# A GUIDE

*for*

# CARBON FOOTPRINT ASSESSMENT

**CLIMATE CHANGE SECRETARIAT**
**MINISTRY OF MAHAWELI DEVELOPMENT AND ENVIRONMENT**

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***(Initial document to understand Carbon Footprint Assessment)***

**CLIMATE CHANGE SECRETARIAT**
**MINISTRY OF MAHAWELI DEVELOPMENT AND ENVIRONMENT**
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## 1. Background

Climate change is becoming one of the most irreversible global threats and the greatest discussed topics in the 21st century. It mainly affects to agriculture, further endangering food security, accelerated erosion of coastal zones, increased intensity of natural disasters, species extinction and the spread of vector borne diseases. Also, it is a result of temperature rise due to Greenhouse Gases (GHGs) concentration in the atmosphere. The climate induced disasters are frequently occurring and severely affecting to developing countries. It is a direct result of excessive emissions of GHGs due to anthropogenic activities, particularly due to the uncontrolled burning of fossil fuels and other land use changes.

Climate change arising has been identified as one of the greatest challenges that encountered by a governments, business and individuals with major implications for both human and natural systems. Therefore, understanding the full range of these impacts is crucial to minimize the adverse effects of climate change. Understanding GHGs and their emitting sources and sinks are the prime importance to reduce the emissions and its impact causes to any level; global, regional, national, organizational, household an individual.

Therefore, this is a guiding document aimed at helping businesses, organizations and individuals to understand and perform Greenhouse Gas Assessment (Carbon Footprint Assessment) to minimize their climate change related impacts to environment, natural resources and human. The increasing interest in assessing 'Carbon Footprint' comes as a result of growing public awareness of global warming. In an organization, there are typically two main reasons to assess a carbon footprint.

1. To manage the carbon footprint and reduce emissions over the time as a voluntary approach; If an organization requires a carbon footprint, it is generally enough to understand and quantify the key emissions sources through a basic process, typically including gas, electricity and transport. This approach is relatively quick and straight forward.
2. To report the carbon footprint accurately to another party as an offsetting or anther requirement, a more robust approach is needed, covering the full range of emissions for which the organization is responsible. It may also be appropriate for the calculation to be independently verified to ensure that the methodology has been correctly used and that the results are accurate.

## 2. Carbon Footprint

The total set of Greenhouse Gases (GHGs) emissions caused directly and indirectly by an individual, organization, event or product is considered as Carbon Footprint. The term carbon footprint is commonly used to describe the total amount of Carbon Dioxide ($CO_2$) including other GHGs emissions for which an individual or organization is responsible. Most of activities that human does at present unsustainable consumption and production patterns and practices produce GHG either directly or indirectly.

Carbon Dioxide ($CO_2$) is the most common Greenhouse Gas emitted by human activities, in terms of the quantity released and the total impact on global warming. As a result, the term "$CO_2$" is sometimes used as a shorthand expression for all greenhouse gases. However, this can cause confusion and the more accurate way of referring the amount of GHGs collectively is to use the term "Carbon Dioxide Equivalent" or "$CO_2e$". Greenhouse Gas

Assessments or Carbon Footprint Assessments are fully completed, if they include all the greenhouse gases and not just $CO_2$.

**2.1 Greenhouse Gases (GHGs):**

Greenhouse Gases are gaseous constituents of the atmosphere, both natural and anthropogenic; those absorb and emit radiation at specific wave lengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere and clouds. This property causes the greenhouse effect. Water vapor ($H_2O$), Carbon Dioxide ($CO_2$), Nitrous Oxide ($N_2O$), Methane ($CH_4$), and Ozone ($O_3$) are primary greenhouse gases in the Earth's atmosphere. Moreover there are a number of entirely human - made greenhouse gases in the atmosphere such as sulphur Hexafluoride ($SF_6$), Hydrofluorocarbons (HFCs) and Perfluorocarbons (PFCs).

Higher greenhouse gas concentrations in the earth's atmosphere causes global warming through the 'greenhouse effect'. The greenhouse effect is a natural process that warms the Earth's surface. When the Sun's energy reaches the Earth's atmosphere, some of it is reflected back to space and the rest is absorbed and re-radiated by greenhouse gases. The absorbed energy warms the atmosphere and the surface of the Earth. The net effect is the gradual heating of Earth's atmosphere and surface, a process known as global warming.

## 2.2 Carbon Dioxide Equivalent ($CO_2e$) :

"Carbon Dioxide Equivalent" or "$CO_2e$" is a term for describing different greenhouse gases in a common unit. For any quantity and type of greenhouse gas, $CO_2e$ signifies the amount of $CO_2$ which would have the equivalent global warming impact. A quantity of GHG can be expressed as $CO_2e$ by multiplying the amount of the GHG by its Global Warming Potential (GWP). E.g. if 1kg of Methane with GWP of 25 times is emitted, this can be expressed as 25kg of $CO_2e$ (1kg CH4 x 25 = 25kg $CO_2e$).

"$CO_2e$" is a very useful term for a number of reasons: it allows "bundles" of greenhouse gases to be expressed as a single number. "$CO_2e$" is also sometimes written as "$CO_2eq$", "$CO_2$ equivalent", or even "CDE", and these terms can be used interchangeably.

## 2.3 Global Warming Potential (GWP):

Global Warming Potential (GWP) is an index, describing the radiative characteristics of greenhouse gases that remain in the atmosphere and their relative effectiveness in absorbing outgoing infrared radiation. This index approximates the time-integrated warming effect of a unit mass of a given greenhouse gas in as in today's atmosphere, relative to that of carbon dioxide.

The above gases in the Table 1 are the gases listed in 1/CMP.8 of Doha Amendment under the Kyoto protocol and published by http://UNFCCC.int/ghg data.

**Table 1 : The GWP of Kyoto Gasses**

| Green house Gas | Global Warming Potential (GWP) of the 2nd Assessment Report | Global Warming Potential (GWP) of the 4th Assessment Report |
|---|---|---|
| 1. Carbon Dioxide ($CO_2$) | 1 | 1 |
| 2. Methane ($CH_4$) | 21 | 25 |
| 3. Nitrous Oxide ($N_2O$) | 310 | 298 |
| 4. Hydrofluorocarbons (HFCs) | 140-11,700 | 124-14,800 |
| 5. Perfluorocarbons (PFCs) | 6,500-9,200 | 7,390-12,200 |
| 6. Sulphur Hexafluoride ($SF_6$) | 23,900 | 22,800 |
| 7. Nitrogen Trifluoride ($NF_3$) | - | - |

Source: Greenhouse Gas Protocol

### 2.4 Global Temperature Change Potential (GTP):

The Global Temperature Change Potential (GTP) is the ratio of change in global mean surface temperature at a chosen point in time from the substance of interest relative to that from $CO_2$. There are significant uncertainties related to both GWP and GTP and the relative uncertainties are larger for GTP.

## 3. Reasons for Carbon Footprint Assessment

Carbon Footprint Assessment records, summarizes and reports the quantity of GHGs emissions by sources and removals by sinks as a direct result from human activities or natural processes that have been affected by human activities.

E.g. companies can quantify and report the total results in $CO_2e$ per unit of analysis which includes all emissions and removals. Therefore, companies can apply Global Warming Potential (GWP) values to GHGs emissions and removals data to calculate the inventory results in units of $CO_2$ equivalent ($CO_2e$).

**3.1 GHGs measured in a Carbon Footprint Assessment:**

Carbon Footprint emissions inventory counts seven main greenhouse gases identified in the Kyoto Protocol :

1. Carbon Dioxide ($CO_2$) which is a naturally occurring gas and also a by-product of burning fossil fuels and biomass as well as land-use changes and other industrial processes such as Aluminium, steel, glass and cement production. It is the principal anthropogenic greenhouse gas that affects the Earth's radiative balance. It is the reference gas against which other greenhouse gases are measured and therefore has a Global Warming Potential of 1.
2. Methane ($CH_4$) which is generated from burning and/or decomposing biomass (organic material) and from producing and/or refining gasoline and natural gas.
3. Nitrous Oxide ($N_2O$) which results from incinerating solid waste, spreading fertilizers and/or various transportation means.
4. Hydrofluorocarbons (HFCs) which occur as a product of industrial processes making insulation, refrigeration and air conditioning etc.
5. Perfluorocarbons (PFCs) which occur as a by-product of Aluminium production.
6. Sulphur Hexafluoride ($SF_6$) which is used for insulation and current interruption in electricity transmission and distribution equipment and electronic systems.

7. Nitrogen Trifluoride ($NF_3$) which is used for manufacturing of flat-panel displays and thin film solar cells.

### 3.2 Measuring unit of Carbon Footprint:

Each type of greenhouse gas has a different potency and atmospheric global warming potential. To reconcile the differences between the warming potentials of various gases and have a consistent measure for varying warming impacts, a specific measurement unit, the ton $CO_2$ equivalent or $tCO_2e$ is used. It expresses the equivalency of one metric ton of GHG to the number of metric tons of $CO_2$ needed to generate the same warming effect over one-hundred years. Carbon Dioxide is the most prevalent greenhouse gas after water vapor and has therefore become the proxy by which we measure greenhouse gas emissions.

## 4. Calculation of Carbon Footprint

The individuals and organization are keen on estimating their 'Carbon Footprint' which is a measurement of total GHG emissions from their operations or/ and activities, can be estimated using the generic equation given below.

**GHG Emissions = Activity data [A] × Emission Factor [EF]**

Where,

GHG = Emissions (e.g. amount of $CO_2$ or $CH_4$, etc)

A = Activity data (e.g. liters of fuel burnt, kg of cement manufactured)

EF = Emission Factor (e.g. kg $CO_2$/liter of fuel burnt, kg$CO_2$/kg cement manufactured)

**4.1 Emission Factors:**

Emission Factors enable a conversion to be made from the input measure of emission source to the amount of relevant GHG emissions that will result. The accuracy of a carbon footprint relies on the emission factors.

E.g. the amount of electricity used or distance travelled, and then multiply it by an (emission) conversion factor which gives an estimate of the GHG emissions. Emission factor data bases which can be used to find relevant emission factors are available.

E.g. UK conversion factors are published by Defra (http://www.ukconversionfactorscarbonsmart.co.uk/) and the International Panel on Climate Change (IPCC) also provides the emission factors (http://www.ipcc-nggip.iges.or.jp /EFDB /main.php). The emission factors have been developed by using Global Warming Potential (GWP) in Seconds Assessment Report and Fourth Assessment Report of International Panel for Climate Change (IPCC).

When activity data is collected, the basic equation to calculate $CO_2e$ for an input, output or process is:

Kg $CO_2e$ = Activity Data ***(unit)*** x Emission Factor ***[kg GHG/unit]*** x GWP ***[kg $CO_2e$ /kg GHG]***

When direct emissions data has been collected, an emission factor is not needed and the basic equation to calculate inventory results for an activity is:

Kg $CO_2e$ = Direct Emissions Data ***(kg GHG)*** x GWP ***[kg*** $CO_2e$ ***/kg GHG]***

Emissions from fossil fuel combustion in electricity generation, refinery operations, industrial process, transport and household sectors are the main contributors of GHG emission to environment. Some of the general examples of estimating GHG emissions are explained in 4.1.1,4.1.2 and Table 3,4 and 5.

**Table 2 : Emissions by burning of Liquid fuels**

| Activity | Fuel | Unit | Total kg $CO_2e$/ Volume | $CO_2$ Kg $CO_2e$/ Volume | $CH_4$ Kg $CO_2e$/ Volume | $N_2O$ Kg $CO_2e$/ Volume |
|---|---|---|---|---|---|---|
| **Burning of Liquid fuels** | Aviation spirit | litres | 2.2615 | 2.2166 | 0.0229 | 0.022 |
| | Aviation turbine fuel | litres | 2.5418 | 2.5157 | 0.0013 | 0.0248 |
| | Diesel (100% mineral diesel) | litres | 2.6705 | 2.6502 | 0.0008 | 0.0195 |
| | Petrol (average biofuel blend) | litres | 2.2144 | 2.2059 | 0.0032 | 0.0053 |
| | Petrol (100% mineral petrol) | litres | 2.3104 | 2.3018 | 0.0032 | 0.0054 |

Source: IPCC Report

### 4.1.1 GHG emissions from Electricity Consumption:

The largest contributor to GHG emission is through the fuel combustion in electricity generation. Ceylon Electricity Board (CEB) generates electricity from three main sources: hydro, thermal and non- conventional (Solar, Wind etc). Thermal plants contributed 40.2 % of total generation in 2011. Carbon Dioxide emission per unit of electricity generated is 0.7208kg of $CO_2$ (National Energy balance : 2011). For more details : Web link of the Sri Lanka Sustainable Energy Authority grid emission factor values: **www.energy.gov.lk.** To calculate $CO_2$ emission (total) from electricity generation can be calculated by using following steps in Table 3.

**Table 3 : Emissions calculation by Electricity Consumption**

| **Grid Electricity Supply** | |
|---|---|
| Electricity Consumption | [A] |
| $CO_2$ Emission from thermal plants | [B] |
| Thermal % in National Supply | [C] |
| Electricity from Thermal Plants | [D=AxC] |
| $CO_2$ Emission (Total)t $CO_2$ /year | [E=DxB] |

**4.1.2. GHG emissions from Fossil Fuel Consumption - Diesel or Petrol:**

GHG emissions from vehicles used for staff transport (managed by the institute or organization), business activities and internal transport and stand by generator GHG emissions can be calculated in accordance with the IPCC revised guidelines based on annual fuel usage (the measurement units should be balanced). Emission Factors and GWP values of Fourth Assessment Report are used for these calculations.

**Table 4 : Emissions calculation by Fuel-Diesel Consumption**

| **Fuel-Diesel** | |
|---|---|
| Fuel (Diesel) Consumption | [A] |
| Fuel (mass) | B = A x (density; 870kg/m3) |
| Net Calorific Value | [C] |
| $CO_2$ (Emission Factor: 74.1)x(GWP: 1) | [D] |
| $CH_4$ (Emission Factor:3.9 )x(GWP: 21) | [F] |
| $N_2O$ (Emission Factor:3.9)x(GWP:310) | [G] |
| $tCO_2e$ (tons of $CO_2$ equivalent) | [E=BxC x(D+F+G)] |

**Table 5 : Emissions calculation by Fuel-Petrol Consumption**

| **Fuel-Petrol** | |
|---|---|
| Fuel (Diesel) Consumption | [A] |
| Fuel (mass) | B = A x (density; 755kg/m3) |
| Net Calorific Value | [C] |
| $CO_2$ (Emission Factor: 74.1)x(GWP: 1) | [D] |
| $CH_4$ (Emission Factor:3.9 )x(GWP: 21) | [F] |
| $N_2O$ (Emission Factor:3.9)x(GWP:310) | [G] |
| $tCO_2e$ (tons of $CO_2$ equivalent) | [E=BxC x(D+F+G)] |

### 4.1.3 GHG emissions from Air Travels:

International Civil Aviation Organization (ICAO) calculator can be used to calculate GHG emissions of air travels (http://www2.icao.int). This calculator is recommended by the IPCC for air travel emission calculations.

### 4.1.4 GHG emissions from Waste Generation:

GHG emissions from waste generated can be calculated according to the IPCC guidelines based on annual waste generation assuming which is sent for composting and feeding swine at a nearby piggery (default factor).

**Table 6: Emissions calculation by Waste Composting**

| **Waste Composting** | |
|---|---|
| Waste Quantity | [A] |
| $CH_4$ (Emission Factor:3.9 )x(GWP: 21) | [B] |
| $N_2O$ (Emission Factor:3.9)x(GWP:310) | [C] |
| $tCO_2e$ (tons of $CO_2$ equivalent) | [E=Ax(B+C)] |

**Table 7 : Emissions calculation by Feed Waste Composting**

| Waste Composting | |
|---|---|
| Number of animals (swine) | [A] |
| $CH_4$ from enteric fermentation (Emission factor 1.0 $CH_4$/head/yr)x(GWP: 21) | [B] |
| $CH_4$ from manure management (Emission factor:6.0 $CH_4$/head/yr)x(GWP: 21) | [C] |
| $tCO_2e$ (tons of $CO_2$ equivalent) | [E=Ax(B+C)] |

### 4.1.5 GHG emissions from Water Consumption:

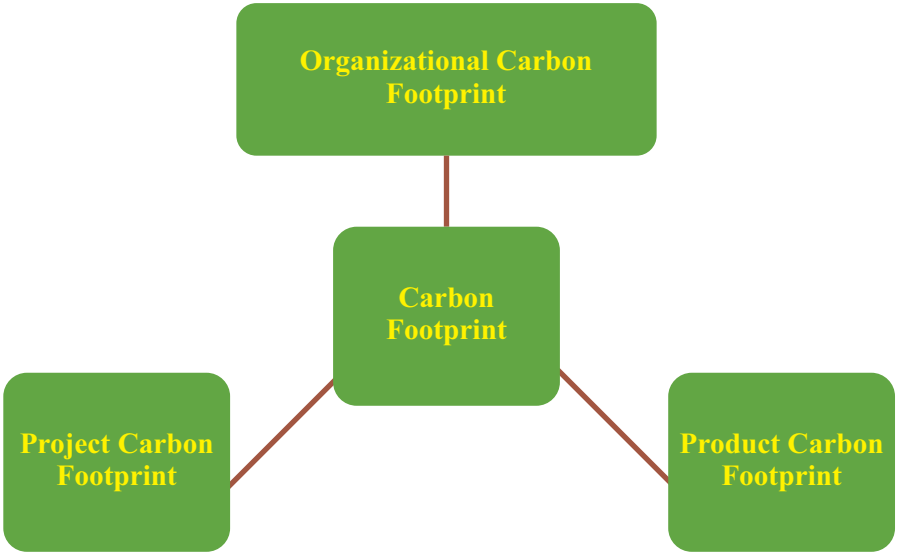
GHG emissions can be calculated according to the IPCC guidelines based on annual electricity consumption only for pumping source to feeding point. This figure has been calculated by the National Water Supply and Drainage Board in Sri Lanka as 0.35 kwh/$m^3$.

**Table 8 : Emissions calculation by Water Consumption**

| Water Supply | |
|---|---|
| Water Consumption | [A] |
| Electricity Consumption per 1$m^3$ water supply | [B] |
| $Co_2$ Emission per 1kwh use from National Water Supply | [C] |
| $Co_2$ Emission from Water Supply | [E=Ax(B+C)] |

## 5. Application of Carbon Footprint

Figure 1: Applications of Carbon Footprint




### 5.1 Organizational Carbon Footprint:

If an organization wishes to conduct an organizational carbon footprint, following steps should be followed;

1. Define the boundary of the assessment is the first step of organizational carbon footprint.
2. The organizational boundary can be defined in terms of ownership and/or control. A company may own several operations but only control a small number and may only wish to assess the operations that it controls.
3. The operational boundary chooses to leave out some activities over which they have limited control (E.g. Staff commuting, outsourced

deliveries) as defined by the Greenhouse Gas Protocol. A greenhouse gas inventory for the facility will be prepared based on energy (input) sources of the factory and other sources of GHG emissions including fugitive emissions and emissions from regular operations. A carbon footprint for an organization is typically measured in tons of $CO_2$ equivalent **(t $Co_2e$)** per year.

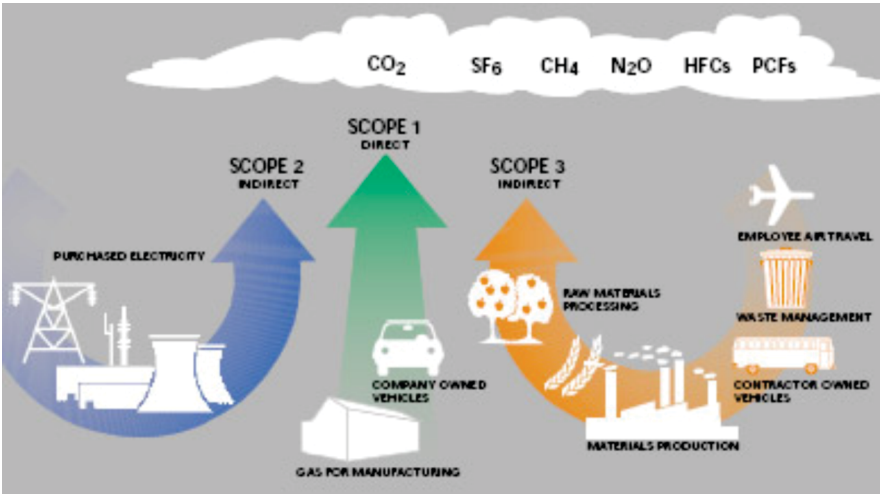
According to GHG Protocol, emission sources are divided into three 'scopes' according to level of responsibility where some indirect sources (E.g. emissions from waste and sub contracted activities) are optional for reporting.

**Table 9 : GHG Emission Calculation Category**

| | |
|---|---|
| **Scope 1** | Direct GHG emissions occurring from sources that are owned or controlled by the Company |
| **Scope 2** | GHG emissions from the generation of purchased electricity consumed by the company |
| **Scope 3** | All other indirect emissions which are optional in terms of reporting are considered under this category. the emissions under scope 3 would include the greenhouse gas emission from raw material transport to the factory, finished product transport from the factor, foreign business travels of employees, feed waste and water supply from the national supply etc.. |

The type of GHG emissions of three scopes are shown in Figure 2.

Figure 2 : Types of GHG Emissions (scope 1, 2 & 3)




Source: Reference Manual for GHG Inventory

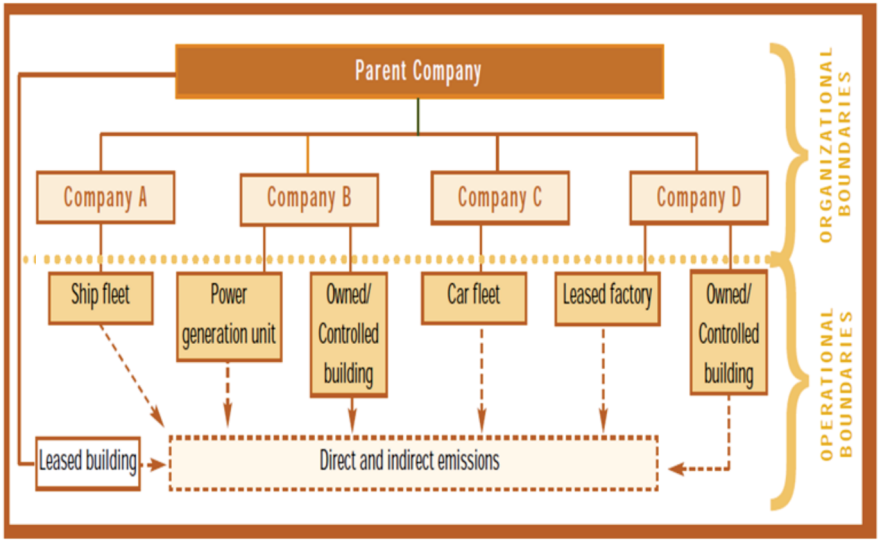
According to ISO 14064, emission sources are divided into two as, direct emissions (GHG emissions which occur from sources that are owned or controlled by the company) and indirect emissions (emissions which occur as a consequence of the activities of the company, but occur from sources not owned or controlled by the company). What is classified as direct and indirect emissions dependent on the consolidation approach (equity share or control) selected for setting the organizational boundary (Figure 3). Generally, some examples for emission sources are as follows;

- **Stationary combustion:** combustion of fuels in stationary equipment such as boilers, furnaces, burners, turbines, heaters, incinerators, engines, flares, etc.

- **Mobile combustion** : combustion of fuels in transportation devices such as automobiles, trucks, buses, trains, airplanes, boats, ships, barges, vessels, etc.
- **Process emissions** : emissions from physical or chemical processes such as $Co_2$ from the calcinations step in cement manufacturing, $CO_2$ from catalytic cracking in petrochemical processing, PFC emissions from aluminum smelting, etc.
- **Fugitive emissions** : intentional and unintentional releases such as equipment leaks from joints, seals, packing, gaskets as well fugitive emissions from coal piles, waste water treatment, pits, cooling towers, gas processing facilities, etc.

The organizational and operational boundaries of a company has defined separately is figure 3.

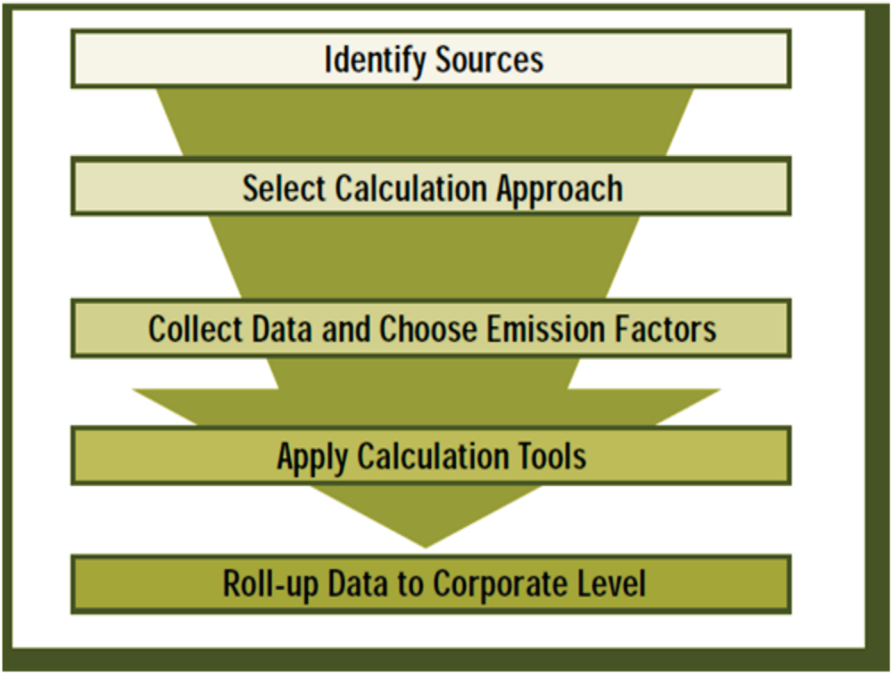
Figure 3: Organizational and Operational Boundaries of a Company




Source: EU, 2010

Once the inventory boundary (operational and organizational) has been established, companies generally calculate GHG emissions using the following steps stated in Figure 4.

Figure 4 : Steps in identifying and calculating GHG inventory




Source: EU, 2010

Organizational Carbon Footprint of a company is calculated by using methodological tools to assess the carbon footprint for the steps in Figure 4 of Greenhouse Gasses protocol which is widely used as international accounting tool for government and business leaders to understand, quantify and manage greenhouse gas emission. Also, GHG Inventories have been developed by the countries using methodological tools in Greenhouse Gasses protocol world widely.

Figure 5 : Methodological tools for assessing Organizational Carbon Footprint



**5.2 Project Carbon Footprint:**

Project Carbon Footprint quantifies and reports GHG reductions from GHG projects and methodological tools are used in the section of project carbon footprint of Greenhouse Gas Protocol.

E.g.: The decreases in GHG emissions or increases in removals and/or storage from climate change mitigation projects. Forestry Projects, Renewable Energy Projects are example for GHG projects.

A GHG Project consists of a specific activity or set of activities intended to reduce GHG emissions, increase the storage of carbon or enhance GHG removals from the atmosphere. It may include modifications to existing production, process, consumption, service, delivery or management systems as well as the introduction of new systems.

Figure 6 : Methodological tools for assessing Project Carbon Footprint



### 5.3 Product Carbon Footprint:

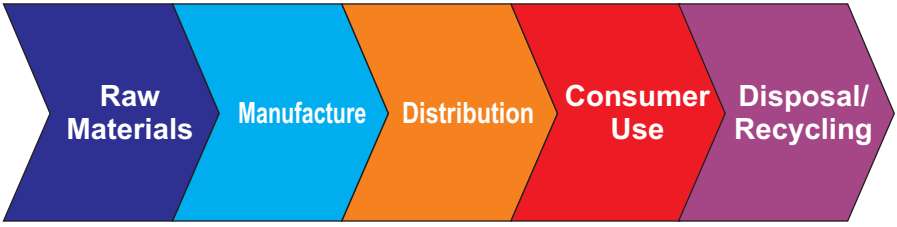
It is evident that the increasing trend of companies quantifies the carbon footprint of their products. Companies make these efforts for multiple reasons: enhancing market reputation, engaging with suppliers, clients and other stakeholders and setting up a first step towards a more comprehensive environmental footprint.

Product Carbon Footprints are commonly expressed either as 'cradle to gate' footprints or 'cradle to grave' depending on the life-cycle stages included. ISO 14067 standard and the Publicly Available Specification (PAS) 2050 guidelines are used by many countries for calculation of Product Carbon Footprint. The Product Carbon Footprint is therefore a measure of the absolute climate impact of a product and its use. A Product Carbon Footprint is calculated by summing up the climate impacts in terms of GWP for all human induced GHGs that are emitted as a consequence of a product over its life

cycle and in a certain use. The Guide to PAS 2050 recommends including the following phases of the life cycle into the model of a consumer product (cradle-to-grave, formerly 'B2C goods') :

› Raw Materials
› Manufacture
› Distribution
› Consumer Use
› Disposal/Recycling

Figure 7: Stages of the Product Life Cycle (Cradle to Grave) according to the PAS 2050 Guide




For materials, components, or semi-finished products that are delivered to companies (cradle-to-gate, formerly 'B2B goods') only the following stages apply:

- Raw Materials
- Manufacture
- Distribution

Figure 8 : Stages of the Product Life Cycle (Cradle to Distributor's Gate)


For all stages of the life cycle model, the direct and indirect emissions must be included in the calculation of the carbon footprint. Indirect emissions are those caused by material and energy expenses of processes or activities. Among these activities are the supply of raw materials, energy use, transport, land use and transformation, waste treatment, waste transport and waste disposal. The use of the product may also be considered as an activity and might cause indirect emissions.

Figure 9 : Methodological tools for the assessment of Product Carbon Footprint


## 6. Greenhouse Gas Management

Calculating a carbon footprint is the initial step towards organizational level, product level or project level carbon management. 'Carbon neutrality' is normally achieved by calculating a carbon footprint, then reducing emissions as far as possible and finally 'offsetting' the remainder by purchasing emissions reductions 'credits' generated by external projects such as renewable energy schemes or forestry projects. Market-based approaches to reducing GHG emissions are emerging in some parts of the world. In most places, they take the form of emissions trading programs such as, UK Emission Trading Scheme, Clean Development Mechanism (CDM), Markit Environmental Registry etc., although there are a number of other approaches adopted by countries, such as the taxation approach.

Carbon neutrality is a term used to describe the action of organizations, businesses and individuals taking action to remove $CO_2$ as much carbon dioxide as possible from the atmosphere as each put into it. The overall goal of carbon neutrality is to achieve a zero carbon footprint.

Most of the time it will not be possible to reduce a carbon footprint to zero, and companies may choose to invest in projects that generate emissions reductions to 'offset' the emissions that they cannot reduce internally. Emissions reductions (also known as 'offset') are sold in tones of $CO_2$ equivalent (also known as “credits”) and can come from a range of projects such as renewable technologies, energy efficiency projects, land-use change projects and methane capture to mitigate $CO_2$ emission in the atmosphere.

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