development using Renewable Energy)	Includes 20 MW solar PV installation across 20 islands and a 44 MW solar battery storage system.
10.Low Emission Climate Resilient Development (LECRd)	Installation of a 66– kW grid– connected PV system in Laamu Atoll. This project is funded from Danish aid.
11.Dhiffushi Solar Ice Project	Developed a 40– kW grid– connected PV system to support local refrigeration and reduce diesel dependency.
12.Support of the Climate Neutrality Strategy of Maldives:	Diesel– solar– hybrid systems built on two pilot islands (324kW)
13.Development of Low– carbon resilient fisheries production and processing sector:	This project aims to instal 10 MWp of solar PV at MIFCO operational sites, improving energy efficiency by 5– 10%. The initiative is expected to se– risk low emissions investment in fisheries sector while reducing the carbon emissions.
14. World Bank-financed projects ASPIRE and ARISE	This project aims to install 53.5 megawatts of solar capacity and 50-megawatt hours of battery storage.

2. Energy Efficiency Initiatives

To complement renewable energy efforts, Maldives has launched several energy efficiency programs to optimize power usage.

Table 3: Energy Efficiency Mitigation Initiatives

Initiatives	Description
Fahiali Program	Focuses on replacing conventional lights with energy– efficient LED fixtures. Over 737,750 LED lights9tube lights and bulbs) were distributed with assistance from China, India, and Germany
Hakathari Program:	Develops comparative energy efficiency labels for refrigerators, air conditioners and washing machines. The initiative aims to improve appliance

Initiatives	Description
	efficiency by 24%– 33% with government– led market adoption.

3. Waste– to– Energy Projects

Waste management remains a key challenge in Maldives. The government has introduced waste– to– energy solutions to address waster disposal issues while generating electricity.

Table 4: Waste– to– Energy Mitigation Initiatives

Initiatives	Description
Greater Male Waste– to– Energy Project:	Aims to build a 500 tonne per day incineration plant at THilafushi, generating 13 MW electricity.
Converting Waste to Energy in Addu City	A plant in Addu City to process waster from four southern atolls (Gaafy Alifu, Gaafu Dhaalu). Expected to generate 1.5 MW of electricity.
Small– Scale Waste– to– Energy Project in Vandhoo	Includes a 0.5 MW thermal turbine for waste processing in the northern region.

4. **Additional projects with limited information** include a 100 MW solar PV installation¹⁷ under the Special Economic Zone Act, a 200 MW LNG– based power plant, vehicle emission control standards and measures to improve diesel– based energy supply.

5. **Transport Sector** – The "Integrated, Sustainable and Low Emissions Transport Project" is a climate– focused initiative funded by the Global Environment Facility (GEF) is being implemented the Maldives. This program aims to support the development of integrated and sustainable low– emissions transport systems. The project is part of the GEF– 7 funding cycle and is executed by the Department of Environment under the Ministry of Environment in collaboration with the United Nations Environment Programme (UNEP).¹⁸

¹⁷ President declares "Project Solar City" as Maldives' First Special Economic Zone - The President's Office

¹⁸ Integrated, Sustainable and Low Emissions Transport in the Maldives | GEF

Annexure 2: SEGR and Grid Emission factor

Annual published data from the Data published from the STELCO, FENEKA were used to derive the grid SEGR and Grid emission factor. Details of the energy generation, fuel consumption are presented in the following section.

Table 5: Grid emission factor and SEGR

Description	Unit	Value	Remarks
Total electricity generation of STELCO in 2022 (A)	kWh	238574998	STELCO Link – annual– report– 2022
Total diesel consumption in 2022 (B)	L	61126585	
SEGR (C)	kWh/L	3.90	SEGR = B/A
NCV of Diesel (D)	GJ/t	43.3	IPCC 2006 Volume 2 Chapter 2
Density of diesel (E)	kg/L	0.849	<u>Engineering Data assumption – Fuels – Densities and Specific Volumes</u>
CO ₂ emission factor for diesel (F)	kgCO ₂ /GJ	74.1	IPCC 2006 Volume 2 Chapter 2
Emissions from diesel use (G)	kgCO ₂	166511383	$G = B \times D \times E \times F / 1000$
Grid Emission Factor (GEF) (H)	kgCO ₂ /kWh	0.698	$H = A / G$ (During the year 2022)

Based on the adoption of renewable energy measures and the integration of that energy into the grid, emissions from the grid can be deduced. Various interventions have been undertaken in the region, and the country has planned to achieve 33% integration¹⁹ by 2028.

Considering the integration of renewable energy and assuming the same SEGR for STELCO, a forward projection of the grid emission factor has been calculated and is presented in the table below.

Table 6: CAGR of GEF reduction from 2022 to 2028

Description	Unit	Value	Remarks
Share of RE in total electricity produced in Maldives in 2028 (A')	%	33%	Workshop on "EU energy independence, security of supply and diversification of sources" ²⁰
Expected electricity generation of Maldives in 2028 (B')	GWh	2400	
RE generation in 2022 (C')	GWh	59	Maldives RE Report ²¹

¹⁹ Workshop on "EU energy independence, security of supply and diversification of sources"

²⁰ Workshop on "EU energy independence, security of supply and diversification of sources"

²¹ Maldives_Asia_RE_SP.pdf

Description	Unit	Value	Remarks
Total generation in 2022 (D')	GWh	1025	
Share of RE in total electricity produced in Maldives in 2022 (E') = C'/D'	%	6%	Fuels – Densities and Specific Volumes
Assuming SEGR to remain at 2022 level, diesel consumption in 2028 (F')	L	411,994,339	$F' = B' \times (1 - A') \times 10^6 / C$ (Data of C from Table 5)
Emissions from diesel use in 2028 (G')	kgCO ₂	1,117,002,287	$G' = F' \times 0.845 / 1000 \times D \times F$ (Data of D, F from Table 5)
GEF for Maldives in 2028 (H')	kgCO ₂ /kWh	0.465	$H' = G' / B' / 10^6$
CAGR of GEF reduction from 2022 to 2028	%	(7%)	$I' = (H' / H)^{1/6} - 1$ (Data of H from Table 5)

Table 7: Projected trajectory of GEF for Maldives from 2022 to 2030

Year		2022	2023	2024	2025	2026	2027	2028
GEF	kgCO ₂ /kWh	0.698	0.652	0.610	0.570	0.533	0.498	0.465

(Note data calculated using CAGR and Grid emission factor from above table)