South African CitiesNetwork

A guideline for the development of a Greenhouse Gas Emissions Inventory for municipalities

A step by step description on how to develop a carbon footprint

SACN Programme:	Sustainable Cities
Document Type:	Guideline
Document Status:	Final
Date:	June 2014

Joburg Metro Building, 16th floor, 158 Loveday Street, Braamfontein 2017

Tel: +27 (0)11-407-6471 | Fax: +27 (0)11-403-5230 | email: info@sacities.net | www.sacities.net

CONTENTS

Executive Summary 2

1. Background 4

1.1 Climate change in South Africa 4

1.2 Carbon footprint parameters 5

2. The carbon footprint implementation process 8

2.1 The carbon footprint implementation process 8

2.2 Data collection methodologies 9

3. Carbon footprint reporting and management 10

3.1 How to report a carbon footprint 10

3.2 How to manage a carbon footprint 11

Executive Summary

For proper measurement and management of local government's impacts on climate change and to develop an effective mitigation strategy, a Greenhouse Gas (GHG) Emissions Inventory (GHGEI) should be developed. In essence a GHGEI is a snapshot of the GHG emissions resulting from the activities undertaken by a municipality or within the control of a municipality over a specific period. It is commonly referred to as a 'carbon footprint' and expressed in tCO2e/year.

To determine a carbon footprint, a number of parameters need to be determined upfront. The diagram below provides a schematic overview of these parameters.

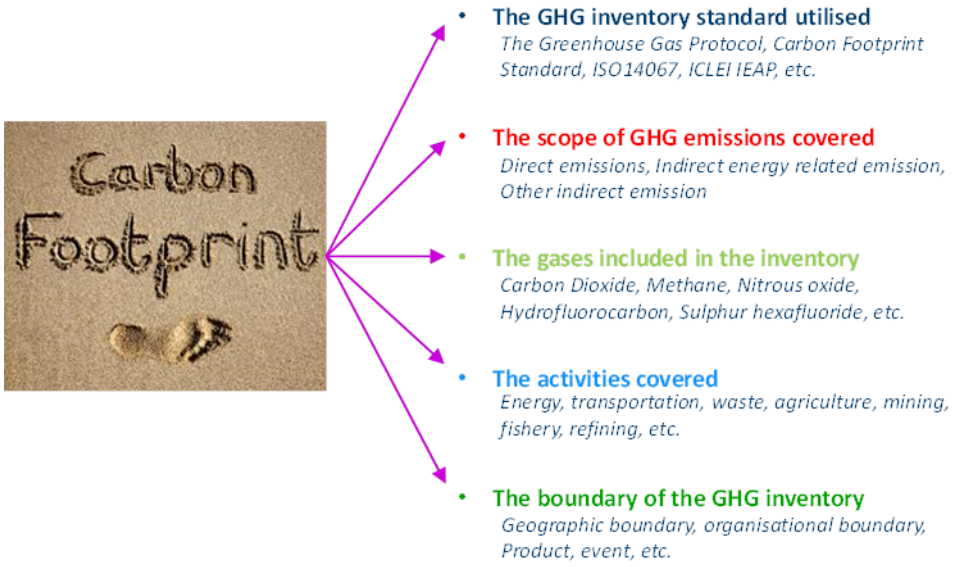

Figure 1: Carbon foot printing parameters.

As indicated in Figure 1, the first parameter that needs to be determined is the standard that will be utilised for the development of a Carbon Footprint. The International Council for Local Environmental Initiatives (ICLEI) has developed a specific standard for local governments under the title 'Local Government GHG Emissions Analysis Protocol' which could be developed in conjunction with the Local Government Operations Protocol for the Quantification and Reporting of Greenhouse Gas Emissions Inventories Version 1.1 . The protocol is different from other standards in the sense that it distinguishes between the emissions of activities within the geographical area governed by not directly controlled by the local government and the emissions resulting from local governmental operations (e.g. the operations of administrative and governmental bodies).

The main bottleneck with developing a GHGEI is the collection and verification of the data needed to calculate the footprint. Generically the data required can be divided into three categories:

- **Static data:** consists of more static information resounding the activities and drivers behind GHG emissions (i.e. square metres of government buildings, number of cars and size/number of landfills in operation). This information is critical for the verification of the activity data and provides more detail on the overall footprint which is useful when setting targets and developing and implementing mitigation plans;

- **Activity data:** consists of information outlining the application and consumption of materials and equipment that result in the emission (i.e. fuel consumed, electricity consumed, kilometres travelled and tonnes of waste generated, etc.);

- **Emissions factor data:** Factors which in essence convert the activity data in actual emissions covered in the footprint (e.g. MWh x tCO2e/MWh = tCO2e).

To obtain and manage this information, most municipalities use a software application. Before arriving at the initial stage (i.e. the completion of a first footprint) a manual data collection exercise is often conducted. When identifying a tool that is suitable for the specific needs as defined by the local government, it is important to take into account the technical infrastructure available within the organisation. Some tools are part of large enterprise resource management software packages such as SAP or Oracle, whereas other tools are more stand-alone and utilise mainstream office software like Microsoft Excel and Outlook.

The overall aim of a GHGEI is to manage and monitor the impact that mitigation activities have within the municipality on the carbon footprint over time. When considering an emission reduction target from the GHGEI in the baseline year, it is important to consider that the systemic development of the footprint over time is taken into account to be able to distinguish changes to the footprint resulting from targeted emission reduction efforts from the 'natural' movement of the footprint. The diagram below provides a schematic overview of the development of a GHGEI over time and how a target set against the baseline should be set taking this into account.

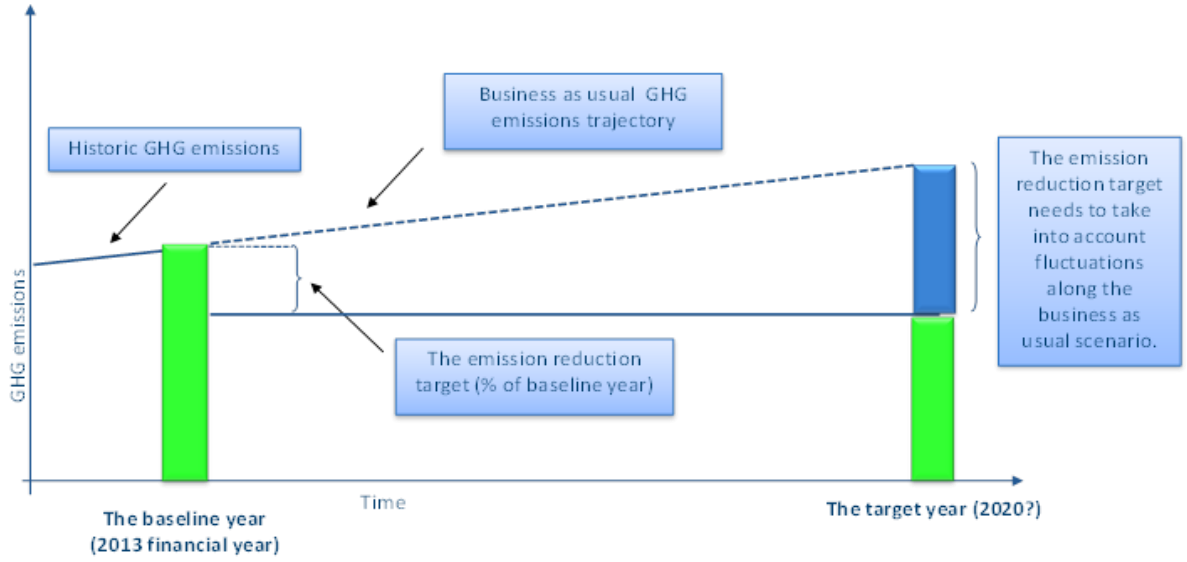

Figure 5: GHGEI target setting dynamics.

As a local government interested in developing a GHGEI it is important to consider that although daunting in nature, the development of a GHGEI conducted in a professional manner will not only provide your organisation with a tool to manage its GHG emission and thereby help the environment but rather also with an instrument that can manage and reduce the organisation's future expenditure in among others, future carbon tax levies, fuel consumption expenses and electricity bills.

1. Background

The South African Cities Network (SACN) supported the City of Tshwane in the development of its first greenhouse gas (GHG) emissions inventory for the 2012/13 financial year. The process of developing Tshwane emissions inventory was technically undertaken by EcoMetrix Africa. As part of the brief, the service provider was requested to produce a generic guideline for developing a carbon footprint inventory.

The first chapter of this Guideline provides an introduction to climate change in South Africa and how the development of a GHG Emissions Inventory (GHGEI) fits within this context. This is followed by a section providing an overview of the parameters that need to be set before entering into the process of developing a GHGEI.

1.1 Climate change in South Africa

With the increased global awareness of the contribution that manmade emission of GHGs make towards climate change, the United Nations Framework Convention on Climate Change (UNFCCC), signed in 1992, represents an international agreement to stabilize greenhouse gas concentrations in the atmosphere at 1990 levels. Parties to the Convention are divided into those countries that take on responsibility for achieving the convention's goal, the Annex I countries (all developed countries and countries with economies in transition), and those that do not, the non-Annex I countries (developing countries). The UNFCCC specifically states that the Parties may implement measures to reduce GHG emissions jointly with other Parties. The Parties to the Convention meet once a year at the Conference of Parties (CoP) to discuss and negotiate measures against global climate change. To further the goals of the UNFCCC, the Kyoto Protocol was adopted at CoP-3 in 1997. The Kyoto Protocol entered into force in February 16th, 2005, which binds the countries that have ratified to emission limitations and reduction commitments against 1990 levels.

With an annual output of approximately 450 million tonnes of CO_{2e} per year, South Africa's contribution to global GHG emissions is small, accounting for less than 2% of total emissions. However, South Africa's highly energy-intensive economy and reliance on coal-based electricity makes the country the 12th largest emitter on the planet in absolute terms. The majority of its emissions can be attributed to the generation of electricity by burning coal and the production of liquid fuel, such as petrol, from coal.

As a Party to the Convention, South Africa is considered to be a Non-Annex I country which in terms of the convention means that it is not required to actively participate in realising the aims of the convention. South Africa is considered to be part of the group of countries that did not materially contribute to the creation of climate change and therefore it is not expected to put measures in place to reduce its GHG output into the atmosphere. However, President Zuma (in December 2009), during CoP15 (the 15th Conference of Parties as in the 15th annual gathering of the UNFCCC) in Copenhagen pledged to reduce the country's total annual emissions with 34% below 'business-as-usual' levels by 2020 and by 42% by 2025. The President stated that the pledge was on condition that South Africa receives the necessary finance, technology and support from the international community that would allow the country to achieve these commitments.

A carbon footprint

Globally the fight against climate change is conducted along two lines:

- **Climate change mitigation**: which focusses on reducing the total volume of man-made GHGs released into the atmosphere over time and thereby reducing future climate change;
- **Climate change adaptation**: which focusses on adapting to the climate change this is already happening and will continue to materialise over the foreseeable future.

A GHG Emissions Inventory or GHGEI (commonly referred to as a 'carbon footprint') is used as a management tool to assist in climate change mitigation and can be defined as '*A measure of the total set of greenhouse gas emissions caused by an organization, event, product or person over a defined period.*' This report is limited to the development of GHGEI's by local governments (i.e. metros, cities, municipalities, etc.). In essence, a GHGEI of local governments encompasses the emissions resulting from activities by local government itself as well as emissions from activities taking place in the geographical area under control of the relevant local government over a specific period of time and is generally expressed in tCO_{2e}/year[1].

1.2 Carbon footprint parameters

Before compiling a carbon footprint, a set of parameters needs to be set to clarify the dimensions of the footprint. The diagram below (figure 3) provides a schematic overview of the parameters followed by a more detailed description of each parameter.

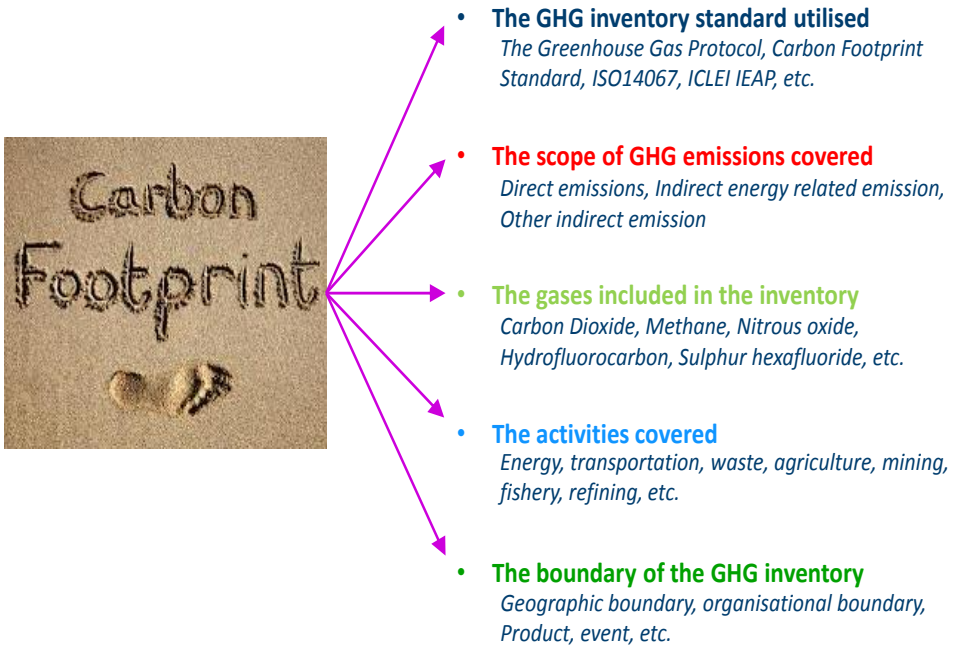

Figure 1: Carbon footprint parameters.

[1] Tonnes of carbon dioxide equivalent per year.

GHG inventory standards

Over the last decade a wide range of GHG standards have been developed for a wide range of purposes. The most commonly standards for the development of a GHG emissions inventory are the; GHG protocol, International Organization for Standardization (ISO) 14064 International Standard Part 1, the International Council for Local Environmental Initiatives (ICLEI) Local Government GHG Emissions Analysis Protocol. The first step towards developing a GHG emissions inventory consists of identifying the standard that is most appropriate for the task at hand.

Emissions scope

Most carbon foot-printing standards apply what are commonly referred to as scope 1, 2 and 3 emissions, where:

- **Scope 1 emissions**: are direct emissions from owned or controlled sources;
- **Scope 2 emissions**: are indirect emissions from the generation of purchased energy;
- **Scope 3 emissions**: are all indirect emissions (not included in scope 2) that occur in the value chain of the reporting entity, including both upstream and downstream emissions.

As per the below diagram (figure 4) the three scopes are not mutually exclusive and are commonly used as an expansion model for quantifying an entities emissions by initially starting with the determination of an installation's scope 1 emission after which this is expanded to include scope 2 and over time scope 3.

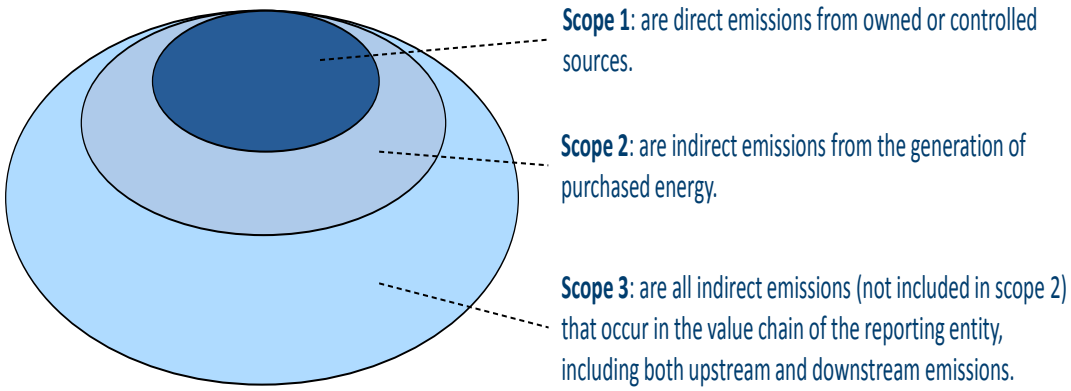

Figure 2: GHG emission scopes.

Greenhouse gasses

In the early nineties the Parties to the UNFCCC identified six GHGs (commonly referred to as the Kyoto GHG basket) as the most relevant contributors to climate change. The table below (figure 5) provides an overview of these gases and their contribution to manmade climate change expressed in the so called Global Warming Potential (GWP). Table 1 below provides GHGs and their Global Warming potential.

#	Name	Composition	GWP
1	Carbon dioxide	(CO_2)	GWP: 1
2	Methane	(CH_4)	GWP: 21
3	Nitrous oxide	(N_2O)	GWP: 310
4	Perfluorocarbons	(PFC)	GWP: 9,200
5	Hydrofluor carbons	(HFC)	GWP: 11,700
6	Sulphur hexafluoride	(SF_6)	GWP: 23,900

A carbon footprint is expressed in tonnes of $CO_{2\text{-equivalent}}$ (tCO_{2e}) whereby the non-CO_2 gasses are converted into tonnes of CO_{2e} by multiplying them by their GWP. For example the emission of one tonne of sulphur hexafluoride equates to the emission of 23,900 tCO_{2e}.

Activities and sectors

In principle a carbon footprint should include all activities (or sectors) the result in GHG emissions within scope 1, 2 and 3. However the data collection efforts required to include all activities and/or sectors from the starts is enormous. It has therefore become common practice to start with the most material set of activities and/or sectors and overtime expand the approach with additional activities and sectors. The diagram below (figure 6) provides a breakdown of the different sectors share of the total global GHG emission[2] within South Africa.

#	Sector	Annual GHG emission (000, tCO_{2e})	% of total footprint
1	Energy Industries	219,491	71%
2	Transport	39,511	13%
3	Manufacturing Industries and construction	39,091	13%
4	Residential	5,928	2%
5	Agriculture/forestry/fishing	3,718	1%
6	Commercial/institutional	1,911	1%
7	Other	161	0%
	Total	**309,811**	**100%**

Table 2: South African GHG emissions per sector.

Inventory boundaries

When defining the parameters along which a carbon footprint is developed it is critical to define upfront which boundaries will be set for the footprint. The footprint boundaries can be set for a geographic, organisation, product, event, etc. and is critical when determining which emissions would fall into scope 1,2 or 3 as one footprints scope 1 emissions are another footprints scope 2 emissions.

[2] Source: Department of Environmental Affairs, Republic of South Africa '*South Africa's Second National Communication under the United Nations Framework Convention on Climate Change*', November 2011.

2. The carbon footprint implementation process

This chapter provides a description of the process that could be followed to develop a carbon footprint and use the footprint to manage an entity's emissions going forward. This is followed by a section on the software applications that could be utilised to calculate a footprint and manage the emission profile of the entity from there on.

2.1 The carbon footprint implementation process

The development of a GHGEI is only the first step towards getting a grip on managing a local government entity's GHG emissions over time. The ICLEI's describes a five milestone methodology which is designed to chart a course for local governments to set and meet their climate mitigation goals over time and is graphically represented in the diagram below (figure 7) followed by a detailed description of the different stages.

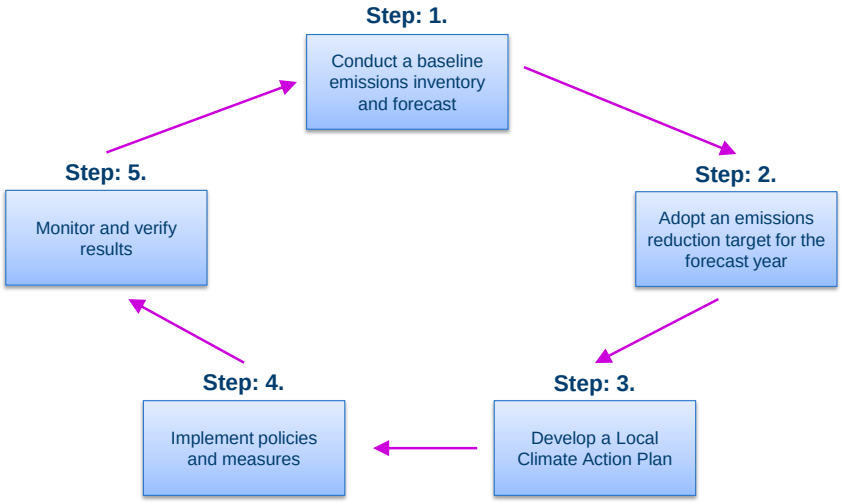

Figure 3: The ICLEI five milestone methodology.

1. **Conduct a baseline emissions inventory and forecast**: The local government first calculates greenhouse gas emissions for a base year (e.g. 2005) from all municipal operations (e.g. city owned and/or operated buildings, streetlights, transit systems and wastewater treatment facilities). It then selects a future year by which it wishes to reach an emissions reduction goal and estimates emissions for that future year presuming Business As Usual (BAU) growth of emissions from the base year. In other words, this is what would be expected if the local government pursues no further measures;
2. **Adopt an emissions reduction target for the target year**: The local government adopts an official reduction target defined as a percent reduction in annual emissions rate below the level reported in the base year (e.g. 20% reduction in emissions from a 2005 baseline by 2020). The target fosters political will and creates a framework that guides the planning and implementation of measures;
3. **Develop a Local Climate Action Plan**: A local government develops a Climate Action Plan, a set of policies and measures designed to meet the emissions reduction target by the target year. Because emissions tend to grow over time, the Climate Action Plan must contain enough reductions to reduce emissions from the amount expected under business as usual to the desired target rate.

These plans must include a timeline, a breakdown of actions and estimated benefits of each action compared to the baseline, a description of financing mechanisms, and an assignment of responsibility to departments and staff. Developing this plan is a multi-stakeholder process and most planning processes also incorporate public awareness and education efforts;

4. **Implement policies and measures**: The next milestone is an ongoing effort to implement the Climate Action Plan. Typical policies and measures include energy efficiency improvements to municipal buildings and water treatment facilities, streetlight retrofits, public transit improvements, installation of renewable power applications, and methane recovery from waste management;
5. **Monitor and verify results**: Monitoring and verifying progress towards target and status on the implementation of measures is a critical part of the milestone process. As part of this step, local governments will also need to conduct regular inventories to effectively gauge progress against the baseline.

Step 1 and 5 are very dependent on the collection of data from within the local government entity. The next section of the report looks at the details of this most challenging element of the GHGEI development process.

2.2 Data collection methodologies

The main bottleneck with developing a GHGEI is the collection and verification of the data needed to calculate the footprint. Generically the data required can be divided into three categories:

- **Static data**: consists of more static information resounding the activities and drivers behind GHG emissions (i.e. square metres of government buildings, number of cars and size/number of landfills in operation). This information is critical for the verification of the activity data and provides more detail on the overall footprint which is useful when setting targets and developing and implementing mitigation plans;
- **Activity data**: consists of information outlining the application and consumption of materials and equipment that result in the emission (i.e. fuel consumed, electricity consumed, kilometres travelled and tonnes of waste generated, etc.);
- **Emission factor data**: Factors which in essence convert the activity data in actual emissions covered in the footprint (e.g. MWh x tCO_{2e}/MWh = tCO_{2e}).

To obtain the information at the initial stage (i.e. the completion of a first footprint) a manual data collection exercise is often conducted. However, a manual process becomes cumbersome if the footprint is periodically renewed with the aim to measure and monitor the results of different mitigation activities.

Most organisations therefore implement a GHG monitoring and reporting system to continually collect and report on the GHGEI. Although these technical backbones come in a wide range of variations they cover roughly the same elements as outlined in the functionality of the EcoMetrix Carbon Action Model (the ECAM model) below (figure 8).

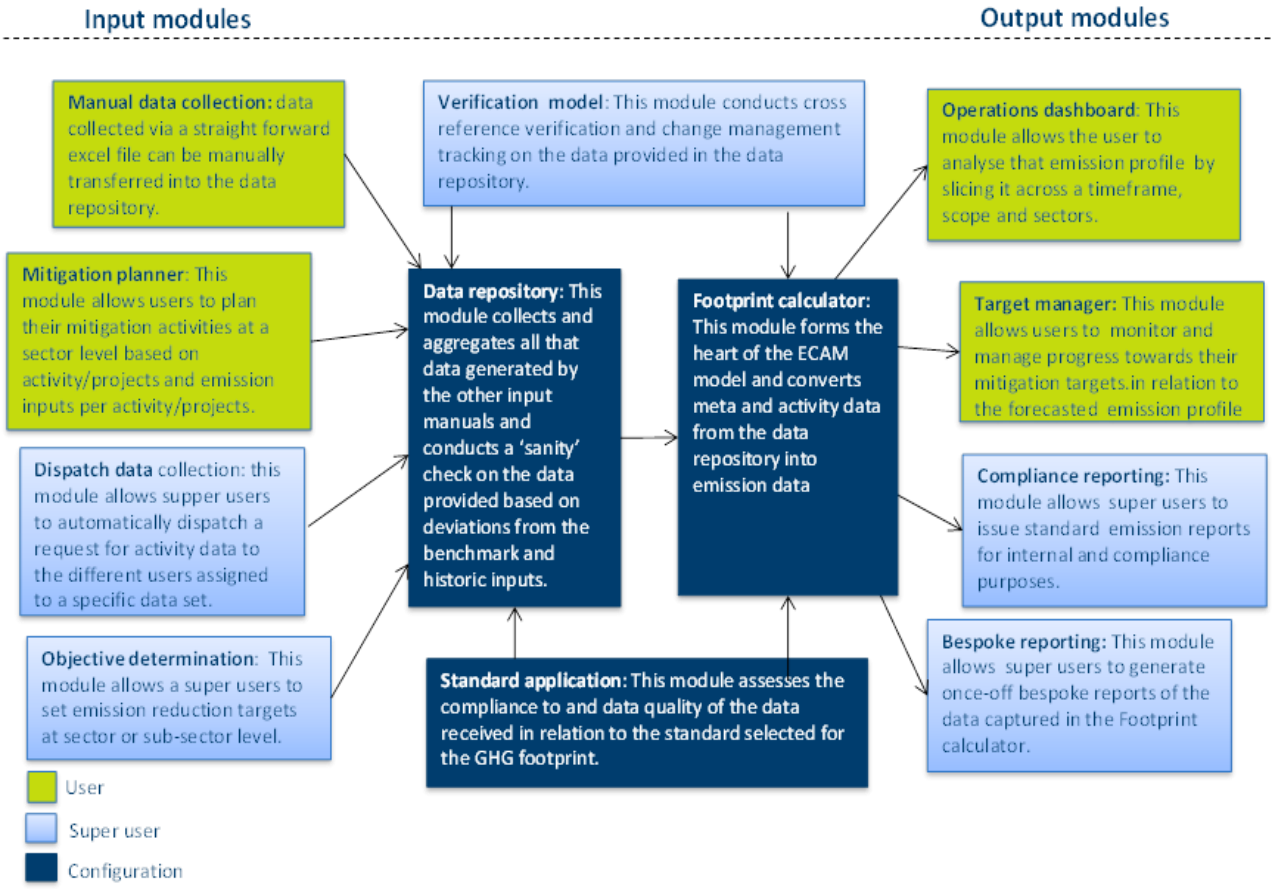

Figure 4: EcoMetrix Carbon Action Model functionality overview.

The model aggregates the decentralised parts of the data provided by a local municipality and utilises this information to generate a carbon footprint according to a predefined standard. The reporting function of the model allows for detailed analysis of the footprint as well as emission forecasting and emission mitigation planning.

When identifying a tool that is suitable for the specific needs as defined by the local government, it is important to take into account the technical infrastructure available within the organisation. Some tools are part of large enterprise resource management software packages such as SAP or Oracle, whereas other tools are more stand-alone and utilise mainstream office software like Microsoft Excel and Outlook.

3. Carbon footprint reporting and management

This chapter describes how to effectively report on one's GHGEI and which elements to take into account when setting targets against an emission reduction baseline.

3.1 How to report a carbon footprint

In addition to reporting the total carbon footprint over a specific period in time according to the reporting guidelines as set out by the standard applied, it is important to consider that a footprint only becomes useful when comparable with other footprints. This manner of reporting is called emission intensity reporting.

Generically, 'emissions intensity' is the average emission rate of a given pollutant from a given source relative to the intensity of a specific activity. For example the ratio of greenhouse gas emissions produced to Gross Domestic Product (GDP). Emission intensities provide useful insight on its own (i.e. in our example information on the carbon intensity of a specific economy activity) may also be used to compare the climate change impact of a specified entity with that of similar entities. Both applications are very useful as they leave out a range of variables that impact on the total footprint but are (for the most part) outside of the control of the different entities such as population growth and size. The table below provides a range of intensity factors as used across different fields.

Pictogram	Intensity factor	Definition	UoM
	Emissions per inhabitant	The GHG emissions per inhabitant of the municipality.	tCO_{2e} / inhabitant
	Emissions per household	The GHG emissions per household within the geographical boundary of the municipality.	tCO_{2e} / household
	Emission per operating expenditure	The GHG emissions per million Rand of operating expenditure of the local municipality.	tCO_{2e} / million Rand of operating budget
	Emission per kilometre travelled	The GHG emissions per kilometre of travel within the geographic boundary of the footprint.	tCO_{2e} / Km
	Emission per MWh consumed	The GHG emissions per Mega Watt hours of electricity consumed.	tCO_{2e} / MWh
	Emission per M^3 water consumed	The GHG emissions per cubic meter of drinking water consumed.	tCO_{2e} / m^3

Figure 3: Commonly used intensity factors.

Although there are many more commonly use intensity factors. It is important to consider which factors would be of particular interest to the local government when calculating the Emission intensities for a specific footprint.

3.2 How to manage a carbon footprint

The overall aim of a GHGEI is to manage and monitor the effect the mitigation activities within the local government have on the carbon footprint over time. When considering an emission reduction target for the GHGEI in the baseline year it is important to consider that the systemic development of the footprint over time is taken into account to be able to distinguish changes to the footprint resulting from targeted emission reduction efforts from the 'natural' movement of the footprint. The diagram below provides a schematic overview of the development of a GHGEI over time and how a target set against the baseline should be set taking this into account.

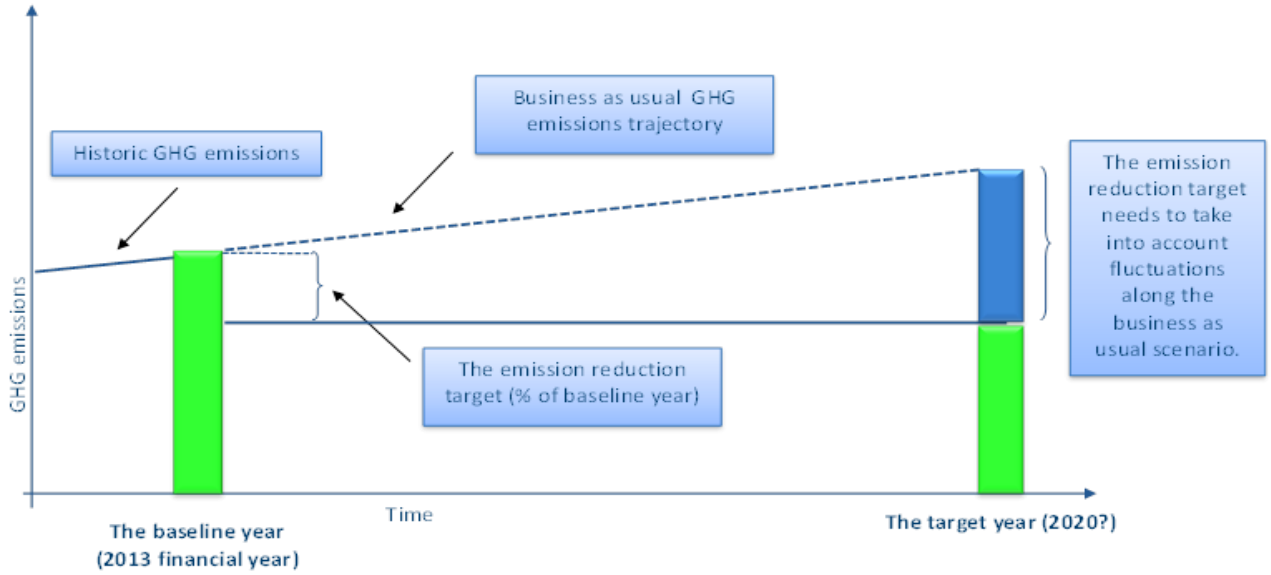

Figure 5: GHGEI target setting dynamics.

As a municipality interested in developing a GHGEI, it is important to consider that although daunting in nature the development of a GHGEI conducted in a professional manner will not only provide your organisation with a tool to manage its GHG emissions and thereby help the environment, but rather also with an instrument that can manage and reduce the organisation's future expenditure in among others, future carbon tax levies, fuel consumption expenses and electricity bills.