Emirates Nature WWF
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DEVELOPING GREENHOUSE GAS INVENTORY: A PRACTICAL GUIDE

ABOUT EMIRATES NATURE-WWF

Emirates Nature-WWF is a non-profit organisation established to drive positive change in the United Arab Emirates to conserve the nation's natural heritage. Founded in 2001 under the patronage of H.H. Sheikh Hamdan bin Zayed Al Nahyan, the Ruler's Representative in the Al Dhafra Region and Chairman of the Governing Board of the Environment Agency–Abu Dhabi, Emirates Nature works in association with WWF, one of the world's largest and most respected independent conservation organisations.

For almost two decades, Emirates Nature-WWF has been a prominent and active partner in environmental conservation, working to alleviate the most pressing threats to nature and wildlife throughout our nation and the region by partnering with government, businesses and civil society on multiple conservation initiatives to protect the UAE's natural heritage – our seas, lands, climate and the biodiversity they support.

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MEASUREMENT AND MANAGEMENT OF GREENHOUSE GAS EMISSIONS IS AT THE CORE OF CLIMATE MITIGATION. THIS GUIDANCE DOCUMENT, DEVELOPED BY EMIRATES NATURE-WWF WITH THE SUPPORT OF HSBC MIDDLE EAST, AIMS TO PROVIDE A CLEAR, STEP-BY-STEP EXPLANATION OF THE PROCESS TO DEVELOP AN ORGANISATION'S GHG INVENTORY. THE DOCUMENT IS PARTICULARLY TARGETED AT PRIVATE SECTOR CORPORATIONS BUT MAY BE UTILISED BY OTHER ORGANISATIONS INTERESTED IN MONITORING THEIR EMISSIONS AND SETTING TARGETS.

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1. INTRODUCTION

1.1 PURPOSE

This document has been developed to provide guidance to organisations for the calculation and reporting of their inventory of Greenhouse Gases (GHG). It assists organisations in defining emission sources, identifying opportunities for emission reductions, defining boundaries and reporting their GHG inventory.

1.2 RATIONALE

At the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) in 2015, 195 nations committed to address climate change: to keep global temperature rise well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the increase to 1.5 degrees Celsius. The Paris Agreement emphasised the need to strengthen the global response to the climate threat by significantly reducing GHG emissions and adapting to the imminent impacts of climate change. Despite commitments from countries to reduce emissions, the world is on a pathway towards an average temperature of more than 3°C above pre-industrial levels.

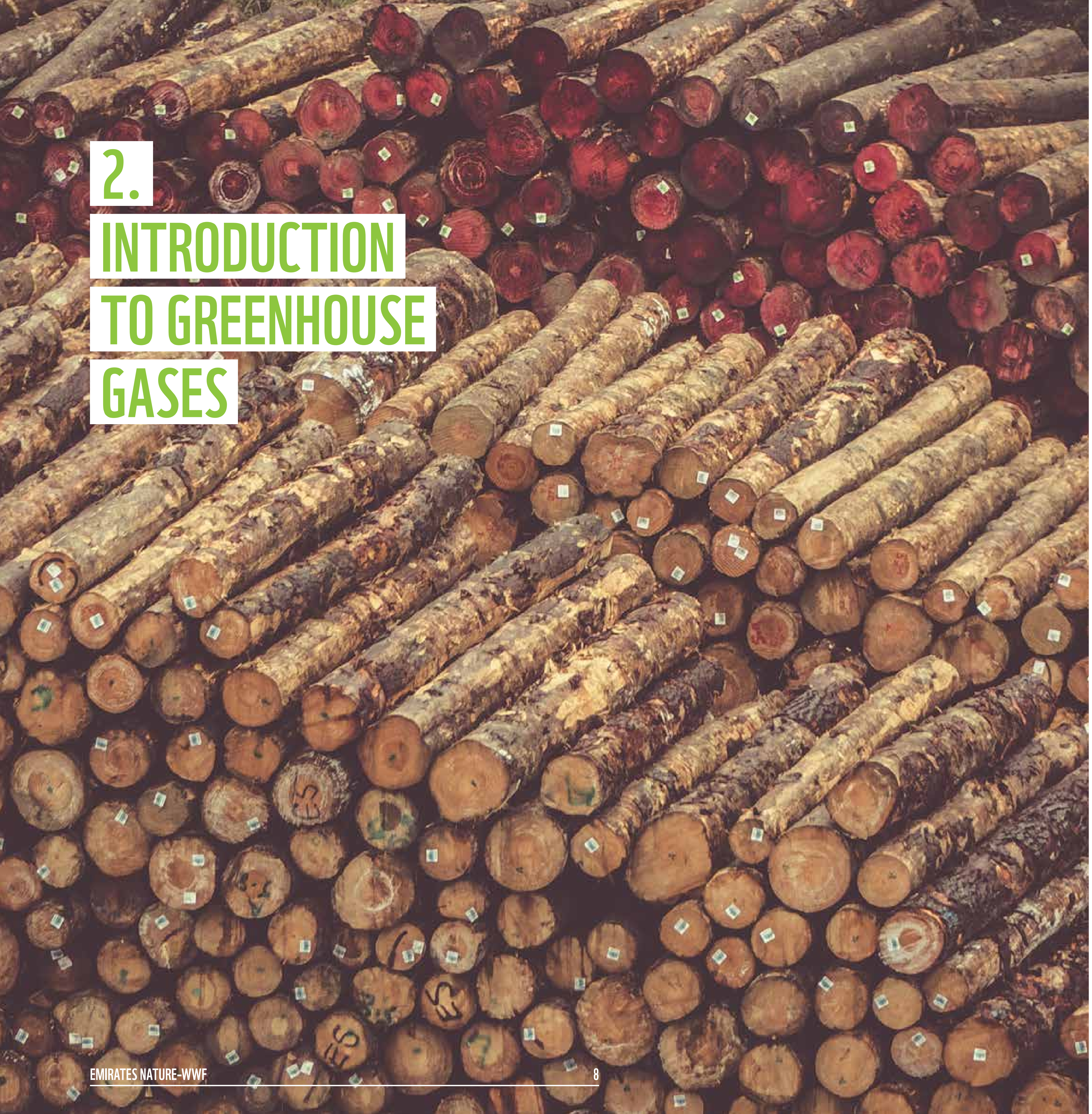
The last two centuries have witnessed increasing levels of greenhouse gas emissions, largely contributed by anthropogenic sources. Anthropogenic GHG emissions, such as those from burning fossil fuels, farming and forestry, manufacturing and industrial processes, amongst other activities, contribute significantly to warming the earth's atmosphere. They are responsible for causing an imbalance in the carbon cycle and shifting earth's energy balance towards warming, thus increasing the likelihood of unprecedented heatwaves, drought and flooding, sea level rise, and irreversible biodiversity loss.

Carbon footprint is a measure of anthropogenic GHG emissions and is expressed in terms of a measure of weight, for example 'tons of Carbon dioxide (CO_2)'. GHG emissions calculations are used as a tool to quantify an individual's or group's emissions. Organisations' global emissions have made it imperative for the private sector to step in and take active measures to calculate their footprint and reduce emissions. Governments alone cannot meet the widening 'emissions gap' – the difference between what is required to keep climate change in check and the business as usual scenario. According to the United Nations Environment Programme, "unless global greenhouse gas emissions fall by 7.6 percent each year between 2020 and 2030, the world will miss the opportunity to get on track towards the 1.5°C temperature goal of the Paris Agreement" (2018).

Private sector companies are the biggest contributors to GHG emissions, with the world's top 100 companies responsible for more than 70% of total global GHG emissions[ii].

In recent years, the private sector entities have come under increasing pressure – from both internal and external stakeholders – to disclose their climate impact. This includes a call for transparency in reporting of GHG emissions, as well as strategies to manage them. Notably, reducing GHG emissions often taps unexplored cost saving measures related to resource efficiency and process optimisation. Consumer behaviour research studies indicate that aware consumers tend to purchase products from companies that care about environment protection and social welfare[v].

Mitigating GHG emissions results in significant economic, social and environmental benefits: it promotes sustainable growth and human wellbeing, advances resource efficiency, saves money in the long run, protects public health and aids nature conservation. Tapping unexplored cost-saving, emission reduction strategies gives a company the opportunity to position itself as a green and sustainable brand. Shifting towards a low-carbon model is a win-win solution for the private sector.



2. INTRODUCTION TO GREENHOUSE GASES

Greenhouse gases are gaseous compounds responsible for absorbing infrared radiations emitted from the earth's surface and re-radiating them back to the earth's surface, thereby trapping heat in the lower atmosphere and causing the greenhouse effect. The increased greenhouse effect is directly proportional to global warming. Carbon dioxide (CO_2), Methane (CH_4), Water vapour (H_2O), Ozone (O_3) and Nitrous oxide (N_2O) are naturally occurring GHGs, while Chlorofluorocarbons (CFCs), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), and Sulphur hexafluoride (SF_6) are synthetic or man-made greenhouse gases.

For thousands of years, the global balance of GHGs was maintained as the quantities of gases removed and released were at an equilibrium. GHGs are important compounds as they help maintain a life-supporting temperature on Earth. Without these gases, the earth's surface would be extremely cold and possibly uninhabitable. Over the last few centuries, however, the atmospheric concentration of GHGs has increased drastically. The industrial revolution and anthropogenic activities such as deforestation, burning fossil fuels for electricity, heat and transportation, have contributed to ever-rising GHG emissions. Methane, Carbon dioxide and Nitrous oxide are at their highest since they have been in nearly half a million years[vi] and are potent GHGs. Table 1 provides a summary of the GHGs covered under Annex 1 of the 'UNFCCC Reporting Guidelines on Annual Inventories for Parties', their sources and Global Warming Potential (GWP)[1].

1 Global Warming Potential (GWP) is a measure of how much energy one ton of a gas will absorb over a given period of time, relative to one ton of CO_2. The larger the GWP, the more a gas warms the Earth compared to CO_2 over a given time period.

Table 1: Major Greenhouse Gases Released by Human Activities

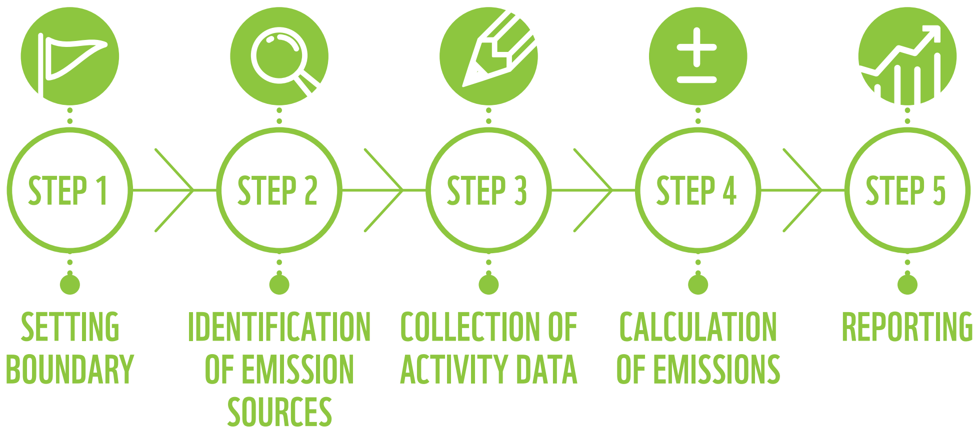
SN	GHG	Sources	GWP
1	Carbon dioxide (CO_2)	Main contributor to global warming and derived from both natural and anthropogenic sources. Natural sources include aerobic decomposition of organic matter and respiration. Anthropogenic sources are activities such as combustion of fossil fuels, deforestation and land-use changes that result in a net increase in emissions.	1
2	Methane (CH_4)	Produced as a result of anaerobic decay of organic matter and is also a constituent of Natural Gas. Cattle farming, landfills, rice farming and the production of oil and gas, are other sources of methane emissions.	28
3	Nitrous oxide (N_2O)	Released from the application of chemical fertilizers and also by combustion of fossil fuels.	265
4	Hydrofluorocarbons (HFCs)	Released during the manufacture of, leakage from and end-of-life disposal of refrigeration and air conditioning equipment and aerosols.	4-12,400
5	Perfluorocarbons (PFCs)	Released during the manufacture of semiconductors, refrigeration equipment and the production of aluminium.	6,630 – 17,400
6	Sulphur hexafluoride (SF_6)	Used for specialised applications like insulation for high-voltage electrical equipment.	23,500

The above mentioned six greenhouse gases are generally included in the GHG inventory of an organisation. Different GHGs are emitted from different processes and activities of an industry/manufacturing unit. Table 1 can be used as a reference while identifying different GHGs that can be emitted from an industry as well as their sources.

3. STEPS FOR DEVELOPING GHG INVENTORY

Carbon footprint is the total amount of GHG emissions produced directly and/or indirectly from anthropogenic activities and are usually expressed in equivalent tons of CO_2. Developing the GHG Inventory of an organisation requires setting up a boundary, identifying emission sources and calculating emissions. This process is summarised in the figure below:

Figure 1: Steps for Developing GHG Inventory



3.1 STEP 1: SETTING BOUNDARY

Every organisation varies in terms of its structure and organisational set-up. While developing the GHG inventory, the organisation is required to calculate and report emissions using one of the two approaches – equity approach or operational approach, and then apply it consistently for the purpose of calculating and reporting the GHG inventory.

3.1.1 EQUITY APPROACH

In the equity share approach, a company accounts for GHG emissions from operations according to its share of equity in operation. The equity share reflects economic interests, which is the extent of the rights a company has to the risks and rewards flowing from an operation. Typically, the share of economic risks and rewards in operation is aligned with the company's percentage ownership of that operation, and equity share will normally be the same as the ownership percentage.

3.1.2 OPERATIONAL APPROACH

In the operational approach, a company accounts for GHG emissions from those facilities where it has full operational control irrespective of the ownership or the share of equity in operation. This criterion is consistent with the current accounting and reporting practice of many companies that report on emissions from facilities which they operate.

3.2 STEP 2: IDENTIFYING EMISSION SOURCES

Once the organisational boundary has been defined, it is required to delineate the geographical boundary. An organisation may have operations across several sites, states or countries. It is important to define, at the outset, which operations are included and which excluded from the GHG inventory along with justification for the decision.

3.2.1 IDENTIFICATION OF EMISSION SOURCES

Following the determination of the boundary of the inventory, it is required to identify emission sources within the defined geographical boundary. The table below enlists the most common GHG emission sources within an industrial set-up.

Table 2: GHG Emission Sources

SN	Emission Sources	Description	GHGs
1	Electricity consumption	Industries utilise electricity for running their operations. This electricity is usually supplied from the utility company/grid. The electricity is generally produced by combusting fossil fuel in power plants, which leads to emissions.	CO_2
2	Water consumption	Industries use water for several purposes in their operations. Most of the supplied water in the UAE is from desalination. Desalination plants in the UAE utilise fossil fuels and thus release GHGs.	CO_2
3	Fuel combustion in equipment	Industries normally have equipment that consumes fossil fuels e.g. boilers, heaters, diesel generators etc. Combustion of fuel leads to greenhouse gas emissions.	CO_2
4	Vehicles	Vehicles owned by companies consume diesel/gasoline, thereby emitting CO_2.	CO_2 & N_2O
5	Solid waste	Generally, solid waste generated is disposed of in landfills. The organic components of solid waste undergo anaerobic decomposition in the landfill and release methane.	CH_4
6	Wastewater	Wastewater treatment also releases methane through anaerobic degradation of the organic content of the water.	CH_4
7	Refrigerants	Refrigerating equipment such as chiller, Heating Ventilation and Air Conditioning (HVAC) contain refrigerants. Many of these refrigerants are HFCs and HCFCs which are greenhouse gases. The leakage of these refrigerants in the atmosphere leads to emission of these GHGs.	HFCs & HCFCs
8	Air travel by employees, cargo movement etc.	The combustion of aviation fuel in the aircraft releases GHGs.	CO_2
9	Chilled water from district cooling	Several residential and commercial units in the UAE receive chilled water from district cooling plants to meet cooling requirements of the buildings. Most of the district cooling plants run on grid electricity and thereby lead to GHG emissions.	CO_2

3.2.2 CLASSIFICATION OF EMISSION SOURCES

To help delineate direct and indirect GHG emission sources, improve transparency and enhance clarity in reporting GHG emissions, three "Scopes" (Scope 1, Scope 2 and Scope 3) are defined for GHG accounting and reporting purposes. The scopes are categories under which the different emission sources (Figure 1) are categorised. Scopes 1 and 2 have been carefully defined to ensure that two or more companies will not account for the same emissions, thus avoiding double counting. Further information on Scope categories are provided in Section 3.2.2.1.

3.2.2.1 Direct GHG Emissions

Scope 1: Direct GHG Emissions

These occur from sources that are owned or controlled by the company, for example, emissions from combustion of fossil fuels in the company-owned or company-controlled boilers, furnaces, vehicles etc. For reporting purposes, all Direct Emissions are reported as Scope 1 emissions.

3.2.2.2 Indirect GHG Emissions

These emissions are a consequence of the activities of the company but occur at sources owned or controlled by another entity. For example, grid electricity is used in an industry set-up but the emissions from the generation of electricity occur at a power plant which is outside the boundary of the industry and is, in most cases, owned by another company/ entity. Indirect GHG emissions are further classified into Scope 2 and Scope 3.

Scope 2: Indirect GHG Emissions from electricity consumption

Scope 2 accounts for GHG emissions from the generation of purchased electricity or chilled water (district cooling) consumed by the company. Purchased electricity is defined as electricity that is purchased or otherwise brought into the organisational boundary of the company.

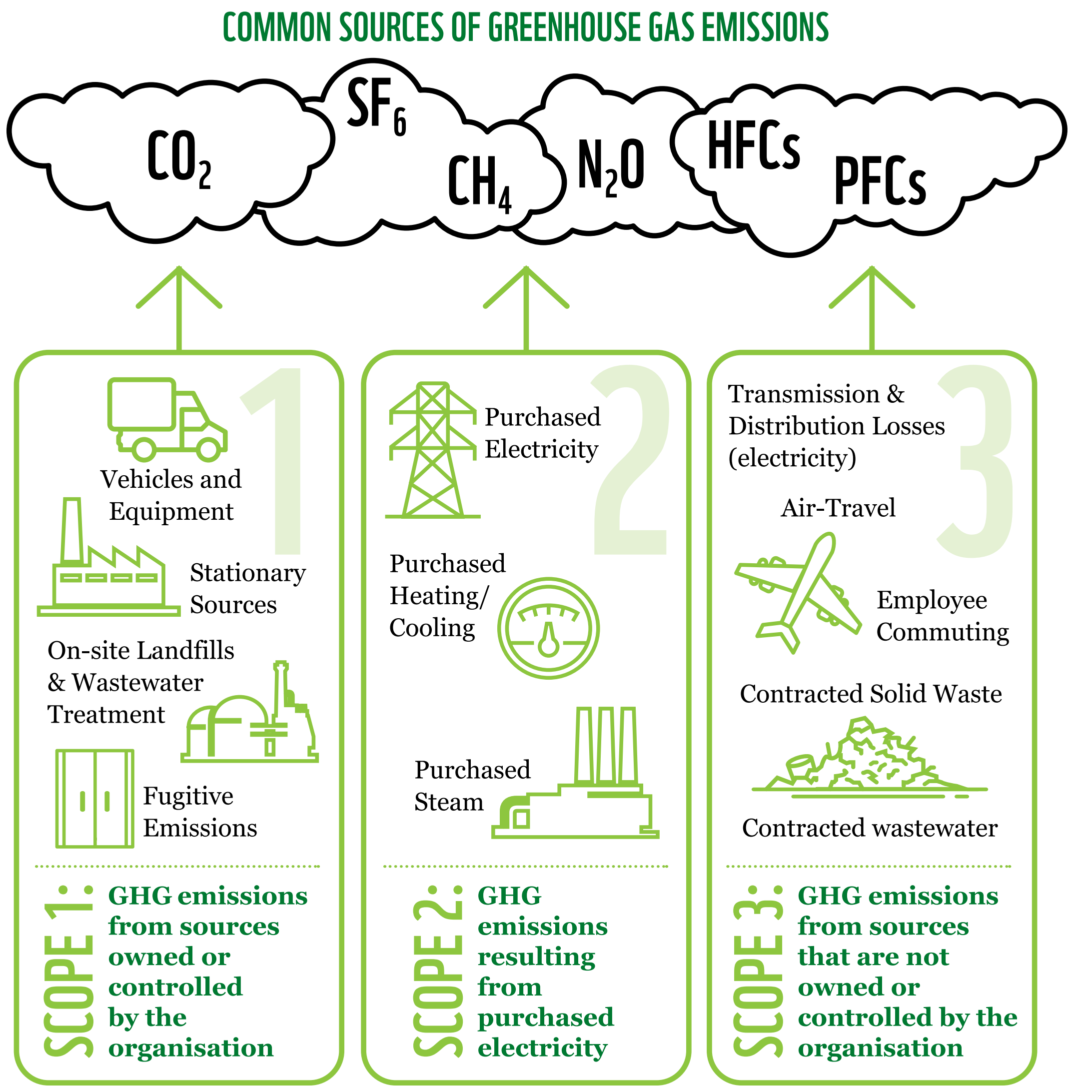
Scope 2 emissions physically occur at the facility where electricity is generated.

Scope 3: Other Indirect GHG Emissions

Scope 3 emissions are a consequence of the activities of the company but occur from sources not owned or controlled by the company. An example of Scope 3 emissions is the extraction and transport of raw material for manufacturing processes. In most cases, a different company does the mining and transportation of the raw materials and provides it to the manufacturing facility. These emissions occur because of the product being manufactured by the manufacturing facility but the manufacturing company has no control over the process of mining and transportation.

Scope 3 emissions physically occur outside the boundary of the facility for which the GHG inventory is being created.

Figure 2: Different Emissions Sources[i]



3.3 STEP 3: COLLECTION OF ACTIVITY DATA

Direct measurement of GHG emissions by monitoring gas concentration[2] and its flow rate is generally neither practical nor economical. The most commonly used approach for calculating GHG emissions is through the application of Emission Factors. Emission Factor is a representative value that relates the quantity of GHG released into the atmosphere from an activity associated with the release of that GHG. These factors are calculated ratios relating GHG emissions to a proxy measure of activity at an emission source.

Activity Data is required to be collected for all identified emission sources in order to calculate emissions and develop the GHG Inventory. Table 3 in the following page provides an example of Activity Data for different emission sources.

2 Gas concentration is measured to estimate the flow of a particular gas in a gas stream. Gas concentration when multiplied with the flow rate of gas stream provides the total quantity of a specific gas in that gas stream.

Table 3: Activity Data for Select Emission Sources

SN	Emission Sources	Activity Data	Units	Activity Data source
1	Electricity consumption	Electricity purchased/ consumed	kWh MWh	• Utility bills • Meter readings • Estimated from rated capacity/ connected load of electricity consuming equipment and running hours
2	Water consumption	Water consumed for each type of water source	Litres Kilolitres M^3	• Utility bills • Meter readings • Estimated from the rated capacity of the water-consuming equipment and running hours
3	Fuel combustion in equipment	Quantity of fuel consumed/ combusted	Litres Kilolitres M^3	• Fuel purchase records • Directly metered from fuel storage • Estimated from fuel-consuming equipment's rated capacity and running hours
4	Vehicles	Diesel/ gasoline consumed and kilometres travelled	Litres Kilolitres M^3 Kilometres	• Purchase records • Records of distance travelled
5	Solid waste	Quantity of waste generated	Kilograms	• Receipt of waste collection from waste haulers • Waste records maintained on site • If the waste is recycled or composted then emissions shall be negligible
6	Wastewater	Quantity of wastewater generated or treated	Litres Kilolitres M^3	• Meter readings • Collection receipt from water treatment unit • Receipts issued from wastewater transport (tankering) company
7	Refrigerants	Quantity of refrigerant released/ leaked	Kilograms Pounds	• Records of refrigerant top-up • Charge quantity from the specifications of the equipment • Leakage rates published by IPCC
8	Air travel	Total distance flown	Kilometres	• Number of people who took flights • Distance travelled for each of the flights taken • Class of travel for flights taken
9	District cooling	Chilled water received	Rth	• Bills from the district cooling provider

3.4 STEP 4: CALCULATING EMISSIONS

Emissions are calculated using Activity Data and respective Emission Factors. Some of the commonly used Emission Factors are provided in Table 4. The locally available Emission Factors for UAE have been provided wherever available. For those emission sources where local Emission Factor was not available, these have been taken from IPCC or other globally recognised bodies.

Table 4: Emission Factors

SN	Emission Sources	Emission Factor	Value	Unit	Source
1	Electricity consumption	Grid Emission Factor (Dubai)	0.4258	tCO_2/MWh	Page 81, Graph: Carbon emission intensity, tCO_2e/MWh of electricity generated, 2016-2018, DEWA Sustainability Report[vii]
		Grid Emission Factor (Abu Dhabi)	0.410	$kgCO_2/kWh$	Page 27, Section 3.3 Emission Indicators, Greenhouse Gas Inventory for Abu Dhabi Emirate, 2019[viii]
2	Desalinated water		13.76	$kgCO_2/M^3$	Page 23, Table 8.2: GHG/CO_2 Emission Indicators for Abu Dhabi Emirate in 2010, Greenhouse Gas Inventory for Abu Dhabi Emirate[ix]
3	Fuel consumption	Diesel	0.0031	tCO_2e/litre	Calculated based on IPCC 2006 Default Values
4		Gasoline	0.00239		
5		LPG	0.00157		
6	Road transport	Diesel	0.16533	$kgCO_2e$/km	UK Government GHG Conversion Factors for Company Reporting, Department for Business, Energy and Industrial Strategy[x]
7		Gasoline	0.2079		
8	Air travel	Emissions per passenger per km of distance flown	0.19562	tCO_2e/ Passenger/km	
9	District cooling		0.432	$KgCO_2/RT$	James Kassim, National Central Cooling Company PJSC, International District Energy Association annual Conference 2014.

In the following section, sample emission calculations have been provided for different types of emission sources.

3.4.1 EMISSIONS FROM ELECTRICITY CONSUMPTION

Activity Data	Value
GHG emissions	= Electricity consumption * Emission Factor
Annual electricity consumption	1,200,000 kWh
Grid Emission Factor	0.4258 tCO_2e/MWh
GHG emissions	= 1,200 MWh * 0.4258 tCO_2e/MWh
	= 511 tCO_2e

(Note: It is important to note the units of Activity Data and the units of Emission Factor. The units should be comparable in order to calculate the emissions correctly. In this example, the Activity Data is in kWh whereas the Emission Factor is in MWh. Therefore, the electricity consumption value must be converted into MWh. Refer to Appendix 2 for conversion factor.)

3.4.2 EMISSIONS FROM WATER CONSUMPTION

Activity Data	Value
GHG emissions	= Water consumption * Emission Factor
Annual water consumption	20,200,000 litres
	20,200,000 litres = 20,200 M^3
Emission Factor	13.76 $kgCO_2e/M^3$
GHG emissions	= 20,200 M^3 * 13.76 $kgCO_2e/M^3$
	= 277,952 $kgCO_2e$
	= 278 tCO_2e

(Note: The Activity Data is in litres whereas the Emission Factor is in M^3. Therefore, the water consumption value must be converted into M^3. Refer to Appendix 2 for conversion factor.

Also, the emission factor is in $kgCO_2e$, however, the emissions are reported in tCO_2e. Therefore, the emissions calculated above have been converted to tCO_2e. The quantity 277,952 kg has been converted to 277.952 tCO_2e)

3.4.3 EMISSIONS FROM FUEL CONSUMPTION

This example provides steps for calculating emissions from diesel consumption. By replacing the Emission Factor of diesel with any other liquid fuel, the emissions for that liquid fuel can be calculated.

Activity Data	Value
GHG emissions	= Diesel consumption * Emission Factor
Annual diesel consumption	70,000 litres
Emission Factor	0.0031 tCO_2e/litre
GHG emissions	= 70,000 litres * 0.0031 tCO_2e/litre
	= 217 tCO_2e

3.4.4 EMISSIONS FROM VEHICLES

This example provides steps to calculate emissions from vehicles. It has been assumed that all vehicles run on gasoline/petrol. The combined mileage or running distance for the reporting period is 130,000 Kilometres. Similarly, the emissions from diesel run vehicles can also be calculated by replacing the respective emission factor.

Activity Data	Value
GHG emissions	= Distance travelled * Emission Factor
Annual distance travelled	130,000 Kilometres
Emission Factor	0.2079 $kgCO_2e$/km
GHG emissions	= 130,000 * 0.2079 $kgCO_2e$/Km
	= 27 tCO_2e

(Note: The above methodology is to be used when data on kilometre run or mileage is available. In a scenario where the direct fuel consumption data is available for the vehicles, it is best to calculate emissions using the formula in example 3.4.3 where quantity of fuel consumed is available.)

3.4.5 EMISSIONS FROM REFRIGERANT LEAKAGE

In this case, we shall assume that there is a single chiller which uses refrigerant R134a. During the reporting period, the chiller was topped up with 2.5 kgs of R134a. R134a is composed of 50% CH_2F_2 and 50% of CHF_2CF_3.

In most cases, the information that is received on refrigerants is based on their industrial/commercial name, for instance, R134a. It is important to then find out the composition of the gases in the refrigerant and calculate the CO_2 equivalent emissions proportionately for the gases as per the composition.

Activity Data	Value
Annual refrigerant top up	2.5 kgs of R134a
Quantity of CH_2F_2 topped up	= 50% * 2.5 kg
	= 1.25 kg
Quantity of CHF_2CF_3 topped up	= 50% * 2.5 kg
	= 1.25 kg
GHG emissions	= Quantity of GHG released * GWP
GHG emissions from CH_2F_2	= 1.25 kg * 677
	= 846 $kgCO_2e$
	= 0.846 tCO_2e
GHG emissions from CHF_2CF_3	= 1.25 kg * 3,710
	= 4637.5 $kgCO_2e$
	= 4.637 tCO_2e
Total GHG emissions from R134a leakage	= 0.846 + 4.637
	= 5.5 tCO_2e

3.4.6 EMISSIONS FROM WASTE DISPOSED

Most of the waste that originates at our homes, offices, and industries end up in landfills. The organic component of the waste undergoes anaerobic decomposition in landfilled and releases methane. This example provides steps for calculating GHG emissions from waste disposal. Under this example, we have assumed that the total waste generated is 100,000 kg and all of this waste is being disposed of in a landfill.

Activity Data	Value
GHG emissions	=Waste disposed * Emission Factor
Annual waste disposed	= 100,000 kg of MSW
	= 100,000 kg of MSW = 110 tonnes of MSW
Emission Factor	0.0904 t CH_4/ tones of MSW
GHG emissions	= 110 tones * 0.0904 t CH_4/ tonnes of MSW = 9.94 t CH_4
	= 9.94 * 28 = 278 tCO_2e

(Note: It is important to understand that methane is emitted from the organic portion of waste, so in cases where significant quantities of organic material have been recycled (paper, food etc) or composted, then waste disposal may not release methane.

Additionally, landfill gas capture and its usage for energy purposes is increasingly becoming common. In a scenario where the waste is disposed in a landfill with landfill gas capture system, again the methane emissions would be insignificant as it would be captured and later combusted.)

3.4.7 EMISSIONS FROM WASTEWATER TREATMENT

Treatment of wastewater containing significant organic load also leads to Methane emissions. Provided below is an example of estimating methane CH_4 emissions from a wastewater treatment process. To estimate emissions, it is required to collect the data on the quantity of the wastewater treated and the organic content of the wastewater, also known as Biological Oxygen Demand (BOD).

In this example, we have assumed that the quantity of wastewater treated was 80,000 litre with an average BOD of 0.207 grams per litre.

Activity Data	Value
GHG emissions	= Total BOD * Emission Factor
Total BOD	= 80,000 * 0.207 = 16560 grams
Emission Factor	0.18 kg CH_4/kgBOD
GHG emissions	= 16.56 kg BOD * 0.18 kg CH_4/kgBOD = 2.98 kg CH_4
	= 2.98 * 28 = 83.4 tCO_2e

3.5 STEP 5: REPORTING EMISSIONS

GHG emissions calculated using the Activity Data and Emission Factors should be reported in a format that is easily comprehensible and technically robust, so that inferences can be drawn and informed decisions can be made to manage emissions. In general, the following components should be included:

1. **The operational and geographical boundary:** It is important to mention whether the organisation has chosen to report on equity approach or operational control approach for aggregating or reporting GHG emissions. Further, it is imperative to delineate the geographical boundary and identify locations that are part of the GHG inventory. This is required to maintain transparency on which emissions have been included in or excluded from the GHG inventory.
2. **The time period or the monitoring period for the GHG inventory:** GHG emissions occur due to activities over a period of time. Therefore, the GHG inventory report must include the time period it covers. Generally, reports are developed in annual cycles.
3. **Identified emission sources:** The GHG inventory report should include all the emission sources that were identified within the operational and geographical boundary of the organisation.
4. **Activity Data collected:** For each of the identified emission sources, the report should include quantitative data. The report should also provide information on the source of the data and the monitoring methodology.
5. **Emission Factors:** All the Emission Factors used for the purpose of GHG emissions calculations should be clearly mentioned in the report. This is required for the reproducibility of the GHG emissions calculations. The report should clearly mention the source from which the Emission Factors have been extracted.

6

GHG emissions: The report should mention the total GHG emissions and include the following details:

a. Emission sources

b. Type of GHG/s for each source; e.g., CO_2, CH_4.

7

Historical annual emissions: Historical annual GHG emissions depicting trends across years for each source of emissions should be presented in the report. This helps the organisation to identify the increasing and/or decreasing trend of GHG emissions for each emission source, identify emission hotspots and take corrective measures.

8

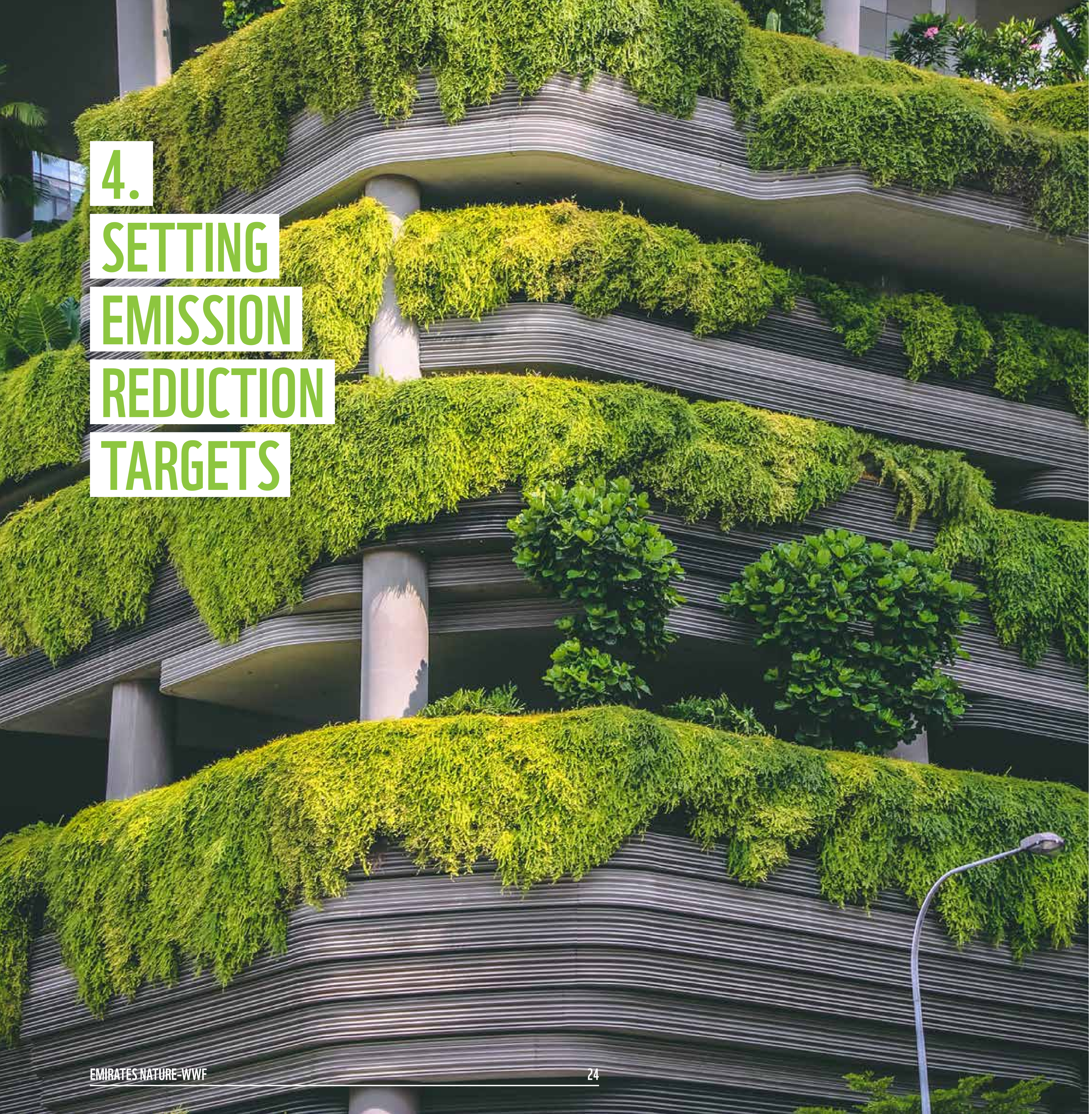
GHG emissions intensity: The GHG emissions intensity is expressed as the GHG impact per unit of activity. It can be assessed in terms of physical activity, revenue generated or on the basis of production. The intensity ratio is inversely proportional to performance improvement. It is an important indicator to track progress on GHG emission reduction. Gross emissions may increase due to business growth; at the same time if the GHG emissions intensity is reducing then it implies that the business is moving towards low-carbon growth.

9

Classifying emissions into Scopes: The GHG emissions should be classified into Scope 1, Scope 2 and Scope 3, for purposes of reporting. The table below provides the classification of the emission sources into Scopes.

Table 5: Emission Sources and Scope Categorisation

SN	Emission Sources	Scope	Explanation
1	Electricity consumption	2	All purchased electricity is accounted under Scope 2. Purchased electricity is defined as electricity that is purchased or otherwise brought into the organisational boundary of the company.
2	Water consumption	3	These emissions are indirect emissions and happen at the utility owned/operated desalination unit which in most cases is outside the reporting organisation's boundary.
3	Fuel combustion in equipment	1	Direct emissions occurring within the boundary of the reporting organisation.
4	Vehicles	1 and 3	Emissions from vehicles that are owned by reporting organisation are reported under Scope 1. Emissions from vehicles leased or rented are reported under Scope 3.
5	Solid waste	3	Indirect emissions occurring at the waste disposal site, usually a landfill.
6	Wastewater	1 or 3	If the reporting organisation has a wastewater treatment plant within its boundary, then it is reported as Scope 1, else, it is reported as Scope 3.
7	Refrigerants	1	Refrigerant emissions occur usually within the boundaries of the reporting organisation and are direct emissions.
8	Air travel	3	These emissions occur outside the reporting organisations' boundary and by aircrafts owned by a third party.
9	District cooling	2	Purchased or acquired electricity, steam, heat and cooling is included in scope 2.



4. SETTING EMISSION REDUCTION TARGETS

As corporations across the world respond to the global climate challenge, a number of them are electing to set emission reduction targets. Although there is no "one size fits all" methodology for setting targets, the generic steps that a company would follow to set these targets are listed in Figure 3.

Figure 3: Setting Emission Reduction Targets

4.1 DEVELOP BASELINE

Baseline emissions are greenhouse gas emissions that have occurred in the past and which are being emitted prior to the introduction of any emission reduction intervention/strategy. Baseline emissions are determined over a set period of time, typically between one to three years in order to capture any operational fluctuations.

In order to develop a baseline, an organisation is expected to estimate its GHG inventory for the set period of time (one to three years). The baseline can be set for either of the following:

1. Absolute emissions: Absolute emissions are the total emissions that occur due to an organisation's activity/operation.
2. Emission intensity: Emission intensity is usually calculated as emissions per unit of a business metric such as product or revenue.

4.2 FORECAST EMISSIONS

Once the baseline GHG emissions have been estimated, it is important to understand how the emissions trajectory may look in the future. The prediction of future emissions or forecast is based on the expected changes in the GHG emission sources and Activity Data collected when calculating the baseline.

In order to forecast emissions, the two important factors that an organisation must consider are:

1. Will the existing GHG emission sources be relevant in the future and are new emission sources expected within the GHG inventory boundary?
2. What would be the change in Activity Data and Emission Factor for each of the emission sources?

Once these two questions are answered, one needs to follow a similar methodology to calculate future emissions as used for the baseline emission calculations.

4.3 IDENTIFY EMISSION REDUCTION POTENTIAL & SET TARGETS

The emissions forecasted under step 4.2 provide the business as usual scenario. However, when an organisation is setting up emission targets, they must identify the emission reduction opportunities/interventions that would be implemented to reduce emissions in future. These then need to be scheduled for future implementation, and based on this schedule, the emission reductions can be predicted for future years vis-a-vis the forecasted emissions.

The emission reductions expected to be achieved in the coming years are then set as targets and necessary resources are mobilised to ensure that the set targets are achieved.

The Science Based Targets initiative (SBTi) is a partnership between CDP, UN Global Compact (UNGC), World Resources Institute (WRI) and World Wildlife Fund for Nature (WWF). It provides companies with a clearly defined pathway to establish the quantum and timeframe of carbon reduction they need to achieve, if they are to be in accordance with what climate science says is necessary to meet the goals of the Paris Agreement i.e. to limit global warming to well-below 2°C above pre-industrial levels and strive to limit global warming to 1.5°C. The SBTi also provides organisations with tools and guidelines on how to set, validate, update, monitor and communicate their emission reduction targets.[xi]

The SBTi Sectoral Decarbonisation Approach methodology allocates carbon budgets to specific sectors, creating sector-specific decarbonisation pathways that are in line with climate science.

4.4 MONITOR & REPORT

Keeping track of the progress made towards achieving emission reduction targets is a key element of an organisation's carbon reduction strategy. The frequency of monitoring and reporting depends on whether the set targets are long-term or short-term, and also on who the end-user for the monitoring report is. Companies, mostly, report annually on GHG emission reduction progress to its various stakeholders. However, internally, progress could be reported to the management as frequently as daily, weekly or monthly. The frequency of reporting should be decided based upon available resources and the duration within which significant GHG reductions are expected to be achieved.

APPENDIX 01: DEFINITIONS

Activity Data: An important input for calculating GHG emissions, it refers to data associated with the activity that led to the generation of the GHG emissions. For example, Activity Data for emissions from purchased electricity would refer to electricity consumption amounts stated in the bills and invoices.

Anthropogenic Emissions: These are emissions of greenhouse gases associated with human activities. Activities include burning of fossil fuels for energy, deforestation and land-use changes that result in a net increase in emissions.

Carbon Footprint: It is the summation of all greenhouse gases, primarily CO_2, released into the atmosphere by a particular human activity during a fixed period of time. Carbon footprint can be calculated for an individual, a family, an event, an organisation or a country.

Climate Change: It is a considerable long-term change in the expected patterns of average weather of a particular region or the Earth over a period of time. It refers to unusual variations in climate and the effects of these variations on the Earth.

Emission Factor: It is generally a multiplication factor or value that relates the quantity of GHG released to the human activity that resulted in the release of the GHG.

Equity Approach: It is a concept used to decide whether to include or exclude a particular emission source from the organisation's GHG inventory. Under the equity share approach, – a company accounts for GHG emissions from operations according to its share of equity in the operation.

Global Warming: It is the increase in earth's global average surface temperature over the past century particularly after the industrial revolution and primarily because of the GHGs released due to the combustion of fossil fuels from anthropogenic activities.

Global Warming Potential: It is a measure of how much energy one ton of a GHG will absorb over a given period of time, relative to one ton of CO_2.

Greenhouse Effect: This is the phenomenon of trapping and build-up of heat in the atmosphere near the earth's surface. Some of the heat flowing back towards space from the earth's surface is absorbed by GHGs in the atmosphere, and then reradiated back towards the earth's surface. If the atmospheric concentrations of these greenhouse gases rise, the average temperature of the lower atmosphere gradually increases.

Greenhouse Gas: It is a gaseous compound in the atmosphere that is capable of absorbing infrared radiation, thereby trapping and holding heat in the atmosphere. GHGs cause the Greenhouse Effect and are responsible for global warming.

Grid Emission Factor: It is an emission factor that refers to CO_2 equivalent emissions associated with each unit of electricity provided by an electricity system.

Kyoto Protocol: It is an agreement adopted in the year 1997 and is linked to the United Nations Framework Convention on Climate Change, which commits its Parties to climate action by setting internationally binding emission reduction targets to be achieved within fixed commitment periods. The protocol entered into force on 16 February 2005. Its first commitment period started in the year 2008 and ended in 2012 while the second commitment period is ongoing and shall end in December 2020.

Net Calorific Value: It is the heat energy produced by combustion of a unit quantity of a solid or liquid fuel when burned, at a constant pressure of one atmospheric pressure under conditions such that all the water in the products remains in the form of vapour.

Operational Control: It is a concept used to decide whether to include or exclude a particular emission source from the organisation's GHG inventory. A company has operational control over an operation if it or one of its subsidiaries has the full authority to introduce and implement its operating policies at the operation. Under control approach of carbon footprint estimation, an entity accounts for all sites/subsidiaries/activities where it has operational control.

Paris Agreement: Signed in 2016, it is an agreement within the United Nations Framework Convention on Climate Change, dealing with climate mitigation, adaptation and finance. The Agreement was signed in 2016. The Paris Agreement's aim is to strengthen the global response to climate change by keeping global temperature rise this century to well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius.

APPENDIX 02: UNITS AND CONVERSIONS

SN	Description	Value
1	Kilo	1000
2	Mega or tonne	1000,000
3	Giga	1000,000,000
4	Terra	1000,000,000,000
5	1 M^3	1000 litres
6	1 Imperial Gallon	4.546 litres
7	1 US Gallon	3.785 litres

APPENDIX 03: GLOBAL WARMING POTENTIAL OF GREENHOUSE GASES

SN	GHG	Chemical formula	GWP values
1	Carbon Dioxide	CO_2	1
2	Methane	CH_4	28
3	Nitrous Oxide	N_2O	265
4	HFC-134a	CH_2FCF_3	1,300
5	HCFC-123	$CHCl_2CF_3$	79
6	R410a (50% of each CH_2F_2 and CHF_2CF_3)	CH_2F_2	677
		CHF_2CF_3	3,170

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