GIZ | Advancing Transport Climate Strategies in Rapidly Motorising Countries (TraCS)

Assessment of climate change mitigation potentials and actions in Uganda's transport sector

Final modelling report

April 2022

Dominic Sheldon, Ian Skinner, Nadja Taeger, Seith Mugume

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:
Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection
of the Federal Republic of Germany

The Republic of Uganda
CLIMATE CHANGE DEPARTMENT
Ministry of Water and Environment

THE REPUBLIC OF UGANDA
Ministry of Works and Transport

Disclaimer

Findings, interpretations and conclusions expressed in this document are based on information gathered by GIZ and its consultants, partners and contributors.

GIZ does not, however, guarantee the accuracy or completeness of information in this document, and cannot be held responsible for any errors, omissions or losses which emerge from its use.

Acknowledgements

This project has been implemented with sincere gratitude to the following Government of Uganda officials and experts for their input, contributions, and support in the development of this assessment: Bob Natifu, Irene Chekwoti, Derick Senyonga and Isaac Rubayiza from the Ministry of Water and Environment, as well as Charles Mutemo and Juliet Atino from the Ministry of Works and Transport, and all stakeholders that contributed relevant information and data for this assessment.

Special thanks go to Dominic Sheldon, Ian Skinner, James Harries, and Dan Forster from Ricardo Energy & Environment Ltd., and Seith Mugume, Andrew Bwambale, and Luanne Stevens from MEIR Engineering Ltd for their technical expertise for this project.

CHANGING TRANSPORT

Facilitating climate actions in mobility

GIZ works on changing transport towards a sustainable pathway and facilitating climate actions in mobility. We support decision-makers in emerging and developing countries through training and consulting services, as well as by connecting stakeholders. Our ultimate goal is to keep global temperature change to well below 2 degrees Celsius.

www.changing-transport.org

Project Context

The ‘Advancing Transport Climate Strategies’ (TraCS) project is funded by the German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection's, International Climate Initiative (IKI).

The project aims to support developing countries in systematically assessing GHG emissions from transport, in analysing emission reduction potentials and in optimising the sector’s contribution to the mitigation target in countries’ NDC. TraCS feeds into other international cooperation projects run by the Government of Germany.

TraCS is part of the Changing Transport family of transport projects implemented by GIZ and financed through the International Climate Initiative (IKI).

Table of Contents

List of tables

List of Figures

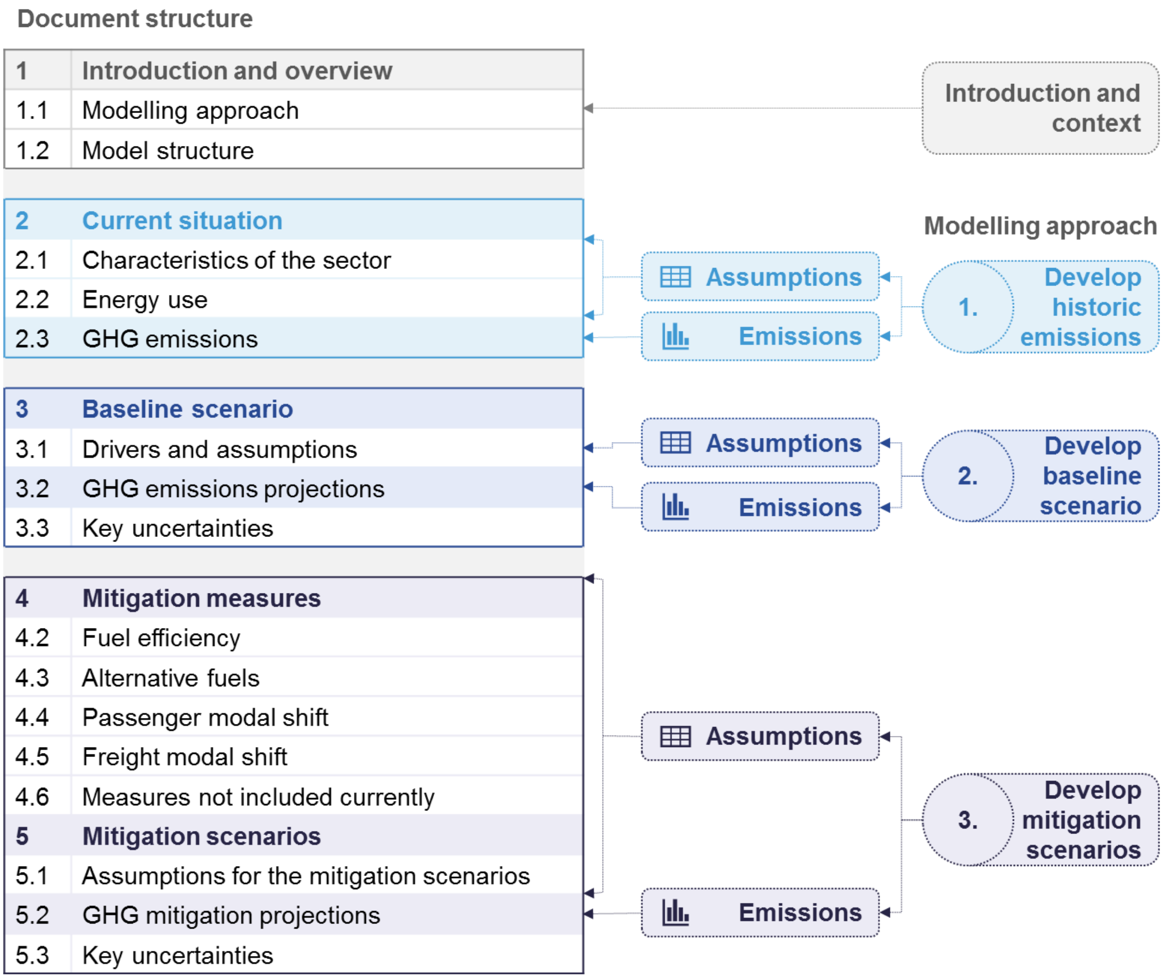
Executive summary

Introduction and overview

This project funded by the German Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) aims to support the Government of Uganda (represented by Climate Change Directorate, CCD) in systematically assessing the country's greenhouse gas (GHG) emissions from transport, analysing the sector's emission reduction potentials and optimising its contribution to the mitigation targets in the country's Nationally Determined Contribution (NDC). Using this data and analysis, decision makers are empowered to make evidence-based decisions about the future of Uganda's transport sector in terms of mitigating greenhouse gases.

This report details the mitigation analysis of the transport sector that has been carried out, detailing the data that have been gathered, the projected future GHG emissions under a business-as-usual scenario, the options for mitigating these emissions and possible mitigation scenarios.

Figure 1 Overview of document structure and relationship with modelling approach



Modelling approach

What is mitigation potential analysis modelling?

The modelling of mitigation potential analysis involves projecting the activities of part of an economy, in this case the transport sector, in order to understand the emissions associated with these activities and the potential impact of measures intended to reduce these emissions.

The process of developing a mitigation potential analysis model is formulated of three steps:

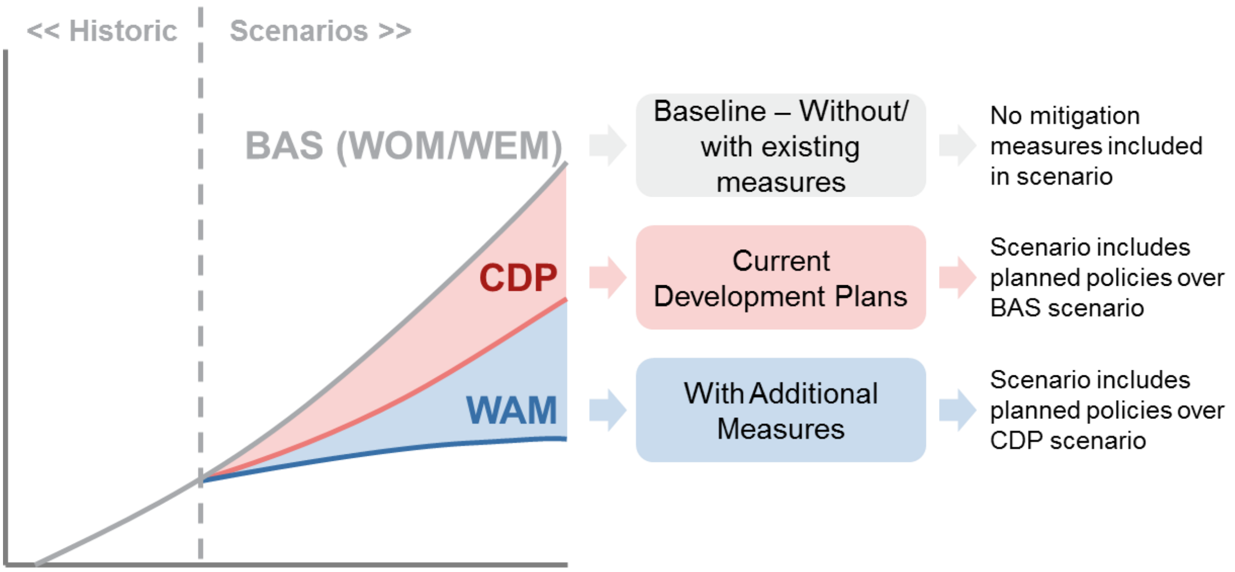
1. Model historic emissions
2. Model baseline scenario
3. Model mitigation scenarios

Model structure

The Low Emissions Analysis Platform (LEAP[1]) model was used to develop future emissions scenarios. Within LEAP, the model has been set-up with the following scenarios, each scenario "inheriting" the conditions of the previous scenario:

- **Baseline scenario: BAS: The baseline scenario forms the foundation of the model.** In this case the BAS is identical to both a without measures and a with existing measures scenario as it is considered that no mitigation measures are currently implemented.
- **Current development plans: CDP = BAS (WEM) + CDP measures**: The CDP takes the conditions modeled in the BAS+WEM and adds the effects of currently planned measures
- **With additional measures: WAM = BAS (WEM) + CDP + WAM measures**: The WAM adds the effects of the final layer of measures

Figure 2 Model scenario structure selected for this modelling exercise



[1] Previously known as the Long-range Energy Alternatives Planning model

Due to the way the mitigation measures are structured, in that each has a clear direct effect, the structure of the model in LEAP and the scenarios must be developed to reflect this. These measure types can be grouped even further based on the effect of the measures modelled.

Table 1 Measure structure in ASIF framework

Measure category	Measure description	Effect of measure		Modelled effect
A – Avoid	Avoiding journeys where possible		Reduction in total vehicle kilometres travelled (VKM)	Change to VKM
S – Shift	Modal shift to lower-carbon transport systems		Shift of VKM from higher to lower emission modes	
I – Improve	Improving the energy intensity of travel per passenger kilometre or tonne kilometre		Increase in the fuel economy (distance travelled per litre of fuel)	Change to energy intensity
F – Fuel	Reducing carbon intensity of fuel consumed		Reducing carbon intensity of fuels, so lowering emissions per litre of fuel consumed	Change to fuel type consumed

Current situation

Uganda's transport system can be divided into five sectors (1) roads and road transport; (2) rail transport; (3) air transport, (4) inland water transport; and (5) other modes (e.g. pipelines)[2,3]

- Road transport is the dominant mode, carrying over 95% of total traffic.[4] In 2018/2019, about 96% of freight cargo and passenger traffic was delivered by road.[5]
- Civil aviation has also expanded rapidly in recent years.
- Rail and waterway services are generally in a run-down state.[6] The rail transport sector has been operating below its capacity due to the dilapidation of the railway lines (only 26% of existing railway lines are operational), the poor state of locomotives, the unavailability of boat ferries to supplement the network, the poor state of real estate property and theft of track materials.[7]

[2] Only sectors 1-4 have been modelled in this exercise, sector 5: other modes was not modelled as this is not a significant source of emissions in Uganda currently.
[3] https://ledsgp.org/wp-content/uploads/2018/03/GIP01883-LEDS-UgandaFinal.pdf
[4] https://ledsgp.org/wp-content/uploads/2018/03/GIP01883-LEDS-UgandaFinal.pdf
[5] http://www.npa.go.ug/wp-content/uploads/2020/08/NDPIII-Finale_Compressed.pdf
[6] https://works.go.ug/wp-content/uploads/2015/08/National-Transport-Master-Plan-2008-2023.pdf
[7] Mitigation assessment of transport sector. MoWT. Unpublished.

Baseline scenario

Total transport emissions show a gradual increase across the modelling period. For the majority of the modelling period, more than 90% of transport activity is road transport. Road transport is modelled to increase by 7% annually from 2015 to 2025 and by 6% from 2025 to 2050 which is the dominant cause for this trend. Civil aviation and water-borne navigation share a similar profile of growth. Railways, however, have an abnormal profile in-line with descriptions of the activity in the rail network in Uganda, yet they make-up a very small proportion of activity.

Table 2 Total GHG emissions for transport by mode in baseline scenario

GHG emissions (Gg CO2e)	2003	2010	2019	2020	2030	2040	2050
Passenger							
Road	518	1671	3416	3700	6688	9400	13964
Aviation	136	212	331	350	539	774	1029
Rail	11.6	11.3	2.2	4.5	11.2	11.3	11.2
Waterborne	0.2	0.3	0.8	0.9	1.6	2.9	5.1
Freight							
Road	683	944	1349	1424	2291	3214	4676
Aviation	15	24	37	38	50	63	78
Rail	3.8	3.7	0.7	1.5	3.7	3.7	3.7
Waterborne	0.2	0.3	0.8	0.9	1.6	2.9	5.1

Table 3 Proportion of total GHG emissions by mode for transport in baseline scenario

Proportion of total GHG emissions	2003	2010	2019	2020	2030	2040	2050
Road	87.8%	91.2%	92.7%	92.8%	93.7%	93.6%	94.3%
Aviation	11.1%	8.2%	7.2%	7.0%	6.1%	6.2%	5.6%
Rail	1.1%	0.5%	0.1%	0.1%	0.2%	0.1%	0.1%
Waterborne	0.03%	0.02%	0.03%	0.03%	0.03%	0.04%	0.05%

Mitigation measures

Mitigation scenarios are constructed by identifying policies and measures that are relevant and evaluating the potential impact they might have on activity. The mitigation measures in this modelling exercise are grouped around four key measure categories:

- Fuel efficiency
- Alternative fuels and electrification
- Passenger modal shift
- Freight modal shift

Table 4 Overview of measure categories within the ASIF framework and modelled effects of measures

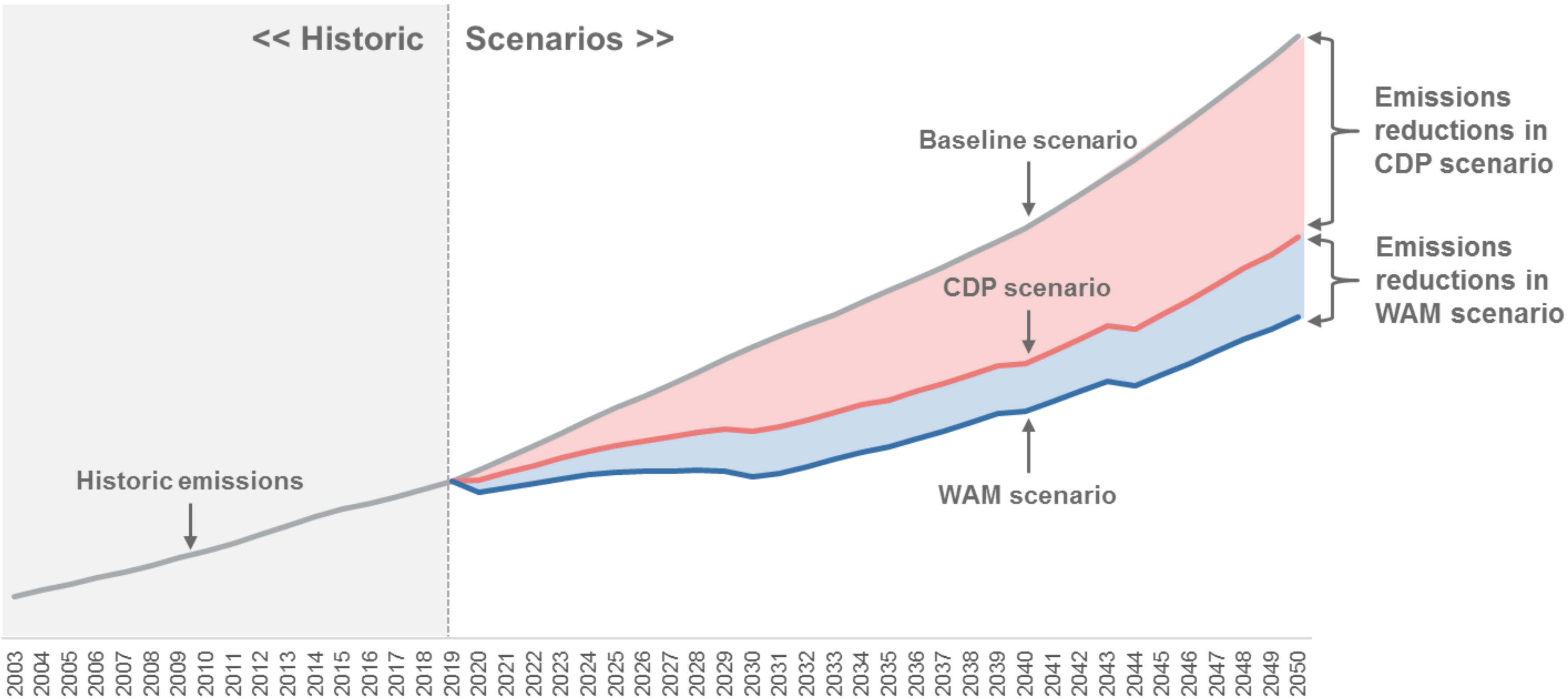
Measure category	ASIF	Modelled effect	Measures included
Fuel efficiency	Improve	Change to energy intensity	Road transport fuel efficiency Efficient operation of public transportation Efficient operation of freight through planning and best practice
Alternative fuels and electrification	Fuel	Change to fuel type consumed	Alternative fuel switch Electrification
Passenger modal shift	Avoid + Shift	Change to VKM	Residential trip avoidance through town planning and transport orientated development (TOD) Development of GKMA-BRT system Redevelopment and extension/expansion of GKMA passenger service Development of the LRT system Development of metro infrastructure
Freight modal shift	Avoid + Shift	Change to VKM	Development of the standard gauge railway system Rehabilitation of the Meter Gauge Railway System Bukasa Port Development

Mitigation scenarios

The outputs of the mitigation potential analysis are the projections of GHG emissions up to 2050 across the three scenarios: baseline, CDP and WAM for all subsectors. By 2050 in the CDP scenario, there is a 33% reduction in emissions against the baseline scenario in the transport sector, this rises to a 47% reduction in the WAM scenario.

Within the CDP scenario, by 2050 the most significant emissions reduction comes from the introduction of alternative fuels and electrification (16% reduction), followed by the fuel efficiency measure (11% reduction), then modal shift to mass public transit (9% reduction) and modal shift to freight (3%). Within the WAM scenario, by 2050 the most significant emissions reduction comes from the fuel efficiency measure (21% reduction), followed by the introduction of alternative fuels and electrification (17% reduction), then modal shift to mass public transit (15% reduction) and modal shift to freight (8%).

Figure 3 Representation of full modelling period in Uganda



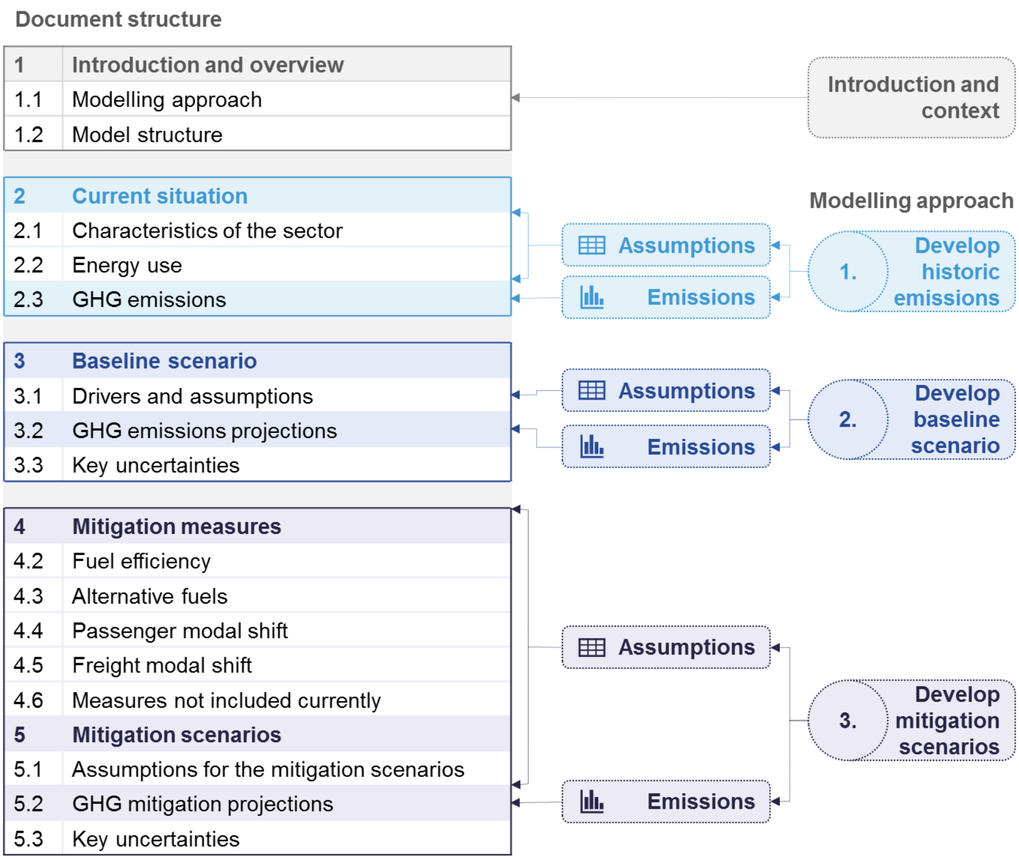
1 Introduction and overview

This project funded by the German Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) aims to support the Government of Uganda (represented by Climate Change Directorate, CCD) in systematically assessing the country's greenhouse gas (GHG) emissions from transport, analysing the sector's emission reduction potentials and optimising its contribution to the mitigation targets in the country's Nationally Determined Contribution (NDC). Using this data and analysis, decision makers are empowered to make evidence-based decisions about the future of Uganda's transport sector in terms of mitigating greenhouse gases.

An update to Uganda's NDC has been prepared with support from Zutari (South Africa), as part of a contract funded by the UNDP. Likewise, the development of a long-term climate change strategy (LTS) for Uganda has been supported by Ricardo (UK), which is also funded by the BMUV and coordinated by GIZ. All of these projects involve the assessment of the projected future GHG emissions in Uganda, and an assessment of the options and pathways for mitigating these emissions. The projects are being carried out in parallel and the teams are working collaboratively to ensure a consistent approach between this project and both the updated NDC and the LTS.

This report details the mitigation analysis of the transport sector that has been carried out, detailing the data that have been gathered, the projected future GHG emissions under a business-as-usual scenario, the options for mitigating these emissions and possible mitigation scenarios.

Figure 4 Overview of document structure and relationship with modelling approach



1.1 Modelling approach

This chapter presents an overview of the modelling approach that was adopted for this analysis as well as explaining the structure of the model that was used.

1.1.1 What is mitigation potential analysis modelling?

The modelling of mitigation potential analysis involves projecting the activities of part of an economy, in this case the transport sector, in order to understand the emissions associated with these activities and the potential impact of measures intended to reduce these emissions.

1.1.2 How do you calculate GHG emissions?

The basic structure of a GHG emissions calculation is presented in Figure 5.

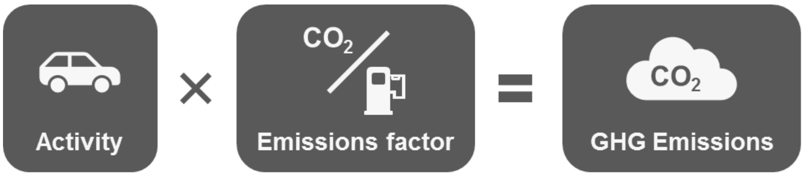
The three constituent parts are:

- **Activity**: This is the action that results in GHG emissions
    - For transport this is the travel taking place
        - **Unit example**: Distance a person travels in a vehicle

- **Emissions factor**: This is the amount of emissions produced for each unit of activity
    - For transport this is the CO_2 emitted when fuel/electricity is consumed in order to travel
        - **Unit example**: KG of CO_2 produced per litre of fuel consumed in order to travel

- **GHG emissions**: Total GHG emissions resulting from the activity (often given in megatons of CO_2 equivalent, or MT CO_2e)

Figure 5 Basic structure of GHG emissions calculation



1.1.3 How do you model future emissions?

The calculation shown in Figure 5 explains the basic structure of calculating GHG emissions at any point in time. How do you then calculate emissions in the future?

The process of developing a mitigation potential analysis model is formulated of three steps:

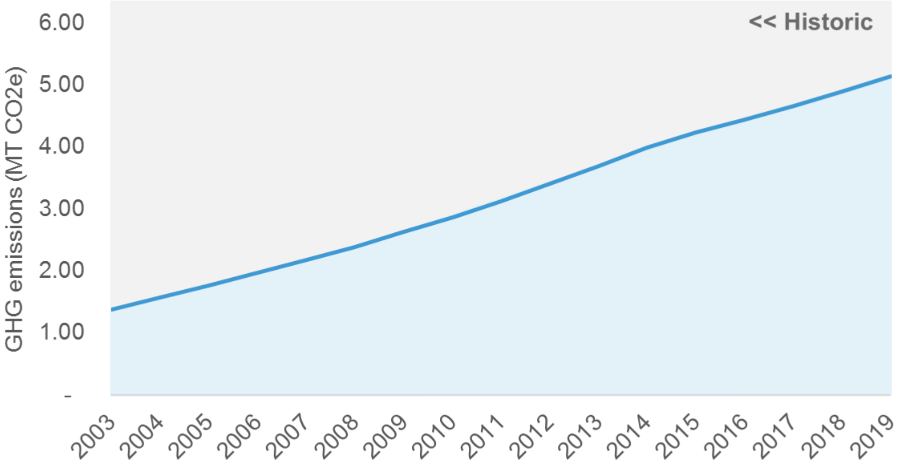
1. Model historic emissions
2. Model baseline scenario
3. Model mitigation scenarios

Following this process allows a user to develop a model of GHG emissions for a sector of the economy and to model the impact different mitigation measures might have on the activities within this sector and therefore the emissions associated with these activities. Each step has its own important role to play in the process:

1. **Model historic emissions**: In order to model projected future GHG emissions, it is key to first develop a model of existing activities and their associated GHG emissions. The model of historic emissions is an essential reference against which to compare projected future emissions to assess whether they seem realistic.

   Figure 6 presents an example of a theoretical historic emissions profile where you can see gradual linear growth in the transport sector.

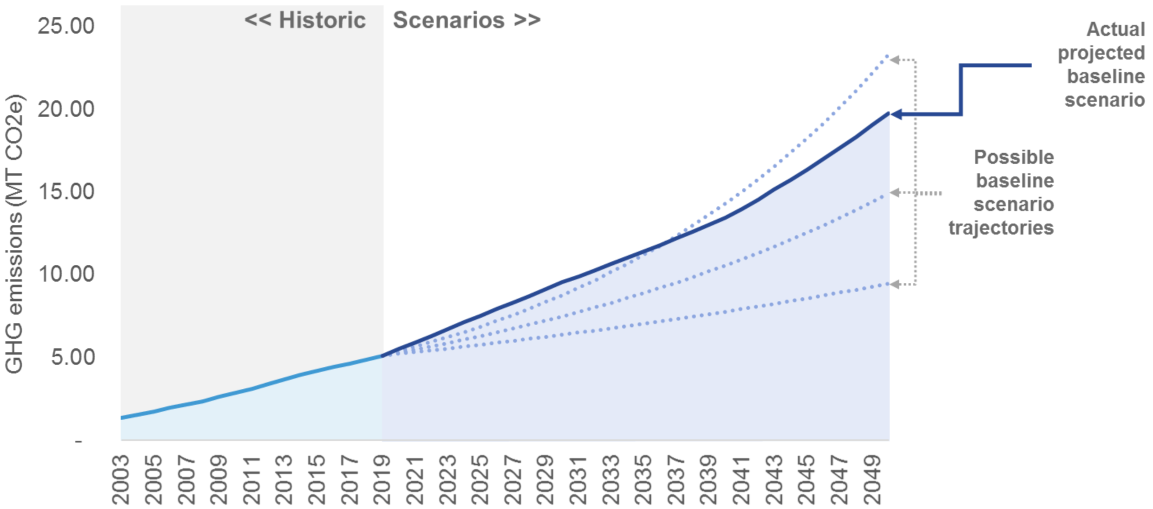
Figure 6 Model of historic GHG emissions



2. **Model baseline scenario:** Once a model of historic activity and the associated emissions have been developed, it is then possible to project into the future what might happen to this activity and the associated emissions. The main assumptions underpinning this are what the expected future trends are in the activity, for example, do you expect the activity to increase or decrease, by how much and over what period.

   The main idea here is that from the historic period, emissions could develop in an infinite number of ways. However, because we know the characteristics of the activity driving emissions from the modelling of the historic activity, there are some trajectories that are more likely than others based on these characteristics. Figure 7 presents a range of possible baseline scenarios, where within each the characteristics are slightly different. The figure then shows the actual modelled baseline scenario which is the most likely scenario based on these characteristics as agreed by stakeholders.

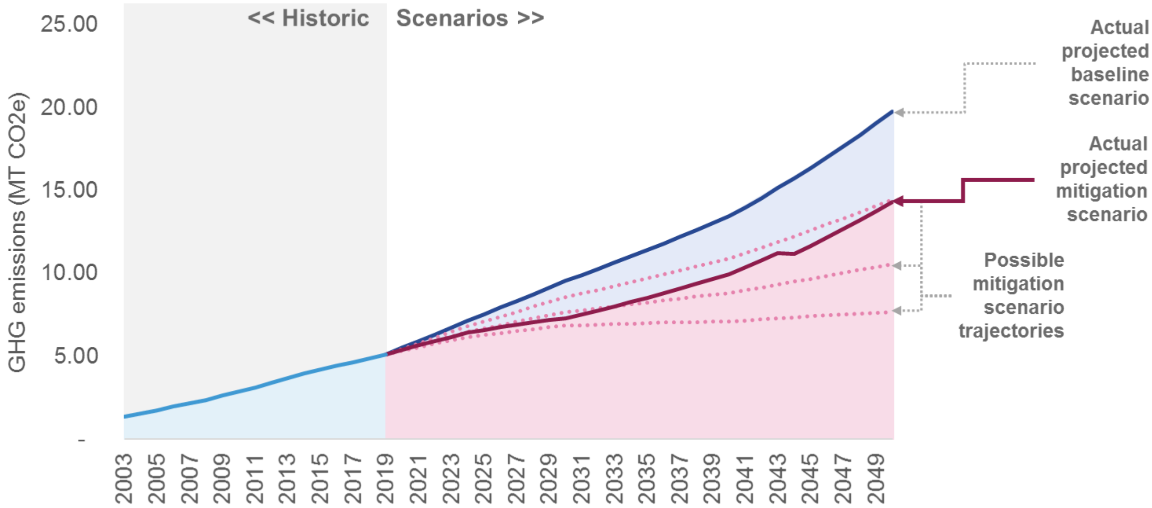
Figure 7 Model of baseline scenarios



3. **Model mitigation scenarios:** Once a model of the baseline activity and associated emissions in the sector has been developed**,** it is then possible to develop a model of what might happen to this activity and the associated emissions if certain measures were implemented. In other words, it is then possible to assess what mitigation (emission reduction) potential there is relative to the baseline.

   This scenario is constructed by identifying policies and measures that are relevant and evaluating the potential impact they might have on activity. This effect can then be modelled and the impact on emissions estimated. The way in which the effects of the measure are modelled of course impacts the trajectory of the projected emissions. Figure 8 presents an overview of different possible mitigation scenario trajectories and then the actual projected mitigation scenario, based on effects of measures that have been validated by stakeholders.

Figure 8 Model of mitigation scenarios against baseline scenario



1.1.4 Methodology used for modelling future scenarios

While the approach to developing a scenario of future activity and the associated emissions is clear, as set out above, in practice it is challenging as many different characteristics must be considered. One of these is the way in which policies and measures are captured within the model.

When modelling a baseline scenario or mitigation scenarios there are different ways that measures can be included. This section will present each in context.

1.1.4.1 Model baseline scenario

When modelling a baseline scenario there are two methodologies that can be used to formulate the scenario which assume different things about existing policies and measures:

- **Without measures (WOM) scenario**: No mitigation measures (planned or implemented) are present, existing measures are ignored, and future GHG emissions are forecast based on expected trends in activity only.

- **With existing measures (WEM) scenario**: Includes adopted and implemented policies at the end of the historic period.[8]

For the purposes of this modelling exercise, the baseline scenario will be a **without measures scenario**, however. This is equivalent to a **with existing measures scenario**, because Uganda is early on its transport emissions mitigation journey and mitigation measures have yet to be adopted.

1.1.4.2 Model mitigation scenarios

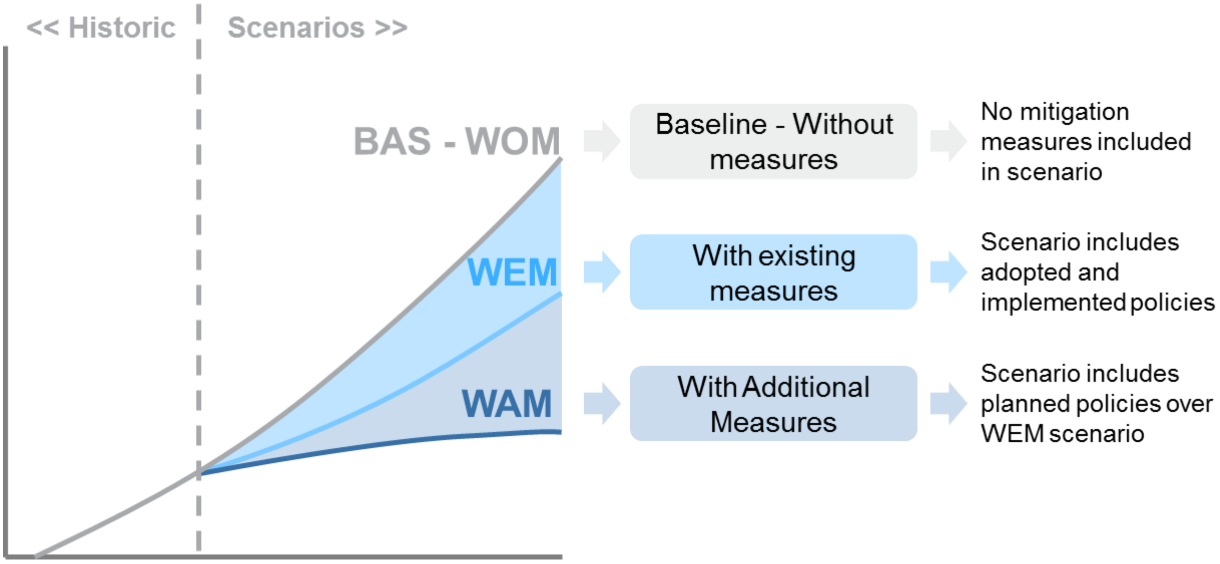
When developing mitigation scenarios there are generally two main scenario types that can be used to formulate the scenario, each assuming different things about existing and future policies and measures:

a. **WEM - With existing measures**
    i. Includes adopted and implemented policies at the end of the historic period[9]

b. **WAM - With additional measures**
    i. Includes planned policies over WEM scenario policies

Figure 9 presents an overview of how these different scenarios interact and are sequenced in practice in an example of a standard model scenario structure.

Figure 9 Standard model scenario structure



[8] For more information on different types of models as compiled by the UNFCCC see here: https://unfccc.int/files/national_reports/non-annex_i_natcom/cge/application/pdf/final-compendium-mitigation-actions.pdf

[9] https://unfccc.int/files/national_reports/non-annex_i_natcom/cge/application/pdf/final-compendium-mitigation-actions.pdf

The exact model scenario structure **used in this exercise for Uganda** is slightly different and is as such

Baseline scenario

a. **WOM – Without measures**
    a. No mitigation measures (planned or implemented) are present

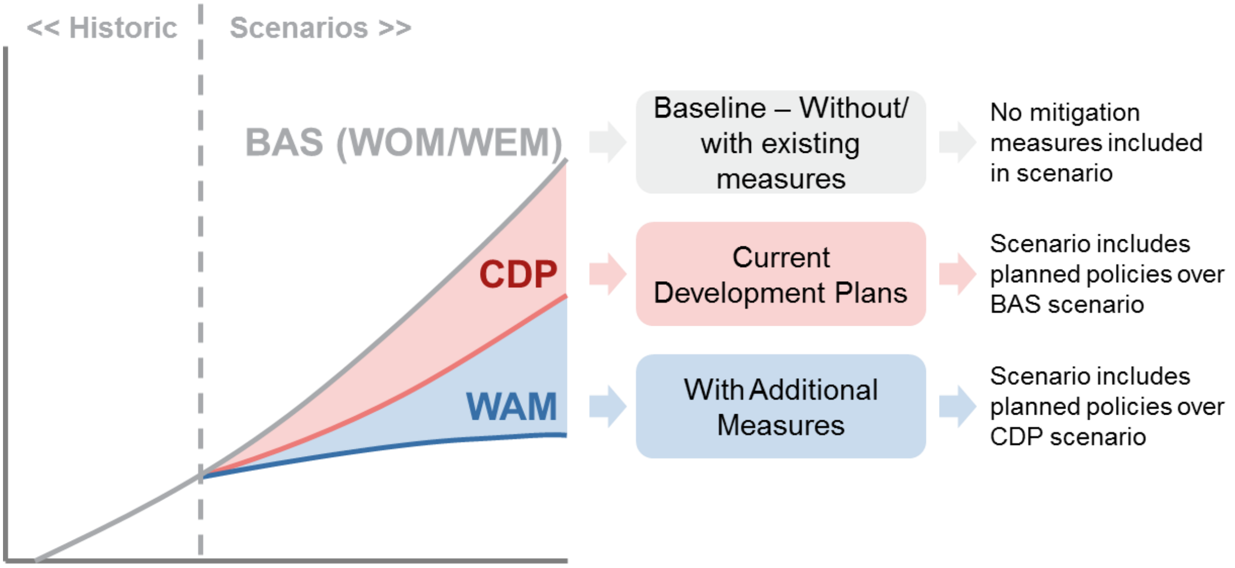
Mitigation scenarios

b. **CDP - Current development plans**
    a. Includes both current mitigation measures that have been introduced since 2015 as included in the baseline, and any planned commitments/targets/policies.

c. **WAM - With additional measures**
    a. Goes beyond CDP, which could mean additional measures that are not in the CDP and/or the same measures in CDP but at a greater level of ambition.

The modelling approach used a CDP scenario, rather than a WEM scenario, as it was considered important to take account of policies that **Uganda has planned**. As noted above, as Uganda is only at the start of its GHG mitigation journey, there are no existing policies that were in place at the end of the historic period on the basis of which a WEM scenario could be developed. However, Uganda has some GHG mitigation policies planned in the transport sector, which are included in the CDP scenario. Figure 10 presents how these scenarios interact and are sequenced.

Figure 10 Model scenario structure selected for this modelling exercise



1.2 Model structure

1.2.1 Introduction to LEAP

In order to develop the scenarios described in the previous section, a pre-existing model, the Low Emissions Analysis Platform (LEAP), was used. LEAP is an integrated, scenario-based modelling tool that can be used to track energy consumption, production and resource extraction in all sectors of an economy. The benefits of using LEAP in this project are:

- It is a model that is familiar to key stakeholders in Uganda and has been used for previous modelling exercises, so will allow for greater comparability with previous GHG scenarios.
- The LEAP model was used for the NDC. Using it for TraCS and the LTS therefore will help ensure strong linkages between this work, the NDC and the LTS.
- The model has recently been updated with increased functionality, but it remains relatively simple to use.
- The model is free for the Ugandan Government to use, increasing the opportunity for the authorities to continue to engage with the model beyond the duration of this project.
- Its low initial data requirements are well suited to a country like Uganda where accessing robust data has been, and will continue to be, a challenge.
- It presents outputs in a transparent and intuitive way.

LEAP is a tool that allows the user to compile a model from the bottom-up, by taking specific technologies and mitigation measures and inputting their effects on the energy system.

Due to this bottom-up structure, the LEAP model provides a great deal of flexibility to the user in developing the structure of the model. For the purposes of developing a transport model however, there are some recommendations on how the model should be structured in order to be able to model the effect of mitigation measures.

On the other hand, if the data are not available – or are not of sufficient quality – to enable a bottom-up approach to be developed, it is also possible to take a top-down approach in the model.

To determine the most appropriate method of structuring the model, first the scope of the model and the nature of the measures themselves must be established.

1.2.1.1 Model scope

The UNFCCC's Paris Agreement (Article 13 paragraph 7(a)) states that each Party *shall* regularly provide a national inventory report of anthropogenic emissions by sources and removals by sinks of greenhouse gases. This should be prepared using good practice methodologies accepted by the Intergovernmental Panel on Climate Change (IPCC[10]) and agreed upon by the Conference of the Parties serving as the meeting of the Parties to the Agreement.

The 2006 IPCC Guidelines for National Greenhouse Gas (GHG) Inventories break the sector '1A3 Transport' down into five specific sub-sectors:

- 1A3a. Civil Aviation
- 1A3b. Road Transportation
- 1A3c. Railways
- 1A3d. Water-borne navigation

[10] The IPCC is the United Nations body that assesses the science related to climate change and is the body responsible for compiling the guidelines for the reporting of GHG emissions.

- 1A3e. Other transportation
  - Including pipeline transport

The IPCC also outlines that the national GHG inventories must be prepared in accordance with the 'TACCC' principles:

- Transparency: Methodologies and assumptions are clearly explained and replicable.
- Accuracy: Uncertainty in emission estimates and removals is reduced as far as possible.
- Completeness: All sources/sinks included in IPCC guidelines are considered.
- Comparability: Methodologies and formats are applied as agreed by Parties.
- Consistency: Modelling is based on same methodology for base year and subsequent years and consistent datasets are used.

These same guidelines should be used for the compilation of GHG emissions projections. In order to adhere to the principle of **completeness**, the model developed for this project should include all five transport sub-sectors of the IPCC's Guidelines.

However, there are several considerations beyond the TACCC principles that must also be taken into account.

- Data availability and accuracy: As data quality is such an important component of GHG projections compilation, the **accuracy** of the model can be compromised if good quality data is not available and data with significant uncertainty are used instead
- Resource efficiency and impact: In Uganda, road transportation is responsible for 90% of transport activity in-country. This sub-sector is therefore the priority focus of the mitigation potential modelling exercise as the greatest mitigation potential will be here. Hence, some emissions sources from other sub-sectors have not been considered, in order to ensure that sufficient resources were dedicated to the priority sector.

The model therefore includes the following four sub-sectors and focuses on road transportation:

- 1A3a. Civil Aviation
- 1A3b. Road Transportation
- 1A3c. Railways
- 1A3d. Water-borne navigation

The other important disaggregation to make in the data is between the type of transport activity, i.e. whether the activity is to transport passengers or freight. The measure implemented will obviously depend on the type of transport activity, so this is a critical distinction to make and the first level of disaggregation presented.

1.2.2 Scenario structure in LEAP

The Low Emissions Analysis Platform (LEAP[11]) model was used to develop future emissions scenarios (see Section 1.2.1 for more detail on this).

Within LEAP, each scenario "inherits" the conditions of the previous scenario.

- **Baseline scenario: BAS:** The baseline scenario forms the foundation of the model. In this case the BAS is identical to both a without measures and a with existing measures scenario as it is considered that no mitigation measures are currently implemented.
    - **Current development plans: CDP = BAS (WEM) + CDP measures:** The CDP takes the conditions modeled in the BAS+WEM and adds the effects of currently planned measures
        - **With additional measures: WAM = BAS (WEM) + CDP + WAM measures:** The WAM adds the effects of the final layer of measures

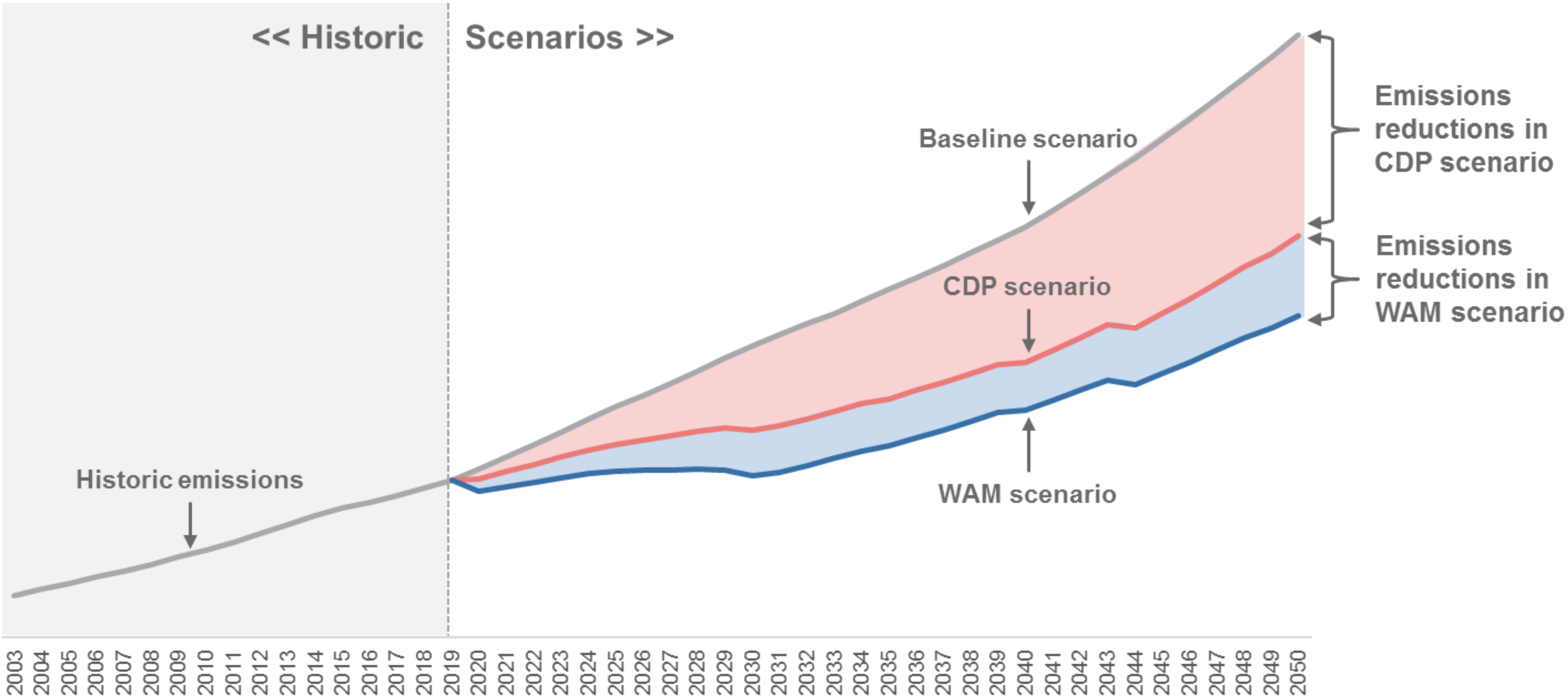
Table 5 outlines the modelling period and Figure 11 on the next page provides a representation of the full modelling period in context with each of the modelled scenarios.

Table 5 Modelling period

Period	Timeline
Historical emissions period	2003-2019[12]
Scenario period	2020-2050

[11] Previously known as the Long-range Energy Alternatives Planning model
[12] This timeframe was used as it was the period for which the best data was available for

Figure 11 Representation of full modelling period in Uganda



1.2.3 Vehicle kilometres travelled

One of the key datapoints for this modelling exercise is vehicle kilometres travelled (i.e., the distance travelled by vehicle type). It is important to understand how this datapoint fits in with the modelling framework, how it is therefore used in the calculations and how mitigation measures would affect it.

Figure 12 Basic calculation of VKM/PKM/TKM

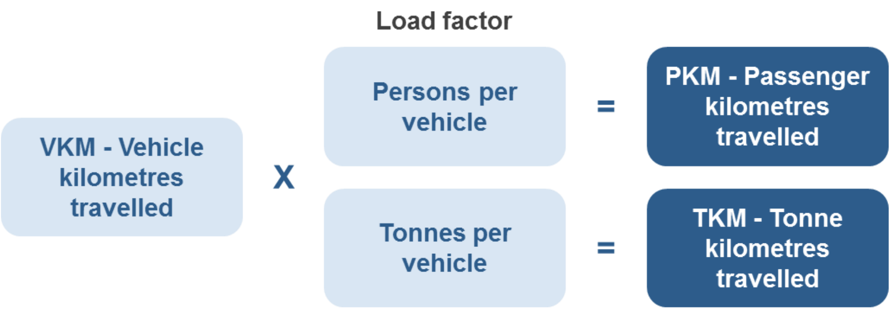


Table 6 Breakdown of VKM/PKM/TKM

Datapoint	Description
Vehicle kilometres travelled (VKM)	Distance travelled by the vehicle itself, assuming no additional load on the vehicle (e.g. passengers or freight transported)
Passenger kilometres travelled (PKM)	Distance travelled by the vehicle itself multiplied by the average number of passengers travelling per vehicle (load factor)
Tonne kilometres travelled (TKM)	Distance travelled by the vehicle itself multiplied by the average tonnage of freight travelling per vehicle (load factor)

1.2.4 Mitigation measure format

Once the scope of the model has been established, the format of the actions to be modelled will dictate the structure of the model. For this analysis a particular hierarchy of actions will be used known as the ASIF framework, this is demonstrated in Table 7. It is important to note that the ASIF framework is relevant in the context of reducing GHG emissions from the transport sector. As part of a GHG mitigation policy framework for the transport sector, the level of use of modes that are already low carbon, such as walking and cycling, should also be increased by measures that focus on improving infrastructure for these modes. These measures have not been explicitly included in the table below, as these modes have no GHG emissions to mitigate.

Table 7 ASIF framework

Measure category	Measure description	Effect of measure	Mechanism	
A – Avoid	Avoiding journeys where possible		Reduction in total vehicle kilometres travelled (VKM)	Achieved by actions such as improving urban planning, public transport planning or freight logistics systems, substituting IT systems for travel
S – Shift	Modal shift to lower-carbon transport systems		Shift of VKM from higher to lower emission modes	Achieved by actions such as implementation of improved infrastructure for public transport, walking and cycling.
I – Improve	Improving the energy intensity of travel per passenger kilometre or tonne kilometre		Increase in fuel economy (distance travelled per litre of fuel)	Achieved by actions that improve vehicle and engine efficiency, or overall transport system efficiency.
F – Fuel	Reducing carbon intensity of fuel consumed		Reducing carbon intensity of fuels, so lowering emissions per litre of fuel consumed	Achieved by replacing oil-based fossil fuels with natural gas, biomethane or biofuels, or electricity or hydrogen produced from renewable energy sources.

Within LEAP, there are several data input types that can be used to formulate the model and to model the effects of the types of measures listed in Table 7, as listed in Table 8.

Table 8 LEAP data input types

LEAP input	Icon	Data required
Total energy		Total energy (e.g. fuel) consumption
Activity level		Total vehicle kilometres travelled by mode
Energy intensity		Fuel consumed per kilometres travelled

1.2.5 Methodology

There are generally two modelling approaches used to compile GHG emission projections:

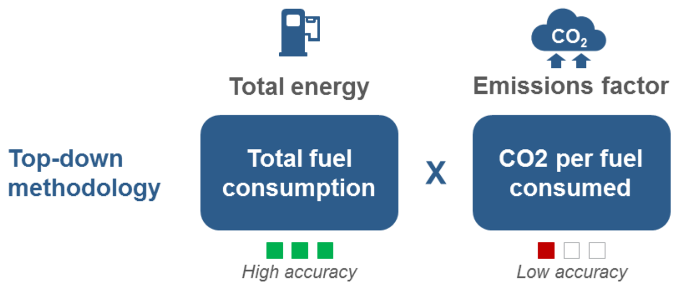
- Top-down
- Bottom-up

Both of these modelling approaches have been used to model the GHG emission projections for this analysis depending on the characteristics of the sub-sector modeled in each case.

1.2.5.1 Top-down

A top-down methodology takes an aggregated input value (such as total energy consumption) and multiplies this by an emissions factor in order to compute emissions.

Calculation: Fuel consumption * emissions factor = GHG emissions



Pros: Simple, fast, often low uncertainty in source data
Cons: Difficult to model mitigation effect

For a top-down transport model, the modellers need at least the following data inputs:

Table 9 Total energy as input variable 1

Variable	Total energy
The total fuel consumed in the modelled year	
Accuracy	**High**
Fuel sales are a reliable, readily available data input. The accuracy challenge is with disaggregating transport activity rather than the accuracy of the source data itself	

Table 10 Emission factor as input variable 2

Variable	Emissions factor
As the main input data is an aggregated value (total energy), either a single emissions factor must be applied for the whole consumption value or assumptions must be made in order to disaggregate the total.	
Accuracy	**Low**
Due to this lack of disaggregation, there is a lack of precision in the emissions factor applied to the fuel consumption	

Top-down is a very simple methodology, however, it comes with significant uncertainty as the aggregated value does not necessarily accurately represent the activity that underpins it. For example, sales of motor gasoline might be for road transport vehicles of several different types (motorcycles, cars and light duty vehicles), ages and conditions, as well as for other transport types such as in outboard motors for waterborne transport or even for uses that are not transport-related, such as in stationary generators.

Each of these different uses will have a different emissions factor associated with it due to the characteristics of the engine in which the fuel is combusted and the operating conditions of this engine. However, this will not be taken into account as the data are not available through this method, therefore a high-level generic emissions factor will be used.

So, whilst the data source is very reliable and there can be high confidence in the overall accuracy of the sales value, the accuracy in terms of the emissions output representing transport activity is very low.

Where an aggregated value is used as the main input, the modelling of the effect of mitigation measure is very challenging, as described below:

Avoid – A reduction in total distance travelled by mode is required to assess the emissions impact of this measure type. Total energy consumption can be reduced proportionally to the expected reduction in VKM, e.g. 10% reduction in VKM leads to a 10% reduction in total fuel consumed. However, as total energy is not disaggregated, if the reduction is mode specific, e.g. 10% reduction in passenger cars but not in motorcycles, significant assumptions must be made to ensure that the adjustment can be represented in the modelling, which leads to inaccuracy.

Shift – Similar to the *avoid* category of measures, an adjustment of distance from one mode to another is required to assess the impact of this measure type. However, for shift, this is not an absolute increase or decrease but rather a shift from one mode to another. As with *avoid,* without disaggregation, it is not possible to model this accurately.

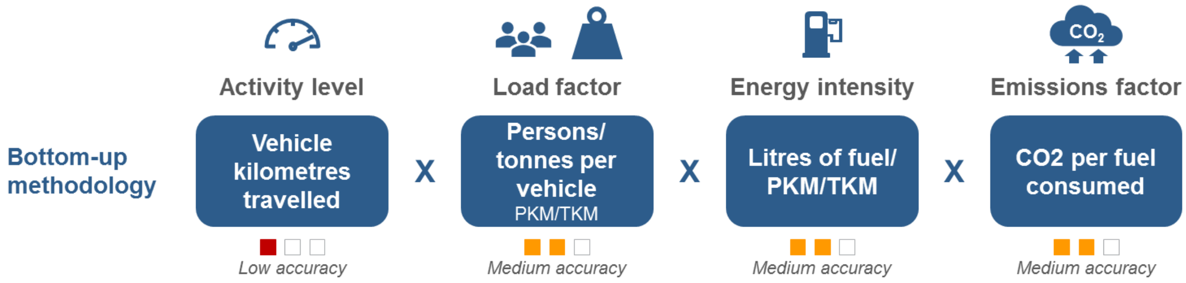
Improve – The effect of this measure type is a reduction in the fuel consumed per distance travelled, i.e. an increase in the fuel efficiency. This can be represented by a proportional reduction in total energy consumed. However, as with *avoid* and *shift* measures, this will not be precise enough if the efficiency changes vary by vehicle type.

Fuel – It is possible to model measures from this measure type as the effect is simply a proportional shift from one fuel type to another. The effect would therefore be a change to the proportion of total fuel consumed.

1.2.5.2 Bottom-up

A bottom-up methodology takes the opposite approach to top-down, attempting to compile the total energy consumption of a mode of transport by modelling the transport activity itself. The total energy consumption computed is then multiplied by an emissions factor for that specific mode and that specific activity.

Calculation: Transport activity by mode of transport (VKM * load factor) * fuel economy value * emissions factor = GHG emissions[13].



Pros: Disaggregated by activity, therefore allows clear modelling of mitigation effect of measures

Cons: High data requirements

In theory, this would be a much more accurate method. However, the data requirements are significantly higher than a top-down approach (see the previous section) and therefore have significantly greater uncertainty. For a bottom-up transport model, the modellers need at least the following data inputs:

Table 11 Activity level as input variable 1

Variable	Activity level
The total annual distance travelled by the specific mode of transport	
Accuracy	**Low**
Unless there is a very strong regulatory regime with mandatory annual vehicle inspections that logs mileage and also an associated vehicle database that records the type of vehicle, size of engine and fuel type. Otherwise, generally the estimation of these data involves significant assumptions to be made relating to annual distance travelled by vehicle types, taking account of different engines and fuels.	

[13] For more information on this method, see section 2.2 of the LEAP training exercise. https://unfccc.int/resource/cd_roms/na1/mitigation/Module_5/Module_5_1/b_tools/LEAP/Training_Materials/LEAP_Training_Exercises_English.pdf

Table 12 Load factor as input variable 2

Variable	Load factor
The load/additional weight on the vehicle from passengers or freight	
Accuracy	**Low**
If data exist for the distance that passengers travel (passenger kilometres (PKM)), or the distance freight is transported (in tonne kilometres (TKM)), or if a mitigation measure aims to improve the efficiency of transport, the load factor is needed. The load factor is generally taken from road transport surveys. For freight, it is simpler as records of vehicle weight might exist at the origin or destination of the trip or at national borders, so a reasonable average is quite readily calculated. Estimating a passenger load factor is more challenging as the average occupancy of a vehicle can vary significantly depending on the location and its economic status; these data are not normally regularly collected.	

Table 13 Energy intensity as input variable 3

Variable	Energy intensity
The fuel economy of the vehicle, i.e. how much fuel is consumed for every km travelled.	
Accuracy	**Medium**
Whilst there will be some variation in fuel efficiency between vehicle types and between individual vehicles of the same type, this variation generally does not differ enough from the average fuel efficiency for a vehicle type to undermine the accuracy achieved from using the average. The accuracy of this datapoint therefore relies on good data regarding the breakdown of distance travelled by vehicle type.	

Table 14 Emissions factor as input variable 4

Variable	Emissions factor
The emissions factor for a bottom-up methodology is generally more precise. If the activity level data is disaggregated by vehicle type, then an emissions factor for that particular vehicle type can be applied, either a default value or a country-specific value.	
Accuracy	**Medium**
The precision in the emissions factor for the specific vehicle type helps to improve the accuracy of the emissions estimate from the activity described.	

A bottom-up methodology is the most effective for modelling the effects of mitigation measures as the disaggregation of the source data provides the precision required for the modelling of the impact on emissions of different measure types:

Avoid – Avoided total VKM, or VKM of specific vehicle types can be easily modelled.

Shift – Modal shift from one vehicle type to another can be easily modelled through a proportional increase and decrease in VKM for the specific vehicle types.

Intensity – Improvements in fuel economy can be easily modelled through a reduction in the litres of fuel consumed per distance travelled.

Fuel – Shifts from one fuel consumed to another can easily be modelled within the energy intensity variable.

Table 15 presents the methodology selected for each sub-sector in the model based on the data available and the data required to model measures in each sub-sector.

Table 15 Methodology selected for each sub-sector

Sub-sector	Methodology
Civil aviation	**Top-down:** Fuel consumption * emission factor
Road transport	**Bottom-up:** (VKM * load factor) * fuel economy * emission factor
Railways	**Top-down / bottom up:** VKM (Fuel consumption) * proportion VKM freight or passenger * fuel economy * emission factor
Water-borne navigation	**Top-down:** Fuel consumption * emission factor

Figure 13 presents an overview of the structure of the LEAP model and the type of data required for each sub-sector and Figure 14 presents examples of the exact data requirements for both a top-down and bottom-up methodology.

Figure 13 Modelling methodology applied to each sub-sector

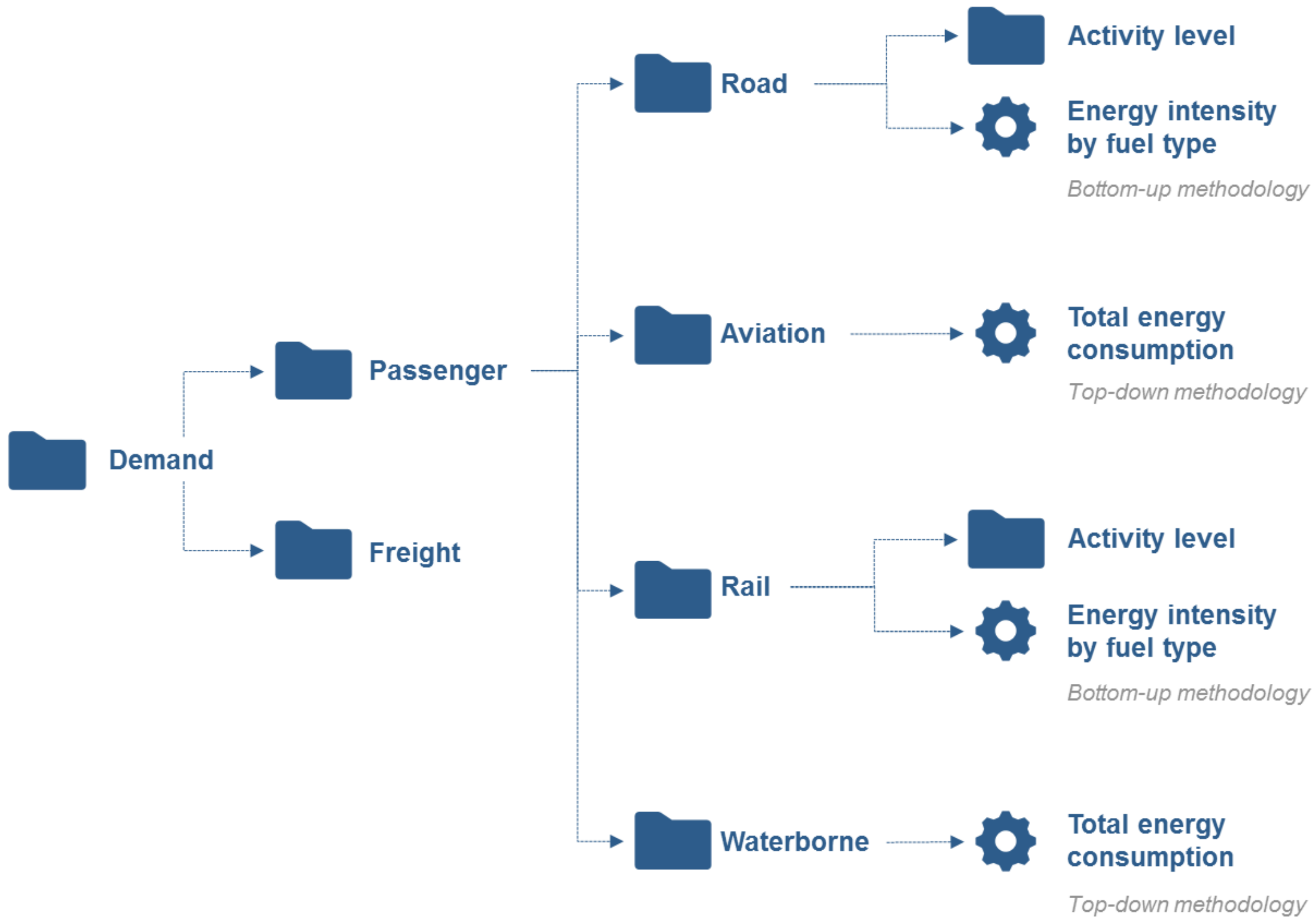
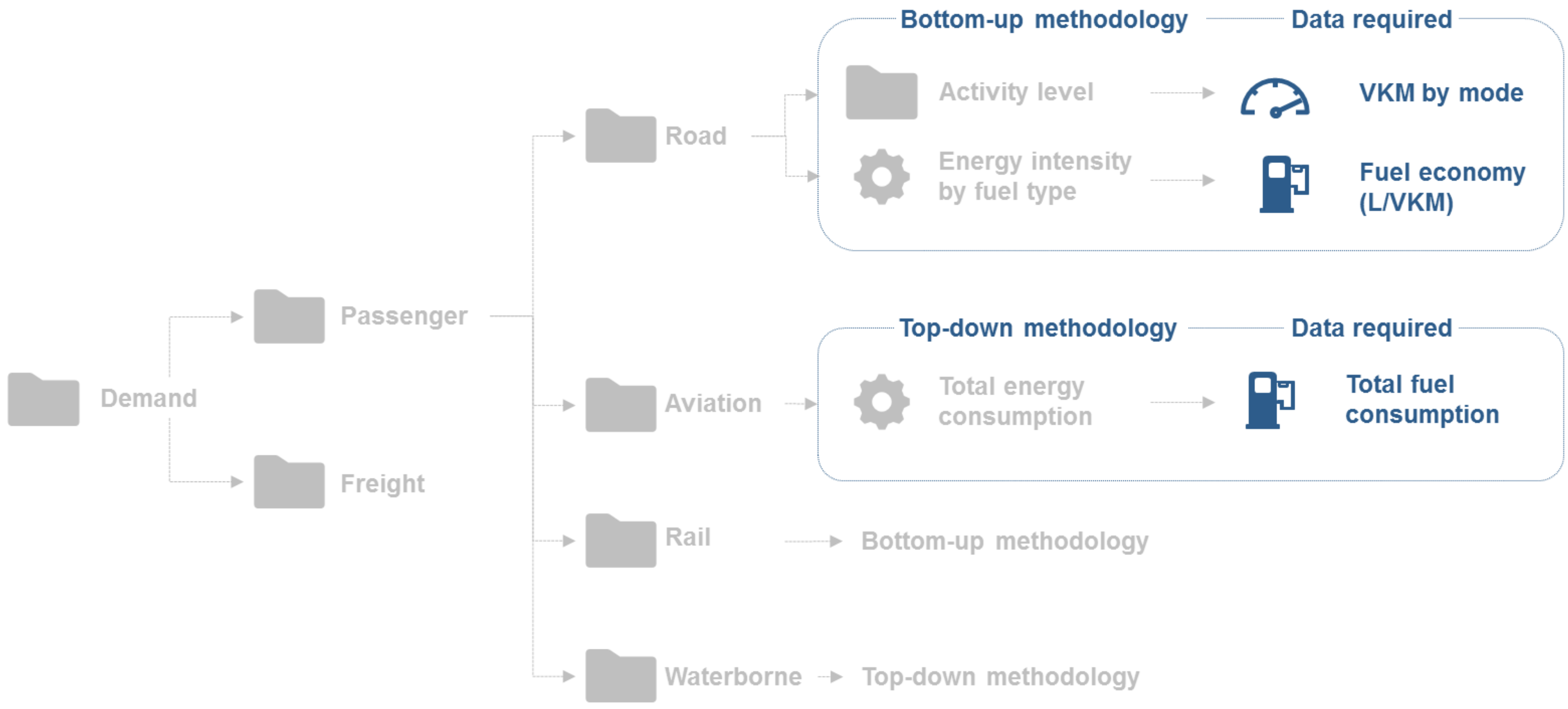


Figure 14 Data required for modelling methodology



1.2.6 Scenario construction

Due to the way the mitigation measures articulated in section 1.2.4 are structured, in that each has a clear direct effect, the structure of the model in LEAP and the scenarios must be developed to reflect this. These measure types can be grouped even further based on the effect of the measures modelled, as described in the "modelled effect" column in Table 16. This column reflects how measures might be grouped when modelling them.

Table 16 Measure structure in ASIF framework

Measure category	Measure description	Effect of measure	Modelled effect
A – Avoid	Avoiding journeys where possible	Reduction in total vehicle kilometres travelled (VKM)	Change to VKM
S – Shift	Modal shift to lower-carbon transport systems	Shift of VKM from higher to lower emission modes	
I – Improve	Improving the energy intensity of travel per passenger kilometre or tonne kilometre	Increase in the fuel economy (distance travelled per litre of fuel)	Change to energy intensity
F – Fuel	Reducing carbon intensity of fuel consumed	Reducing carbon intensity of fuels, so lowering emissions per litre of fuel consumed	Change to fuel type consumed

2 Current situation

This chapter will establish the characteristics of the sector that inform the development of the historic emissions model.

2.1 Characteristics of the sector

Uganda's transport system can be divided into five sectors (1) roads and road transport; (2) rail transport; (3) air transport, (4) inland water transport; and (5) other modes (e.g. pipelines)[14].[15]

Road transport is the dominant mode, carrying over 95% of total traffic.[16] The public road network, including both classified and unclassified roads, comprises more than 140,000 km. In 2018/2019, about 96% of freight cargo and passenger traffic was delivered by road.[17] The Kampala District in particular accounts for over 50% of the vehicles in Uganda.[18]

The majority of vehicles in Uganda originate from Japan, imported as reconditioned units, usually more than 5 years old. The current motorised vehicle fleet is approximately 1,355,090 vehicles, up from 739,036 in 2012, with the average age of vehicles being more than 15 years old. Passenger transport in Uganda is a mix between private cars, motorcycles, minibuses and buses.[19]

Civil aviation has also expanded rapidly in recent years. International passenger numbers per annum increased from 781,428 in 2008 to 1,303,484 in 2016. International traffic dominates flights at Entebbe International Airport, up to 97% for passengers and 99% for cargo. This airport is currently undergoing expansion in order to cater for the increasing passenger traffic and cargo freight.[20]

Rail and waterway services are generally in a run-down state.[21] The current market shares of railways declined from 12% to 5% within the last 8 years.[22] The rail transport sector has been operating below its capacity due to the dilapidation of the railway lines (only 26% of existing railway lines are operational), the poor state of locomotives, the unavailability of boat ferries to supplement the network, the poor state of real estate property and theft of track materials.[23]

2.2 Energy use

In Uganda in 2015, 64,330 TJ of liquid fuel was consumed, including 24,999 TJ of motor gasoline, 4,560 TJ of aviation gasoline and 30,483 TJ of gas/diesel oil.

---

[14] Only sectors 1-4 have been modelled in this exercise, sector 5: other modes was not modelled as this is not a significant source of emissions in Uganda currently.
[15] https://ledsgp.org/wp-content/uploads/2018/03/GIP01883-LEDS-UgandaFinal.pdf
[16] https://ledsgp.org/wp-content/uploads/2018/03/GIP01883-LEDS-UgandaFinal.pdf
[17] http://www.npa.go.ug/wp-content/uploads/2020/08/NDPIII-Finale_Compressed.pdf
[18] https://www.mwe.go.ug/sites/default/files/library/National%20Climate%20Change%20Policy%20April%202015%20final.pdf
[19] Mitigation assessment of transport sector. MoWT. Unpublished.
[20] Mitigation assessment of transport sector. MoWT. Unpublished.
[21] https://works.go.ug/wp-content/uploads/2015/08/National-Transport-Master-Plan-2008-2023.pdf
[22] Mitigation assessment of transport sector. MoWT. Unpublished.
[23] Mitigation assessment of transport sector. MoWT. Unpublished.

2.3 GHG emissions

CO_2 emissions from the transport sector in Uganda in 2015 were 2,652 Gg, methane emissions were 1 Gg[24].

3 Baseline scenario

This chapter explains the data and assumptions used to inform the development of the baseline scenario.

3.1 Drivers and assumptions

3.1.1 Key drivers

The main drivers for transport activity are population and economic growth, while the associated emissions depend on the fuels and vehicles that are used. As Uganda's population grows and becomes wealthier, the overall demand for transport will increase and there may be a shift from non-motorised and public transport, to private car use. Vehicle ownership (excluding motorcycles) increased from only 2/1000 people in 2008 to 22/1000 in 2016. It is important to note that around 40% of registered vehicles currently are motorcycles. Whilst population and economic growth are key drivers of transport activity, these are not the available datapoints used to build the model, as the impact of these on emissions depends on other factors (as noted above).

3.1.2 Assumptions

The key long-term strategy document for Uganda, Vision 2040 (National Planning Authority, 2010)[25] has emphasised the need for an integrated transport infrastructure network to spur economic growth. This will entail the development of a highly interconnected transport network and services optimizing the use of rail, road, water and air transport modes.

This has been reinforced by the Second National Development Plan (National Planning Authority, 2015[26]) which has recognised infrastructure as one of the development fundamentals required to attain middle income status for the country. As a result, a sizeable share of commitments is being directed to infrastructure investments with a focus on reducing travel times between regions, integrating the national market and connecting it to other markets in the East African Community.

As outlined in the National Transport Master Plan, the dominant growth will be in the road sector, where traffic growth is expected to reflect economic growth and grow by about 7% a year until 2025 when annual growth rate is expected to reduce to 6%[27].

---

[24] Ministry of Water and Environment (2019), Uganda's First Biennial Update Report (BUR) to the United Nations Framework Convention on Climate Change. Accessed from: https://unfccc.int/sites/default/files/resource/FBUR%20Final_2019.pdf

[25] National Planning Authority (2010). Uganda Vision 2040. National Planning Authority, Kampala Uganda. Accessed from: http://www.npa.go.ug/uganda-vision-2040/

[26] National Planning Authority (2020), Third National Development Plan (NDPII) 2015/16 – 2019/20. Accessed from: http://npa.go.ug/wp-content/uploads/NDPII-Final.pdf

[27] https://www.researchgate.net/publication/285766191_Energy_Report_for_Uganda_A_100_Renewable_Energy_Future_by_2050

The rail sector should also be able to grow in order to accommodate the marginal increase in passengers that will result from the increase in population that is expected in Uganda. This increase will not be large due to the dilapidated nature of the network and substantial investment is needed in order to overcome the challenges presented in Section 2.1. Ambitious goals were set out in Vision 2040, of at least 80% of Uganda's freight transport to be carried by rail and the standard gauge rail will transport at least 10% of all persons for interurban and international trips by 2040. However, existing project timelines for revitalising the rail network do not currently align with these goals.

In the air sector, stagnation in the international passenger market between 1997- 2002 was followed by rapid growth in 2002-07. International air freight has grown rapidly in recent years, particularly in the export market, and the market as a whole may expand at about 9% annually over the next 15 years. Domestic air traffic is expected to grow at between 5 and 10% annually, with strong growth in general aviation a possibility as the tourist sector expands. Domestic air freight will remain at a low level. The upgrade and expansion of Entebbe International Airport is ongoing.

In the water sector, traffic by wagon ferry will be determined by the development of rail traffic, and also by the relative use of the Southern Route through Tanzania for imports and exports. Similarly, the utilisation of the 'road bridge' ferries will follow growth of road traffic. The growth of other lake and river traffic will follow that of local economies in the districts concerned, where the waterways will remain a lifeline for some rural communities.

For the modelling exercise, the BAS scenario was developed using the following assumptions for each mode.

3.1.3 Assumptions for road transport

Modelling approach: Bottom-up (VKM)

Table 17 Bottom-up calculation methodology used for road transport

Activity		Load factor			Fuel economy		Emissions factor
Vehicle kilometres travelled (VKM)	X	Persons per vehicle	Tonnes per vehicle	X	Litres of fuel/ (PKM/TKM)	X	CO2 produced per litre fuel consumed

Activity

Activity data was split by passenger and freight and then by mode of transport.

To calibrate the modelling, statistics on petrol and diesel consumption published in the national energy balances were compared against the estimated petrol and diesel consumption of the model, as calculated bottom up based on the VKM data and estimated vehicle fuel economy. It was found that the fuel consumption in the model was significantly higher than the energy balances reported. Therefore, the VKM values in the base year (2019) were scaled down to better reflect the fuel consumption statistics in the energy balance.

VKM were extrapolated forward in BAU with a growth rate of 7% to 2025 and 6% from 2025 to 2050.[28] Energy consumption and GHG emissions by mode of transport were determined based on the estimated split of VKM by mode given in Table 18 and Table 19.

Table 18 VKM split - Passenger

Mode	2019 proportion of total passenger VKM
Motorcycles	57%
Cars	29%
Small Bus (Matatu)	13%
Medium and large bus	2%

Table 19 VKM split - Freight

Mode	2019 proportion of total freight VKM
Light Trucks (2 Axles)	62%
Medium Trucks (3 Axles)	9%
Large Trucks (4 Axles)	5%
Heavy Trucks (5+ Axles)[29]	24%

Load factor

Load factors for both passenger and freight transport are presented in Table 20 and Table 21. The 2019 values are assumed to remain constant across the modelling period in the baseline.

Table 20 Load factor - Passenger

Mode	2019 Load factor[30] (People/vehicle)
Motorcycles	1.6
Cars	3.0
Small Bus (Matatu)	15.0
Medium and large bus	37.5

28 https://www.researchgate.net/publication/285766191_Energy_Report_for_Uganda_A_100_Renewable_Energy_Future_by_2050

29 Heavy Trucks combines VKM data for 2019 for 5, 6, 7 and >7 axle vehicles into one category

30 Gathered directly from the Government by MEIR under TraCS programme

Table 21 Load factor - Freight

Mode	2019 Load factor (Tonne/vehicle)
Light Trucks (2 Axles)	10
Medium Trucks (3 Axles)	15
Large Trucks (4 Axles)	20
Heavy Trucks (5+ Axles)	30

Fuel economy

Fuel economy figures were taken from Vehicle Fuel Economy Baseline for Uganda[31], which provided fuel economy by engine capacity. These categories were aggregated and averaged to provide 2 distinct categories of light duty vehicle (LDV) and heavy-duty vehicle (HDV), as well as including separate calculations for motorcycle fuel economy.

Table 22 Vehicle category by engine capacity

Category	Engine capacity
LDV	500_1200CC
	1201_1500CC
	1501_2000CC
	2001_2500CC
	2501_3000CC
	3001_3500CC
HDV	3501_4000CC
	4001_5000CC
	>5000CC

Data on the fuel split of the total number of vehicles is publicly available,[32] i.e. the proportion of the total number of vehicles (new and old), not differentiated by vehicle type, that are petrol and diesel fuelled. These data are also disaggregated by engine capacity. However, as the fuel split by vehicle type was not available, expert judgement was used to estimate the fuel split by vehicle type. It was assumed that a higher proportion (70-100%) of VKM of the vehicles with a smaller engine capacity and those used for passenger transport used a petrol engine, while vehicles with a larger engine capacity and used for freight transport were assumed to be predominantly diesel, as presented in Table 23 and Table 24.

[31] https://www.fiafoundation.org/media/461028/africa_vehicle-fuel-economy-baseline-for-uganda.pdf
[32] https://www.fiafoundation.org/media/461028/africa_vehicle-fuel-economy-baseline-for-uganda.pdf

Table 23 Fuel split assumptions – Passenger

Category	Mode	Petrol	Diesel
Moto	Motorcycles	100%	0%
LDV	Cars	70%	30%
LDV	Small bus (Matatu)	50%	50%
HDV	Medium and large bus	30%	70%

Table 24 Fuel split assumptions – Freight

	Mode	Petrol	Diesel
LDV	Light Trucks (2 Axles)	50%	50%
HDV	Medium Trucks (3 Axles)	30%	70%
HDV	Large Trucks (4 Axles)	0%	100%
HDV	Heavy Trucks (5+ Axles)	0%	100%

One strange trend in the data is that the fuel economy for petrol and diesel vehicles (except motorcycles) has actually decreased over time, meaning the Ugandan vehicle fleet is consuming more fuel per kilometre (see Table 25 and Table 26). The reason for this has been explored in the literature, as observed in the Vehicle Fuel Economy Baseline for Uganda, "we notice that despite the imposition of the environmental tax by URA in 2008, the average age has been worsening for all categories of engine capacity…The relatively high age of vehicle at registration is of concern to promoting fuel economy national policy, since older cars for any engine capacity and vehicle technology consume more fuel and hence emit more CO2 per kilometre. One major weakness of a flat environmental tax for instance the current 20% on the value of the vehicle irrespective of age, is that older vehicles have a lower value hence carry a lower charge, accordingly their purchase price is low; and the reverse is true for newer versions; they are of a higher value and they fetch a higher environmental fee hence making their purchase price to rise. For that matter most of the consumers would opt to purchase older cheaper vehicles instead of the newer ones" (see Figure 15).

Figure 15 Average age of vehicles and category by fuel type and year of registration[33]

	Diesel				Petrol			
Weight Category	**2005**	**2008**	**2011**	**2014**	**2005**	**2008**	**2011**	**2014**
Heavy Duty	9.8	12.2	12.3	17.0	7.0	8.2	8.7	11.5
Light Duty	6.5	8.4	8.7	15.0	10.4	11.8	12.9	15.5
Grand Average	**8.1**	**10.2**	**10.5**	**16.4**	**10.4**	**11.7**	**12.8**	**15.4**

[33] https://www.fiafoundation.org/media/461028/africa_vehicle-fuel-economy-baseline-for-uganda.pdf

Table 25 Petrol fuel economy (L/100km) [34]

Mode	2005	2008	2011	2014
Moto	2.7	2.5	2.4	1.9
LDV	10.6	10.8	11.1	11.8
HDV	22.2	21.4	21.5	22.9

Table 26 Diesel fuel economy (L/100km)

Diesel	2005	2008	2011	2014
LDV	11.6	11.7	11.9	13.4
HDV	24.2	24.9	27.7	29.3

It is assumed that there are limits to this historical downward trend in vehicle fuel economy and therefore this has not been extrapolated forwards into the future. These limits are that:

- As the fuel economy baseline explains[35], as the age of a vehicle increases there is a decrease in its fuel economy/efficiency. However, this decrease is not linear but exponential. Meaning that the difference in fuel efficiency between vehicles that are 0-5 years old is much larger than the difference in fuel efficiency between vehicles that are 10-15 years old and so on until the difference is negligible.[36]
- Also, it is assumed that there are limits to the effects of the environmental levy on purchasing behaviour, as costs of maintenance increase with a vehicle's age and therefore it will not always be the most cost-effective decision to buy an older car.

The Global Fuel Economy Initiative (GFEI)'s 50by50 campaign[37] has set targets for the global vehicle fleet to achieve, as detailed below:

- By 2020: 20% improvement in stock average (on-road) efficiency (against 2005 baseline), reflecting both the improvements in new car fuel economy (with some lag time for stock-turnover) and additional measures such as eco-driving, improved aftermarket components, better vehicle maintenance, etc.
- By 2030: 35% improvement in stock (against 2005 baseline), roughly trailing new car improvements plus on-road improvement measures.
- By 2050: 50% (50 by 50: the ultimate goal) improvement in global stock average fuel economy (against 2005 baseline), following the new car improvement in 2030 and with in-use improvement measures.

As Uganda is reliant on vehicle imports, these timescales can be used as a benchmark to gauge future fuel efficiency developments in the country in the baseline based on the average age of the vehicle fleet. Extrapolating the trend shown in Figure 15 to 2019, across both LDVs and HDVs, for petrol and diesel, the average age of the fleet would be

[34] https://www.fiafoundation.org/media/461028/africa_vehicle-fuel-economy-baseline-for-uganda.pdf
[35] https://www.fiafoundation.org/media/461028/africa_vehicle-fuel-economy-baseline-for-uganda.pdf
[36] This effect is presented very clearly in Figure 6: Relation between Fuel Efficiency and Age of vehicle, of the fuel economy baseline: https://www.fiafoundation.org/media/461028/africa_vehicle-fuel-economy-baseline-for-uganda.pdf
[37] https://www.globalfueleconomy.org/media/46127/50by50-report-2009-lr.pdf

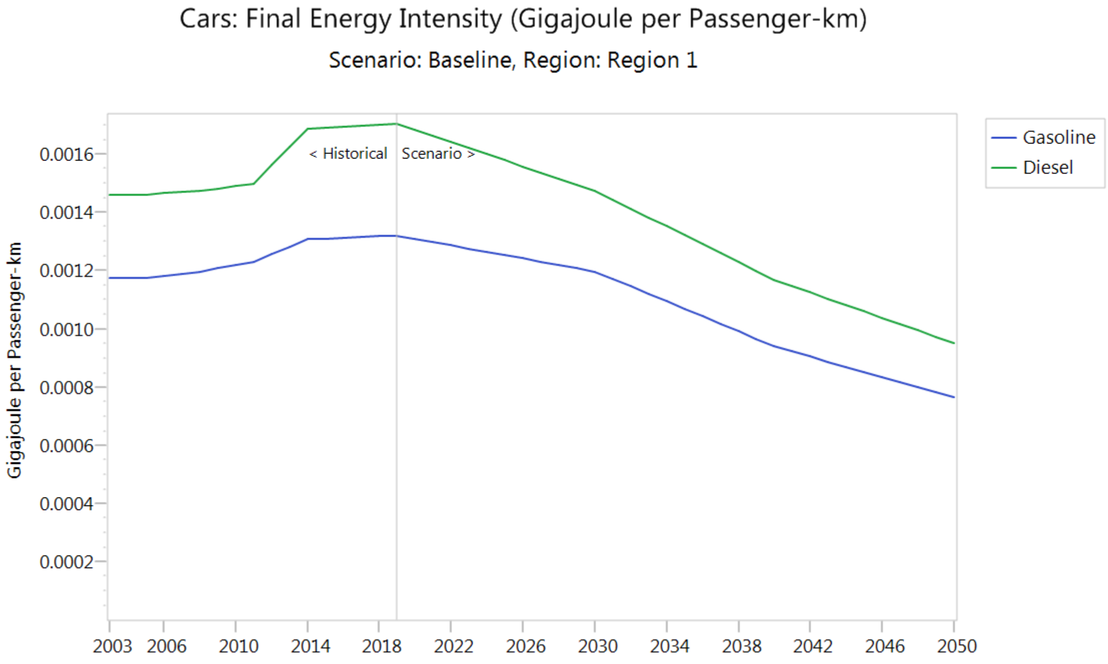
approximately 20 years old. This would mean that updates to vehicle technology have a lag time of roughly 20 years before they penetrate the Ugandan vehicle fleet.

It is assumed that this average fleet age of 20 years old is a peak after which incentives to purchase an older vehicle will diminish due to costs of maintenance. The downward trend in fuel economy will also therefore peak in 2019. After this point, the BAU assumes that the Uganda vehicle fleet moves towards the GFEI targets with the 20-year lag time. The exact assumptions are presented below in Table 27 and the fuel economy trajectory for cars in the baseline scenario is presented Figure 16.

Table 27 Baseline fuel economy assumptions

Scenario	20% improvement	35% improvement	50% improvement
GFEI Targets	2020	2030	2050
Uganda BAU	2040	2050	2070

Figure 16 Car fuel economy in baseline scenario



3.1.4 Assumptions for civil aviation

Modelling approach: Top-down (fuel consumption)

Table 28 Top-down calculation methodology used for civil aviation

Fuel consumption		Emissions factor
Total fuel sold	X	CO2 emitted per litre fuel consumed

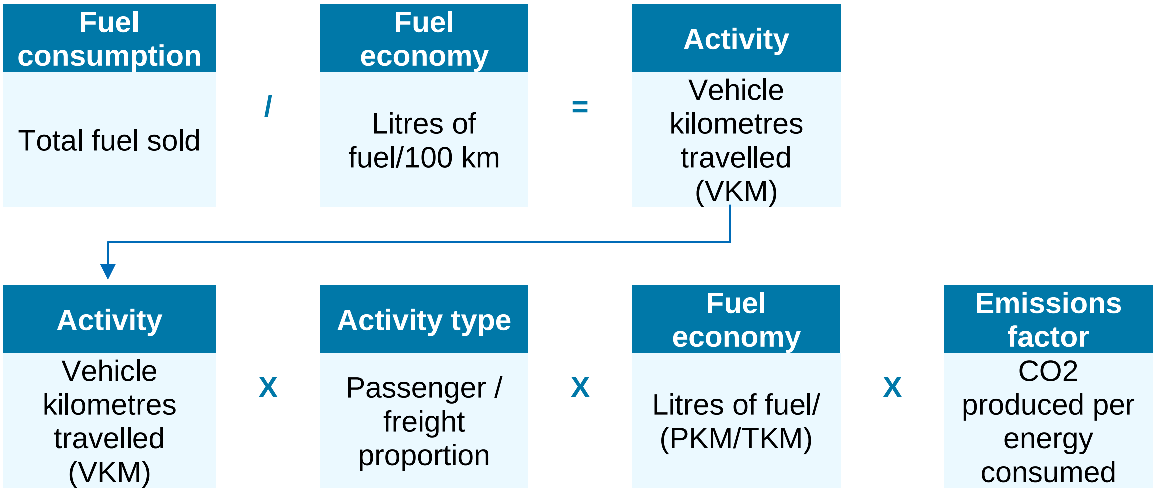
Current levels of jet kerosene consumption, taken from the national energy balance, are extrapolated forward based on expected growth rates. The upgrade and expansion of Entebbe International Airport is included in the BAU. This assumes an increase in passenger capacity from 1.9 million to 3.0 million and increased freight capacity of 100,000 tonnes per year. These data were taken and used to scale jet kerosene consumption. A linear historical growth was assumed across the modelling period and, as no baseline fuel economy was provided, no change to vehicle technologies or efficiencies across the modelling period have been assumed.[38]

No other airport infrastructure projects were included at this point either due to lack of data or due to the relatively small impact they would have on total VKM.

3.1.5 Assumptions for rail

Modelling approach: Top-down (fuel consumption) validated with bottom-up (VKM)

Table 29 Hybrid calculation methodology used for rail transport



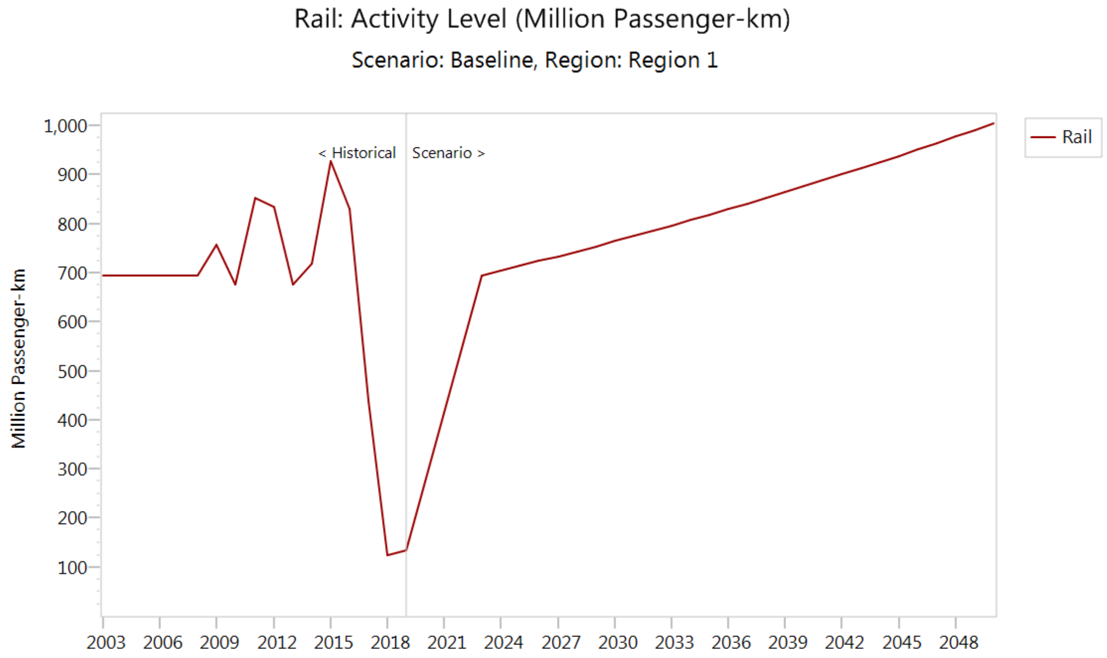
A full bottom-up methodology was not possible due to a lack of passenger VKM data and no fuel economy data provided for rail locomotives. Therefore, the fuel consumption was taken, as the datapoint with the lowest uncertainty, and a reference fuel economy value was used to infer VKM. This VKM figure was then scaled by the proportion of PKM/TKM that were undertaken by passenger and freight trains to get the passenger and freight shares. Having the model in this format allows measures to be modelled that directly affect VKM travelled and vehicle fuel economy or fuel use with much greater sensitivity.

Whilst the rail network has experienced some significant dilapidation ("the current market shares of railways declined from 12% to 5% within the last 8 years"[39]), it is assumed that the state of the railway remains roughly stable and that the historic growth in usage experienced between 2008 and 2015 continues following recovery from the extreme lows in activity

[38] As civil aviation is modelled using a top-down methodology which does not include fuel efficiency as a variable that is modelled but rather total fuel consumption and also considering the small contribution to total emissions that the sub-sector represents, it was deemed too uncertain and insignificant to model.
[39] Mitigation assessment of transport sector. MoWT. Unpublished. Exact year unknown.

experienced during the past few years. These lows are assumed to be anomalous and that activity on the railway returns to normal by 2022.

Figure 17 Baseline rail passenger KM travelled



It is assumed that no infrastructure development occurs in the baseline as the two primary projects planned to develop the rail network (meter gauge and SGR) are included under the CDP scenario and therefore the BAU assumes that no further investment is provided.

As no baseline fuel economy was provided, a reference fuel economy from South Africa was used. Assuming an aging vehicle stock, the fuel economy for 1994 was taken and used across the historic time-series. It is assumed that the fuel economy improves in-line with the trend presented in Figure 18 however still delayed, reaching the 2009 levels in 2060.

Figure 18 South Africa railway specific energy consumption (KJ/transport unit)[40]

[40] https://www.uic.org/com/IMG/pdf/iea-uic_2012final-lr.pdf

3.1.6 Assumptions for water-borne transport

Modelling approach: Top-down (fuel consumption)

Table 30 Top-down calculation methodology used for water-borne transport

Fuel consumption		Emissions factor
Total fuel sold	X	CO2 produced per fuel consumed

Very little data were available for this mode: only the fuel consumed, however no unit or fuel type was provided. It was assumed that this mode consumed 100% diesel. Assumptions were made on the units used and consumption was extrapolated based on historical time-series.

Consumption extrapolated forward in BAU under growth rate of 7% to 2025 and 6% from 2025 to 2050 (Energy Report for Uganda).

3.2 Baseline scenario GHG emissions projections

This section presents the GHG emissions projections for the baseline scenario based on the drivers and assumptions described in section 3.1.

Total transport emissions, as shown in Table 31and Figure 19, show a gradual increase across the modelling period. For the majority of the modelling period, more than 90% of transport activity is road transport, as shown in Table 32. Road transport is modelled to increase by 7% annually from 2015 to 2025 and by 6% from 2025 to 2050 which is the dominant cause for this trend, as is described in in the introduction. Civil aviation and water-borne navigation share a similar profile of growth, railways however have an abnormal profile in-line with descriptions of the activity in the rail network in Uganda yet make-up a very small proportion of activity.

Table 31 Total GHG emissions for transport by mode in baseline scenario

GHG emissions (Gg CO2e)	2003	2010	2019	2020	2030	2040	2050
Passenger							
Road	518	1671	3416	3700	6688	9400	13964
Aviation	136	212	331	350	539	774	1029
Rail	11.6	11.3	2.2	4.5	11.2	11.3	11.2
Waterborne	0.2	0.3	0.8	0.9	1.6	2.9	5.1
Freight							
Road	683	944	1349	1424	2291	3214	4676
Aviation	15	24	37	38	50	63	78
Rail	3.8	3.7	0.7	1.5	3.7	3.7	3.7
Waterborne	0.2	0.3	0.8	0.9	1.6	2.9	5.1

Table 32 Proportion of total GHG emissions by mode for transport in baseline scenario

Proportion of total GHG emissions	2003	2010	2019	2020	2030	2040	2050
Road	87.8%	91.2%	92.7%	92.8%	93.7%	93.6%	94.3%
Aviation	11.1%	8.2%	7.2%	7.0%	6.1%	6.2%	5.6%
Rail	1.1%	0.5%	0.1%	0.1%	0.2%	0.1%	0.1%
Waterborne	0.03%	0.02%	0.03%	0.03%	0.03%	0.04%	0.05%

Figure 19 Total GHG emissions for transport in baseline scenario

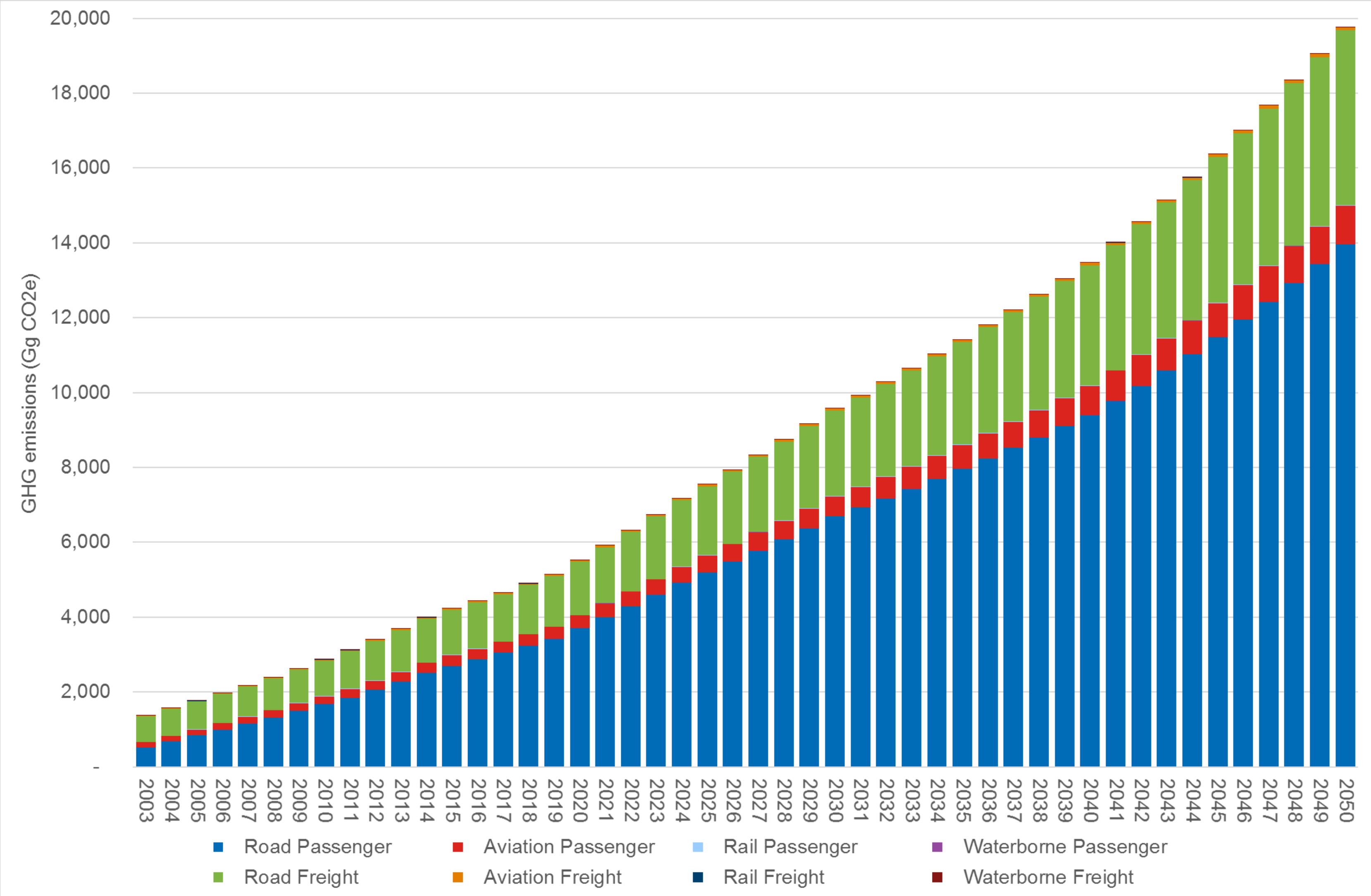
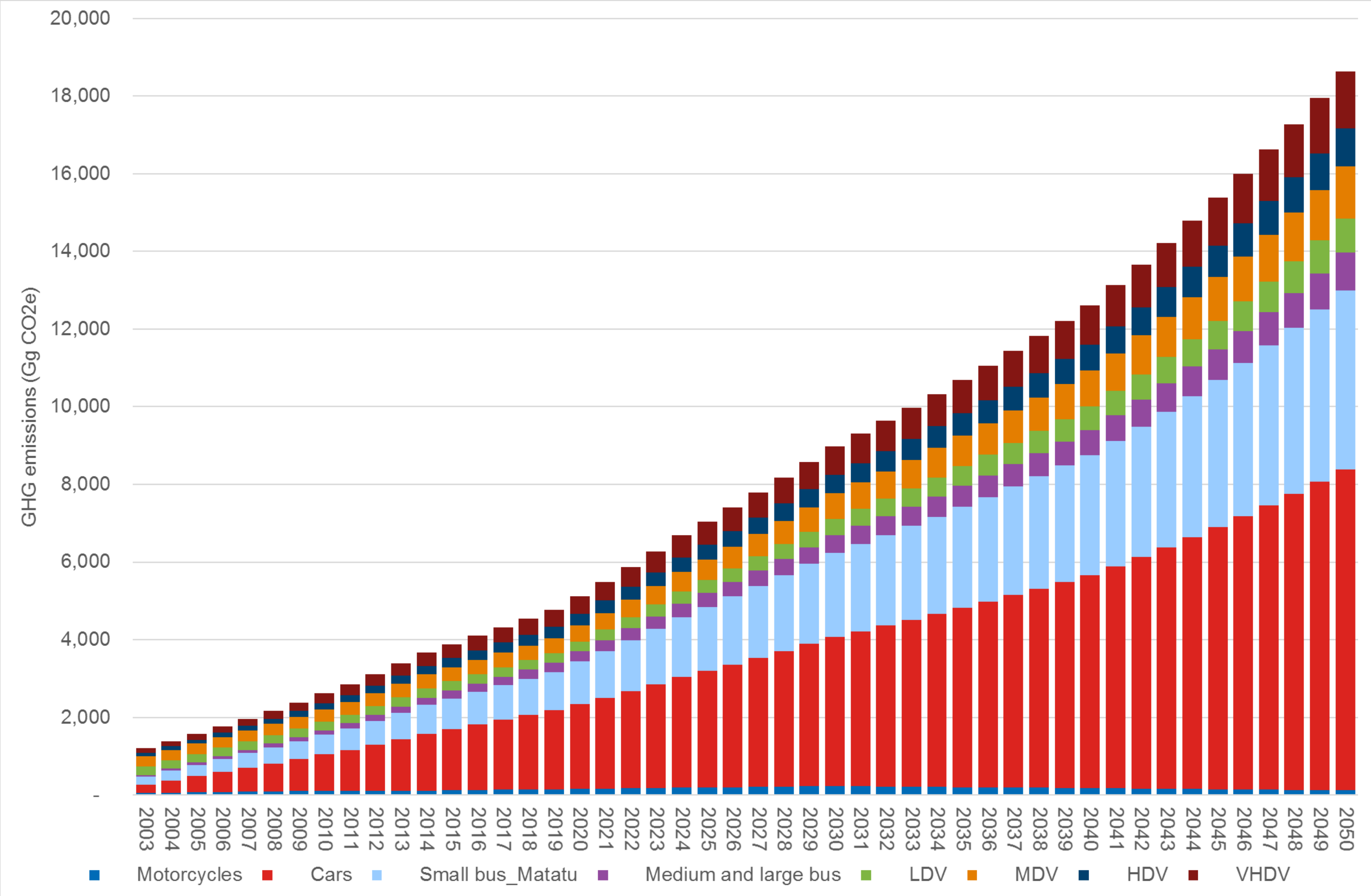


Figure 20 GHG emissions by mode for road transport in baseline scenario



3.3 Key uncertainties

Road transport

Modelling approach: Bottom-up (VKM)

All assumptions detailed in Section 3.1.1 above for this sub-sector are key uncertainties. However, there are some uncertainties that are particularly important to highlight.

As the modelling approach is bottom-up, the key uncertainty for the road transport sector is the split by mode that underlies the historic emissions and on which the growth assumptions going forward are based.

As already explained in Section 0, when validating the road transport numbers against the energy balance values and the 2015 NIR, there were significant differences in the fuel consumed when modelled from a top-down perspective and from a bottom-up perspective.

A disaggregated sub-sectoral breakdown of the 2015 NIR for transport would allow bottom-up values to be scaled to more closely match the energy balance and inventory. Ideally, as much disaggregation as possible will be required as the energy balance simply provides the total fuel consumed (e.g. petrol), which comes from the activity of several different vehicle types all of which are used with very different driving behaviour. Vehicle numbers are useful for disaggregated the total figures, but are not sufficient, as you could have equal numbers of two vehicle types (car and boda boda) yet one travels significantly further than the other. The validation of the VKM travelled by mode is therefore key.

It is also assumed that under the BAS, the fuel economy of the fleet will achieve the GFEI average stock targets with a 20-year lag time.

Rail

Modelling approach: Top-down (fuel consumption) validated with bottom-up (VKM)

The BAS for the rail transport sector assumes that the existing network is maintained and that roughly the same level of activity will be seen across the modelling period, following a return to normal following the recent sudden drop in ridership; the slight historic growth that was evident prior to the recent sudden drop will be maintained. This is a key assumption that must be validated.

The VKM for rail transport has been inferred from the fuel consumption data divided by the average fuel economy of the rail transport fleet in South Africa, assuming a lag time. It is assumed that this trend will continue going forward. Considering the impact that this has on the estimates of VKM, it would be useful to identify specific fuel economy values for the Ugandan rail fleet, or alternatively comprehensive PKM data for the Ugandan rail sector, and their expected change over time under the baseline.

4 Mitigation measures

This chapter will establish the data and assumptions used to inform the development of the mitigation scenarios.

4.1.1 Key policies and strategies

Uganda currently lacks an up to date, comprehensive, "approved" national transport policy which "is a disadvantage to the country in general and to Kampala District in particular, which accounts for over 50% of the vehicles in Uganda."[41]

However, several key policies form the general vision for the transport sector in Uganda:

- National Transport Master Plan 2008-2023[42]
- Uganda Vision 2040[43]
- Uganda's Third National Development Plan (NDPIII) 2020/21 – 2024/25[44]
- Uganda National Climate Change Policy[45]

The National Climate Change Policy neatly outlines the high-level general priorities for GHG reduction in the transport sector:

- Promote the development, approval and effective implementation of a long-term national transport policy and plan that will take GHG mitigation concerns into account.
- Effect a gradual shift to the use of less carbon-intensive fuels (including compressed natural gas, ethanol and LPG) in vehicles instead of relying heavily on gasoline and diesel fuels.
- Promote modes of transport that take into account GHG emission reduction.

It is around this framework that the mitigation modelling for this sector has been constructed. In addition, some more specific points that require attention in Uganda are:

- Mass transit in the city was reintroduced after an absence of more than 20 years. There is currently a very limited number of buses operating in urban centres.
- There is heavy dependence on roads for freight and cargo transport, which leads to fast deterioration of roads.
- Uganda once had 1,232 kilometres of rail network. At present, only 251 kilometres is operational, on the Kampala-Jinja-Malaba line.

[41] https://www.mwe.go.ug/sites/default/files/library/National%20Climate%20Change%20Policy%20April%202015%20final.pdf
[42] https://works.go.ug/wp-content/uploads/2015/08/National-Transport-Master-Plan-2008-2023.pdf
[43] https://www.greengrowthknowledge.org/sites/default/files/downloads/policy-database/UGANDA%29%20Vision%202040.pdf
[44] http://www.npa.go.ug/wp-content/uploads/2020/08/NDPIII-Finale_Compressed.pdf
[45] https://www.mwe.go.ug/sites/default/files/library/National%20Climate%20Change%20Policy%20April%202015%20final.pdf

4.1.2 Mitigation measure structure

As stated in section 1.2.4 and shown in Table 33, the mitigation options can be grouped by the effect that is modelled, as this facilitates the modelling.

Table 33 Measure structure in ASIF framework

Measure category	Measure description	Effect of measure	Modelled effect
A – Avoid	Avoiding journeys where possible	Reduction in total vehicle kilometres travelled (VKM)	Change to VKM
S – Shift	Modal shift to lower-carbon transport systems	Shift of VKM from higher to lower emission modes	
I – Improve	Improving the energy intensity of travel per passenger kilometre or tonne kilometre	Increase in the fuel economy (distance travelled per litre of fuel)	Change to energy intensity
F - Fuel	Reducing carbon intensity of fuel consumed	Reducing carbon intensity of fuels	Change to fuel type consumed

Following this structure, within this model, there are therefore four categories of measures modelled within this analysis:

Table 34 Overview of measure categories within the ASIF framework and modelled effects of measures

Measure category	ASIF	Modelled effect	Measures included	Comment
Fuel efficiency	Improve	Change to energy intensity	Road transport fuel efficiency Efficient operation of public transportation Efficient operation of freight through planning and best practice	The main measure modelled in this category is the road transport fuel efficiency measure. However, other measures are also included, as these are also relevant in improving fuel efficiency. For instance, the efficient operation of public transportation and freight will increase the load factor of the vehicles used and therefore improve the energy intensity.
Alternative fuels and electrification	Fuel	Change to fuel type consumed	Alternative fuel switch Electrification	There are two measures captured within this category: One is alternative fuel switch, directly switching from one fuel to another, lower carbon alternative. The other is electrification where a mode switches away from liquid fuels to electric power.
Passenger modal shift	Avoid + Shift	Change to VKM	Residential trip avoidance through town planning and transport orientated development (TOD) Development of GKMA-BRT system Redevelopment and extension/expansion of GKMA passenger service Development of the LRT system Development of metro infrastructure	There are two types of measure in this category, there are *avoid* measures: avoiding residential trips through town planning and TOD and then a series of *shift* measures: infrastructure measures resulting in modal shift to mass transit.
Freight modal shift	Avoid + Shift	Change to VKM	Development of the standard gauge railway system Rehabilitation of the Meter Gauge Railway System Bukasa Port Development	The main measure type here is infrastructure measures resulting in modal shift of freight from road to rail.

4.2 Fuel efficiency measures

This chapter provides an overview of the “fuel efficiency” measure category, explaining the measures within the category and the modelled effect captured in this modelling exercise. This measure category groups the impacts of measures that affect the fuel efficiency of transport as explained in Table 35.

Table 35 Fuel efficiency measures overview

Measure group	ASIF	Modelled effect		Measures included
Fuel efficiency	Intensity		Change to energy intensity	Road transport fuel efficiency Efficient operation of public transportation Efficient operation of freight through planning and best practice
Alternative fuels and electrification				
Passenger modal shift				
Freight modal shift				

4.2.1 Road transport fuel efficiency

Within Uganda there are very few explicit road transport fuel efficiency policies or measures. The most prominent is Uganda’s Vehicle Fuel Efficiency NAMA[46] outlines a bundle of possible activities which could be implemented independently:

- Development of a national database on vehicle fleet, fuel consumption and efficiency (set up to eventually include inspection data)
- Development of fuel efficiency policy and standards have benchmark/target consumption for light, medium and heavy duty vehicles being imported into the country
- Development of a regulation limiting the age of imported vehicles (compliance linked to pre-shipment inspection)
- Promotion of cleaner fuels and setting of fuel standards
- Design of a vehicle inspection and maintenance system, including certification programme, standards for inspections and establishment of vehicle inspection centres.
- Development of tax incentives to encourage acquisition of more fuel efficient vehicles
- Establishment of a financial incentives scheme for vehicle replacement
- Public information and awareness campaign

46 https://www4.unfccc.int/sites/PublicNAMA/_layouts/un/fccc/nama/NamaSeekingSupportForPreparation.aspx?ID=139&viewOnly=1

Assumptions in CDP scenario for this measure

As explained previously, the BAU assumes the Uganda vehicle fleet moves towards the GFEI 50by50 targets with a 20-year lag time due to the average age of the fleet. Whilst no interventions are currently explicitly planned, it is assumed, on the basis of the Vehicle Fuel Efficiency NAMA[47], that action is taken.

Hence, the Current Development Plans (CDP) scenario for this measure assumes a reduction in the average age of the vehicle fleet to 10-years and an achievement of the GFEI targets with only a 10-year lag time.

Table 36 Baseline fuel economy assumptions

Scenario	20% improvement	35% improvement	50% improvement
GFEI Targets	2020	2030	2050
Uganda CDP	2030	2040	2060

Assumption in WAM scenario for this measure

Building upon the CDP scenario, the With Additional Measures (WAM) scenario for this measure assumes the full achievement of the GFEI 50by50 targets (for 2030 and 2050) in-line with their outlined timeframe. This assumes additional measures to reduce the vehicle fleet average age, such as incentives and taxes to encourage the purchase of more efficient vehicles, and to improve the associated fuel economy, e.g. stricter fuel standards than those put in place under the CDP.

Table 37 Baseline fuel economy assumptions

Scenario	20% improvement	35% improvement	50% improvement
GFEI Targets	2020	2030	2050
Uganda WAM	N/A	2030	2050

4.2.2 Efficient operation of public transportation

Several proposed interventions are described in the Energy Efficiency Strategy of Uganda for 2010 – 2020, including the improved organisation of urban public transport leading to reduced congestion and increased efficiency in the service and a reduction in associated VKM and increase in load factor, increasing the utilisation of the mode.

This would be achieved through interventions such as: the introduction of fixed bus routes with defined frequency, the reorganisation of transport in urban centres, the introduction of traffic lights as much as possible and the introduction of fixed routes with defined frequency as well as working with the taxi industry to achieve service quality improvements and

47 https://www4.unfccc.int/sites/PublicNAMA/_layouts/un/fccc/nama/NamaSeekingSupportForPreparation.aspx?ID=139&viewOnly=1

operator consolidation. Introduce 1,000 high-quality city buses in Greater Kampala Metropolitan Area (GKMA) together with bus shelters, terminals, and depots.

Introduce ITS systems, automatic fare collection, and control centre for public transport in GKMA 2025.

Assumptions in CDP scenario for this measure

The CDP scenario for this measure assumes the associated interventions described above are implemented however as no quantified impact is provided, a default assumption of a 5% reduction in PKM is included (including an increase in the load factor and a decrease in the distance travelled).

Assumption in WAM scenario for this measure

The WAM scenario for this measure assumes increased interventions that would achieve an associated 10% reduction in PKM.

4.2.3 Efficient operation of freight through planning and best practice

No specific interventions are included in strategy documents or have been otherwise identified for this measure. However, this is an equivalent measure to the earlier one targeting public transport efficiency, only this measure addresses similar inefficiencies in urban freight transport.

Assumptions in CDP scenario for this measure

No existing policy is in place and therefore the CDP scenarios include no difference from the BAU for this measure.

Assumption in WAM scenario for this measure

The WAM scenario for this measure assumes an achievement of a 10% reduction in TKM (including an increase in the load factor and a decrease in the distance travelled) from improved efficiency in planning.

4.3 Alternative fuels and electrification

This measure category groups the impacts of measures that affect the use of alternative fuels as explained in Table 38.

Table 38 Alternative fuels measures overview

Measure group	ASIF	Modelled effect		Measures included
Fuel efficiency				
Alternative fuels & electrification	Fuel		Change to fuel type consumed	Alternative fuel switch
Passenger modal shift				
Freight modal shift				

4.3.1 Alternative fuel switch

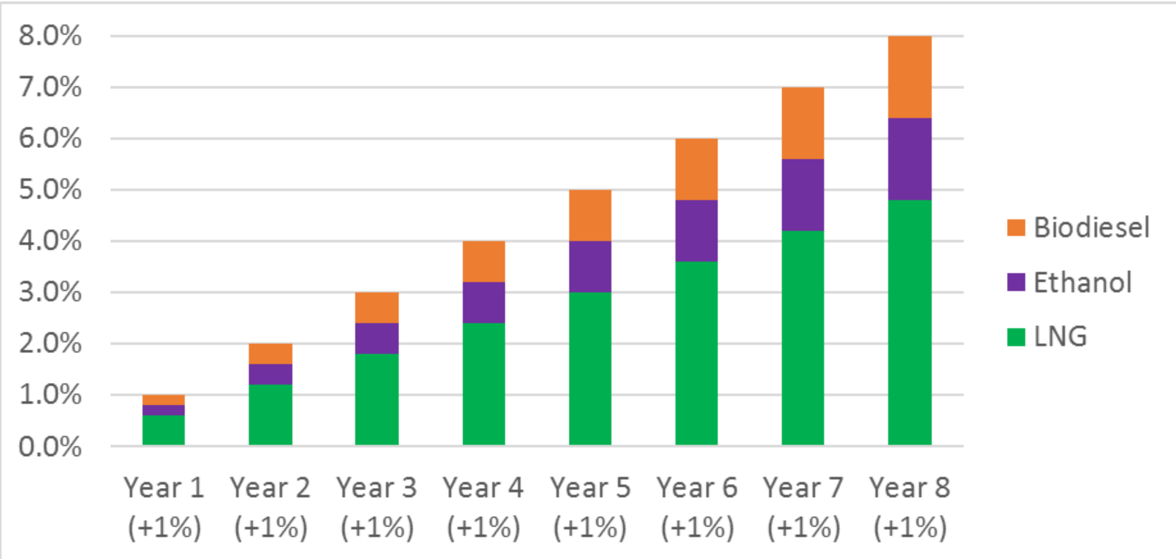
The Vehicle Fuel Efficiency NAMA[48] refers to the “promotion of cleaner fuels and setting of fuel standards,” however no specific interventions are currently planned. The Energy Efficiency Strategy of Uganda for 2010 – 2020 however describes specific aspirations on the use of alternative fuels (LNG and biodiesel), therefore this measure has been modelled separately to explore the effect of the increased use of these fuels. The strategy describes a possible aim of increasing the use of blended fuels by 1% per year. This is used as the basis for the measure here except that this goal is applied to other alternative fuels, i.e. both biofuels and LNG.

Assumptions in CDP scenario for this measure

As no specific interventions are currently planned, the indicative goals from the Energy Efficiency Strategy are used as the basis for this scenario. It assumes the increase of alternative fuels by 1% per year as stated in the Energy Efficiency Strategy, starting in 2021. This 1% increase is divided evenly between liquefied natural gas (LNG) 60%, ethanol (E10)[49] 20% and biodiesel 20%.

The profile of the introduction of these alternative fuels is demonstrated in Figure 21 and the profile of all fuels as alternative fuels are introduced is demonstrated in Figure 22.

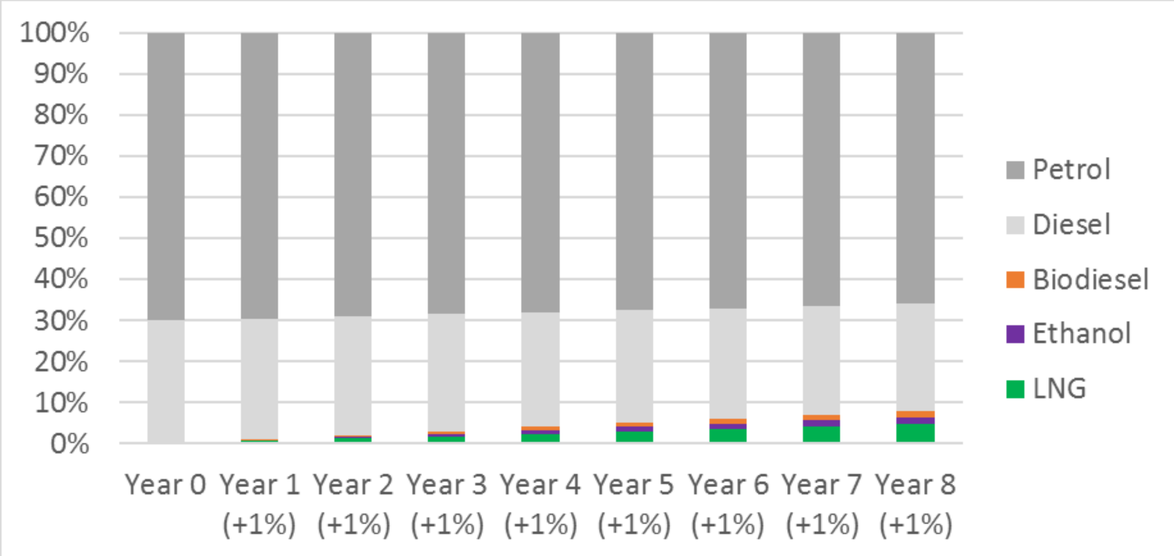
Figure 21 Profile of introduction of alternative fuels



48 https://www4.unfccc.int/sites/PublicNAMA/_layouts/un/fccc/nama/NamaSeekingSupportForPreparation.aspx?ID=139&viewOnly=1

49 E10 – a blend of 10% ethanol to 90% petrol - was used here for modelling simplicity. However, Uganda would probably introduce ethanol in smaller proportions initially, rather than going straight for E10, as has been done in the UK and the EU.

Figure 22 Profile of all fuels as alternative fuels are introduced



Currently, as all transportation fuels are imported,[50] the model does not account for emissions from LNG, ethanol and biodiesel production.

Assumption in WAM scenario for this measure

For LNG, ethanol and biodiesel consumption, the WAM scenario assumes an increase in ambition to a 2% annual increase.

4.3.2 Electrification

Electrification of road transport is an important yet challenging measure to consider in Uganda. Here the electrification of only certain road transportation modes has been considered as there is so much uncertainty surrounding the measure.

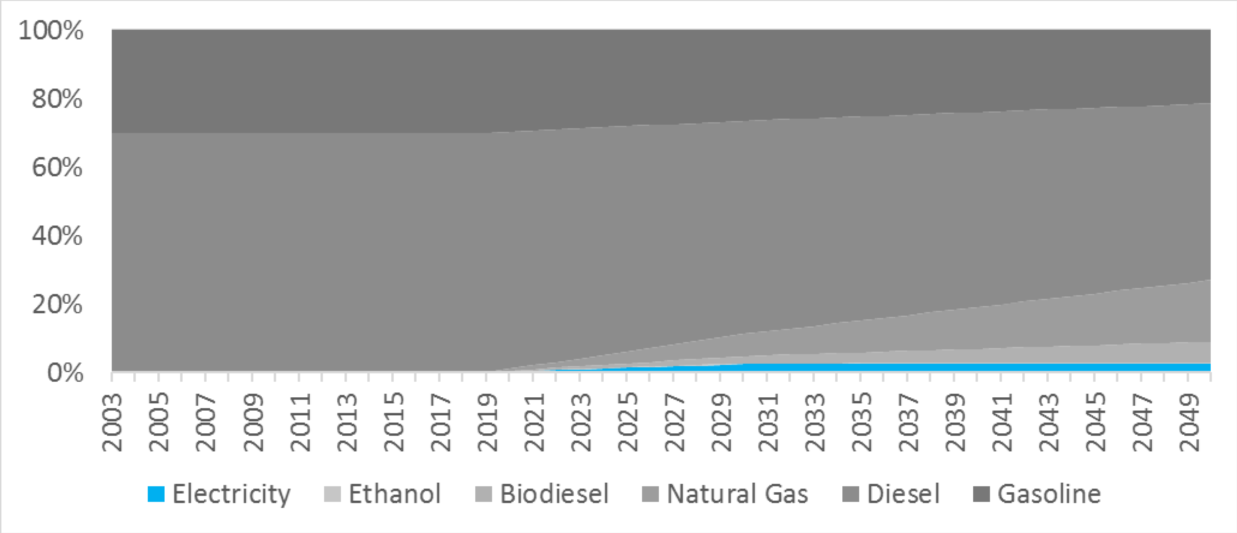
Assumptions in CDP scenario for this measure

The CDP scenario here is quite conservative, including only this planned pilot:

- Introduction of at least 200 e-buses in GKMA by 2030

[50] https://www.energyandminerals.go.ug/site/assets/files/1017/2015_statistical_abstract.pdf

Figure 23 Penetration of electricity for buses in CDP scenario



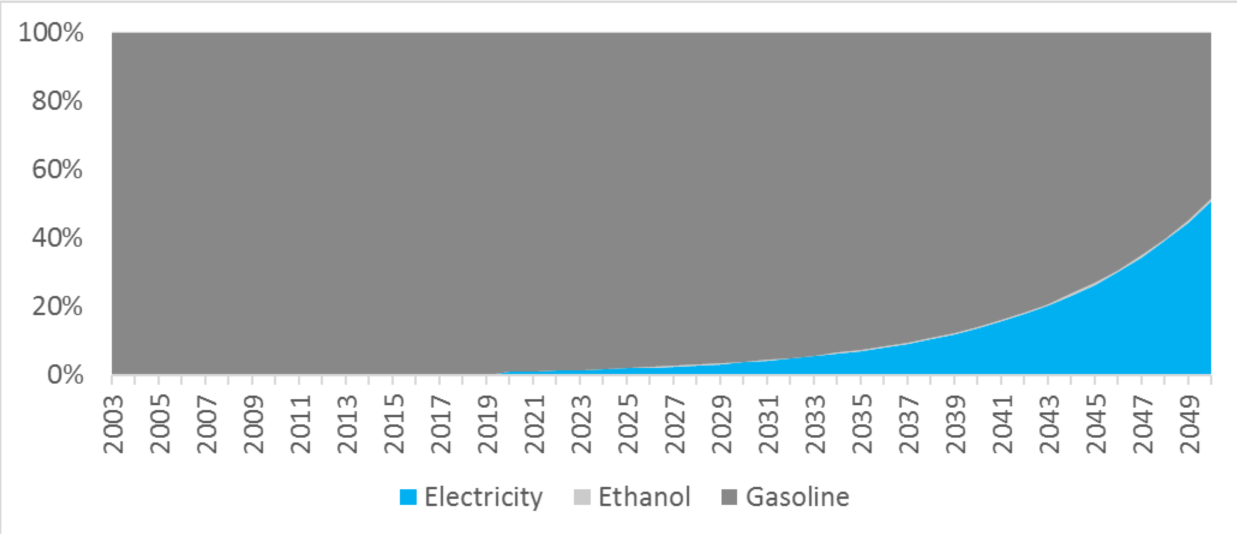
Assumption in WAM scenario for this measure

The WAM scenario includes far more significant penetration of electric vehicles as part of the motorcycle, passenger car and motorcycle modes.

Motorcycles

- Introduction of electric motorcycles (boda boda) from 2020 to achieve 50% total motorcycles electrified by 2050[51].

Figure 24 Penetration of electricity for motorcycles in WAM scenario

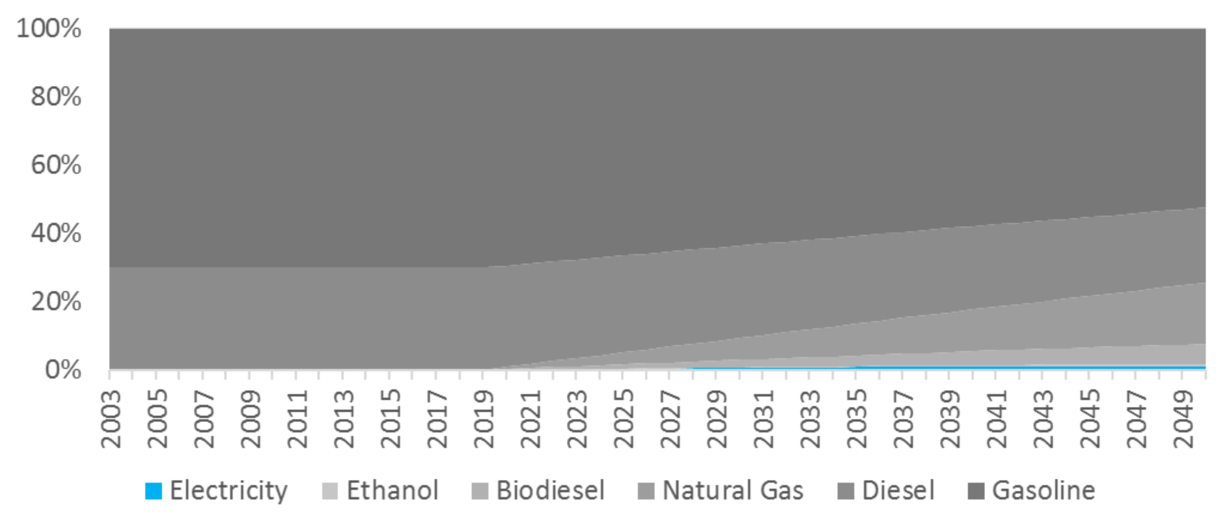


[51] Data collected as part of project. Unpublished.

Private cars

- Introduction of private electric cars from 2020 to achieve 1% total private cars electrified by 2040 as per the Africa Energy Outlook 2019[52].

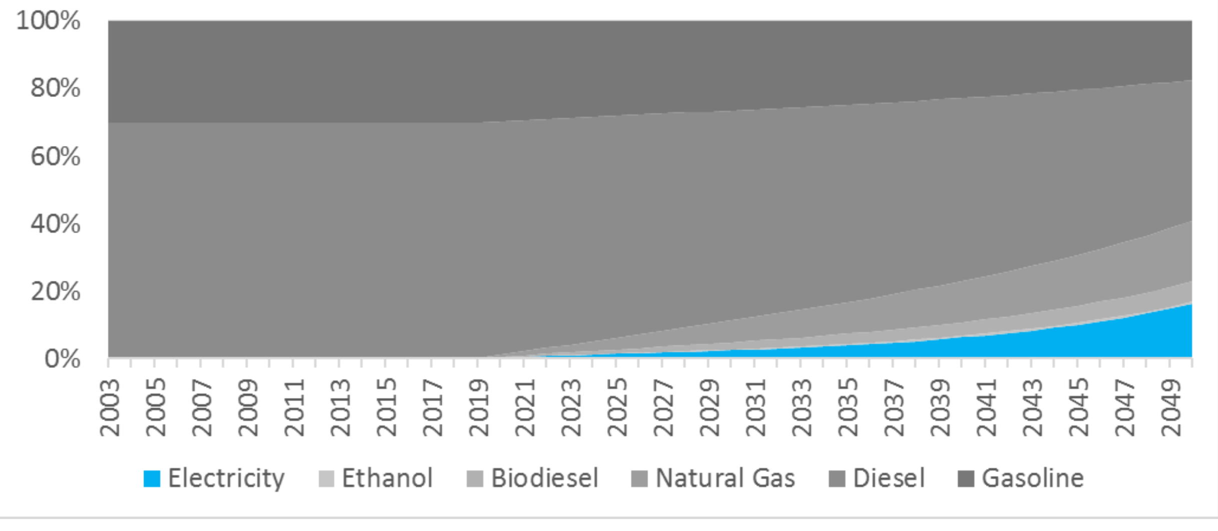
Figure 25 Penetration of electricity for passenger cars in WAM scenario



Buses

- Introduction of at least 200 e-buses in GKMA by 2030, as in the CDP scenario, and a subsequent 10% annual growth in e-buses in Uganda between 2030 and 2050[53].

Figure 26 Penetration of electricity for buses in WAM scenario



4.4 Passenger modal shift

This measure category groups the impacts of measures that result in the modal shift of passengers as explained in Table 39 on the following page.

[52] https://www.iea.org/reports/africa-energy-outlook-2019
[53] Transformative Urban Mobility Initiative (TUMI) E-bus Mission.

Table 39 Passenger modal shift measures overview

Measure group	ASIF	Modelled effect		Measures included
Fuel efficiency				
Alternative fuels and electrification				
Passenger modal shift	Avoid + Shift		Change to VKM	Development of GKMA-BRT system Redevelopment and extension/expansion of GKMA passenger service Development of the LRT system Development of metro infrastructure
Freight modal shift				

4.4.1 Modal shift to Non-Motorised Transport (NMT)

This measure uses the planned NMT corridors in the GKMA as well as in other urban areas across Uganda as its basis. However, as no data on the VKM avoided as a result of the installation of these corridors is available, assumptions must be made about related reduction of private car use.

The NMT corridors included are based on the planned implementation of NMT corridors across the country. The CDP scenario presents a realistic, as validated by the Government, implementation schedule for the plans articulated in Kampala's Multi-Modal Urban Transport Master Plan and the WAM scenario accounts for the full ambition of the plan. Additional assumptions about corridors implemented outside of Kampala are also included. Table 40 shows the full assumptions and calculations.

Assumptions in CDP scenario for this measure

100 km of complete streets or dedicated NMT corridors, constructed in greater Kampala area by 2030 leading to a shift in PKM by mode from other passenger modes.

Construction of 100 km of NMT facilities in secondary cities by 2030.

In addition, it is assumed that policies are introduced to manage the use of personal motor vehicles to reduce congestion and encourage a shift to public transport, walking, and cycling, including parking management and secure cycle parking.

Assumption in WAM scenario for this measure

407 km of complete streets or dedicated NMT corridors, constructed in greater Kampala area by 2030 leading to a shift in PKM by mode from other passenger modes.

Construction of 200 km of NMT facilities in secondary cities by 2030.

As with the CDP scenario, it is assumed that policies are introduced to manage the use of personal motor vehicles to reduce congestion and encourage a shift to public transport, walking, and cycling, including parking management and secure cycle parking.

Table 40 NMT modelling assumptions and calculations

ID	Category	Value	Unit	Source
A.	Uganda total roads	10,615	KM	*Source: http://ric.works.go.ug/rc/files/1.1_National_transport_master_plan.pdf*
B.	Uganda total paved roads	2,647	KM	*Source: http://ric.works.go.ug/rc/files/1.1_National_transport_master_plan.pdf*
C.	Kampala city council total roads	1,030	KM	*Source: https://openjicareport.jica.go.jp/pdf/12013025_01.pdf*
D.	Kampala city council paved roads	330	KM	*Source: https://openjicareport.jica.go.jp/pdf/12013025_01.pdf*
E.	Kampala proportion total roads	9.7%		*Calculated: C./A.*
F.	Kampala proportion paved roads	12.5%		*Calculated: B./D.*
G.	Kampala proportion Uganda	7%		*Source: This study*
H.	Total motorised transport trips	66,715	Mil PKM	*Source: This study*
I.	Total Kampala motorised transport trips	8,317	Mil PKM	*Calculated: H.*F.*
J.	Trips rearranged from motorised transport by NMT	11%		*Source: https://www.unil.ch/files/live/sites/ouvdd/files/shared/Colloque%202006/Communications/Mobilite/Theorie/R.%20Frick.pdf*

ID	Kampala project NMT	CDP	WAM	Unit	Source
K.	Total NMT corridors implemented	100	407	KM	*Source: Consultations with government*
L.	Project NMT proportion total KM	9.7%	39.5%		*Calculated: K./C.*
M.	Kampala project NMT proportion total Kampala roads	9%	28%		*Calculated: K./(C.+K.)*
N.	Kampala project NMT PKM	736	2,356	Mil PKM	*Calculated: I.*M.*
O.	Trips rearranged from motorised transport by NMT	77	247	Mil PKM	*Calculated: J.*N.*

ID	Kampala project NMT	CDP	WAM	Unit	Source
P.	Non-Kampala project PKM	100	200	KM	*Source: Consultations with government*
Q.	Non-Kampala project NMT proportion	9%	16%		*Calculated: P./(C.+P.)*
R.	Non-Kampala project NMT PKM	736	1,352	Mil PKM	*Calculated: I.*Q.*
S.	Trips rearranged from motorised transport by NMT	77	142	Mil PKM	*Calculated: J.*R.*

4.4.2 Residential trip avoidance through town planning and transport-oriented development

Uganda's Third National Development Plan (NDPIII) 2020/21 – 2024/25[54] articulates several infrastructure interventions including the development of transit-oriented developments along transport infrastructure corridors (such as roadside stations).

Assumptions in CDP scenario for this measure

- Develop land use and transport master plans incorporating transit-oriented land use and measures to incentivise well-located affordable housing along planned mass rapid transit lines.[55]
- Adoption of TOD friendly building control rules by 2025.

The impact of measures of this kind is incredibly difficult to model, therefore for the sake of this modelling exercise, an assumption has been made using an example from South Africa which used the assumption that TOD reduces motorised travel demand by 10% in 2050[56]. For the CDP scenario it is assumed that only 50% of this effect is realised and additional measures would be required to fully achieve this value, resulting in the achievement of a 5% increase in NMT and mass transit and a 5% decrease in private vehicles in the CDP scenario.

Assumption in WAM scenario for this measure

The WAM scenario for this measure assumes the necessary additional measures are implemented to achieve the full value provided in the example from South Africa, assuming that TOD reduces motorised travel demand by 10% in 2050[57], assuming additional measures were implemented beyond the CDP scenario.

4.4.3 Develop mass transit solutions to facilitate modal shift

Uganda's Third National Development Plan (NDPIII) 2020/21 – 2024/25[58] articulates several infrastructure interventions including the implementation of an integrated mass rapid transport system (including intercity rail, light rail transport (LRT), metro and bus rapid transit (BRT)). This measure takes planned infrastructure projects and models the projected increase in capacity to the associated modes. This increase is then offset in part by a reduction in the use of other modes (particularly private car use).

This will also be supported by policies introduced to manage the use of personal motor vehicles to reduce congestion and encourage a shift to public transport, walking, and cycling. Including parking management and secure cycle parking.

The infrastructure projects included in the modelling are set out in the following sections.

Development of GKMA-BRT system

The overall objective of the BRT is traffic decongestion in the city. BRT routes are designed to complement the proposed Metro network, providing similar services but with a higher

[54] http://extwprlegs1.fao.org/docs/pdf/uga199743.pdf
55 Kampala Capital City Authority (KCCA). (2018). Multi-Modal Urban Transport Master Plan for Greater Kampala Metropolitan Area (GKMA): Final Report. Section A-5.
[56] https://www.climate-transparency.org/wp-content/uploads/2020/08/CT-Low-Carbon-Transport-SA-DIGITAL.pdf
[57] https://www.climate-transparency.org/wp-content/uploads/2020/08/CT-Low-Carbon-Transport-SA-DIGITAL.pdf
[58] http://extwprlegs1.fao.org/docs/pdf/uga199743.pdf

frequency of stations thus providing higher accessibility. This measure assumes the implementation of 101km of BRT in GKMA by 2030, as set out in Table 41.

Table 41 GKMA-BRT system general assumptions[59]

BRT Line	Length (km)	Daily ridership	Daily PKM	Yearly PKM	Operational
BRT 1	22.2	462,418	10265680	3.75E+09	2030
BRT 2	38.5	170,735	6573298	2.4E+09	
BRT 3	19.9	291,258	5796034	2.12E+09	
BRT 4a	9.8	161,331	1581044	5.77E+08	
BRT 4b	10.6	234,602	2486781	9.08E+08	

Redevelopment and extension/expansion of GKMA railway passenger service

Project to develop high-capacity railway transit of passengers in Kampala to reduce traffic congestion in Kampala. This measure assumes the implementation of 61km of rail by 2030 as shown in Table 42

Table 42 GKMA passenger service general assumptions

Rail line	Length (km)	Annual PKM	Operation
Bujjuko-Mukono	53	2315585	2030
Kampala-Port	8	349522.3	2030

Fuel: It is assumed this measure is diesel powered based on the information available on the measure.[60]

Development of the LRT system

Project to develop light rail transit system in order to reduce travel time and increase rail modal share. This measure assumes the implementation of 100km of LRT in GKMA by 2036 as shown in Table 43.

Table 43 LRT system general assumptions

---

[59] Data collected as part of project. Unpublished.
[60] Data collected as part of project. Unpublished.

LRT line	Length (km)	Daily ridership	Daily PKM	Yearly PKM	Operational
LRT 4	21	421,353	8848413	3.23E+09	2031
LRT 5	24	453,015	10872360	3.97E+09	2035
LRT 7	54.9	415,603	22816605	8.33E+09	2040

Fuel: It is assumed this measure is electrically powered based on the information available on the measure.[61].

Development of metro infrastructure

This project aims to provide high capacity metro services along very congested axes of the city of Kampala. This measure assumes the implementation of 75km of Metro in GKMA by 2040 as shown in Table 44.

Table 44 Metro system general assumptions

Metro line	Length (km)	Daily ridership	Daily PKM	Yearly PKM	Operational
Metro 1	26	544,842	14165892	5.17E+09	2031
Metro 2	26	506,647	13172822	4.81E+09	2031
Metro 3	23	493,531	11351213	4.14E+09	2036

Fuel. It is assumed this measure is electrically powered based on the information available on the measure.[62]

Assumptions in CDP scenario for this measure

The CDP scenario for this measure assumes full implementation of the projects on the timelines outlined above. The computed yearly PKM data is used to scale fuel consumption data for rail to input into the model, while for bus travel the PKM data is inputted directly; associated emissions are then calculated.

It is assumed that 100% of the additional PKM comes from a modal shift from road transportation[63], i.e. the shift comes from motorcycles, private cars and matatus use proportionally and that these decrease in line with the projects' timelines.

Fuel: For the GKMA project, the fuel used is assumed to remain as diesel throughout the modelling period based on the information available on the measure.[64] Fuel economy is assumed to improve faster than in the baseline scenario, achieving the 2009 levels outlined in section 3.1.5 by 2040 as opposed to 2060 in the baseline scenario.

[61] Data collected as part of project. Unpublished.
[62] Data collected as part of project. Unpublished.
[63] This assumption was made in order to model the maximum impact of the measure, the effect can be scaled in proportion to alternative expected levels of modal shift.
[64] Data collected as part of project. Unpublished.

Bus fuel efficiency increases in-line with the road transport fuel efficiency measure.

The LRT and metro measures remain electrically powered throughout modelling period.

Assumption in WAM scenario for this measure

The WAM scenario for this measure assumes significant technological improvement in vehicle technologies or efficiencies for the rail fleet.

Fuel: For the GKMA project, the fuel is assumed to remain as diesel throughout the modelling period based on the information available on the measure.[65] Fuel economy is assumed to improve faster than in the baseline scenario, achieving the 2009 levels outlined in section 3.1.5 by 2030 as opposed to 2060 in the baseline scenario and achieving a 50% reduction on the baseline historic fuel economy by 2050.

Bus fuel efficiency increases in-line with the road transport fuel efficiency measure.

The LRT and metro measures remain electrically powered throughout modelling period.

4.5 Freight modal shift

This measure category groups the impacts of measures that result in the modal shift of freight as explained in Table 45.

Table 45 Freight modal shift measures overview

Measure group	ASIF	Modelled effect		Measures included
Fuel efficiency				
Alternative fuels and electrification				
Passenger modal shift				
Freight modal shift	Avoid + Shift		Change to VKM	Development of the standard gauge railway system Rehabilitation of the Meter Gauge Railway System Bukasa Port Development

4.5.1 Freight modal shift to rail

The expansion of rail services and the associated modal shift are key priorities for Uganda. Vision 2040[66] outlines that at least 80% of Uganda freight transport will be carried by rail.

However, under the current estimated project timelines, the projects will only be completed and enter into operation after 2040 meaning that the timelines in Vision 2040 are not compatible with the project timelines.

Uganda's Third National Development Plan (NDPIII) 2020/21 – 2024/25[67] also articulates the aim.

[65] Data collected as part of project. Unpublished.
[66] https://www.greengrowthknowledge.org/sites/default/files/downloads/policy-database/UGANDA%29%20Vision%202040.pdf
[67] http://extwprlegs1.fao.org/docs/pdf/uga199743.pdf

The infrastructure projects included in the modelling are:

Development of the standard gauge railway system

Table 46 Standard gauge railway general assumptions

Standard Gauge Railway	Length (km)	Annual TKM	Annual PKM	Operation
Eastern line	273	3.82E+07	1.04E+09	2040
Western line	377	5.26E+09	1.43E+09	2049
Southern line	430	2619	2.62E+09	*2052*[68]
Northern line	762	3.09E+10	2.89E+09	2044

Fuel: It is assumed this measure is electrically powered based on the information available on the measure.[69]

Rehabilitation of the Meter Gauge Railway System

Table 47 Metre gauge railway general assumptions

Metre Gauge Railway	Length (km)	Annual TKM	Operation
Northern Line (Tororo-Gulu)	342	451440	2024
Eastern Line (Kampala-Malaba)	292	385440	2026

Fuel: It is assumed this measure is diesel powered based on the information available on the measure.[70]

Assumptions in CDP scenario for this measure

The CDP scenario for this measure assumes the full implementation of the projects according to the timelines outlined above. The computed yearly TKM data is used to scale fuel consumption data for rail to input into the model, associated emissions are then calculated.

As no specific assumptions for the impact of the infrastructure projects on modal shift have been identified, some basic assumptions have been made to estimate the effect of this measure.

[68] It is estimated that the Southern Line will not be operational by 2050.
[69] Data collected as part of project. Unpublished.
[70] Data collected as part of project. Unpublished.

- It is assumed that 100% of the increased TKM from the infrastructure projects is achieved as a result of a modal shift[71]
- This increase in TKM is assumed will be achieved through a modal shift from all road freight vehicles.

Fuel: Fuel is assumed to remain as diesel for all rail projects throughout the modelling period based on the information available on the measure.[72] Fuel economy is assumed to improve faster than in the baseline scenario, achieving the 2009 levels outlined in section 3.1.5 by 2040 as opposed to 2060 in the baseline scenario.

Assumption in WAM scenario for this measure

The WAM scenario for this measure assumes the delivery of the standard gauge railway project 5 years ahead of current predictions as a reasonable acceleration of the project in order to achieve the goals of Vision 2040 sooner.

Standard Gauge Railway	Predicted Operation	WAM Operation
Eastern line	2040	2035
Western line	2049	2044
Southern line	2052	2047
Northern line	2044	2039

The WAM scenario for this measure also assumes significant technological improvement in vehicle technologies or efficiencies for the rail fleet.

Fuel: Fuel is assumed to remain as diesel throughout the modelling period for all rail projects based on the information available on the measure.[73]. Fuel economy is assumed to improve faster than in the baseline scenario, achieving the 2009 levels outlined in section 3.1.5 by 2030 as opposed to 2060 in the baseline scenario and achieving a 50% reduction on the baseline historic fuel economy by 2050.

No electrical power has been assumed at this point

4.5.2 Bukasa Port Development

This measure models the impact of the development of Bukasa Port into a trimodal port (ships, rail and road). This development will allow a modal shift of freight from road transport to rail and waterborne transport.

[71] This assumption was made in order to model the maximum impact of the measure, the effect can be scaled in proportion to alternative expected levels of modal shift.
[72] Data collected as part of project. Unpublished.
[73] Data collected as part of project. Unpublished.

Table 48 Phase 1 (2020-2030) Bukasa Port Development

Mode	Annual Trips – Low estimate[74]	High estimate	Midpoint	Proportion total TKM	Annual TKM[75]
Ships	800	1600	1200	6.72%	6.34E+06
Rail cars	13000	15000	14000	1.88%	1.77E+06
Road trucks	89000	127000	108000	91.40%	8.62E+07

Table 49 Phase 2 (2030-2040) Bukasa Port Development

Mode	Annual Trips – Low estimate	High estimate	Midpoint	Proportion total TKM	Annual TKM
Ships	2000	2600	2300	6.61%	1.21E+07
Rail cars	19000	20000	19500	1.34%	2.46E+06
Road trucks	210000	214000	212000	92.05%	1.69E+08

Table 50 Phase 3 (2040-2050) Bukasa Port Development

Mode	Annual Trips – Low estimate	High estimate	Midpoint	Proportion total TKM	Annual TKM
Ships	3500	4300	3900	6.43%	2.06E+07
Rail cars	23000	25000	24000	0.95%	3.03E+06
Road trucks	344000	400000	372000	92.63%	2.97E+08

Assumptions in CDP scenario for this measure

The CDP scenario for this measure assumes full implementation of the port development and the achievement of the associated annual TKM estimated and detailed above. The impact of the measure is a modal shift from road transport towards rail and waterborne transport based on the proportions described in the tables above. The road transport associated with the port development is assumed to be included in the existing assumptions of growth in road freight and is therefore not additional whilst the additional waterborne and rail TKM are additional, representing an overall shift in proportion of total freight TKM away from road transport.

Assumption in WAM scenario for this measure

The port development is planned with no additional measures considered.

4.6 Measures not included currently

Below is a list of measures that are currently not included due to a lack of detail on the specifics of the measure, which means that in order to model them would mean having to make assumptions that would be too uncertain (see Table 51). With more detail, these could

[74] Data collected as part of project. Unpublished.
[75] Calculated using existing tonne KM travelled data for road and rail and fuel consumption for waterborne to scale trip data collected.

have been included in the CDP scenario, as Uganda has already expressed some level of plans to introduce these measures.

Table 51 Possible additional measures

Measure	Description	Data that would be required
Road improvement projects	Included in the assumed growth rates of the road transport sector and the improved fuel economy. Not included explicitly as a measure.	N/A
Oil pipeline	Plans for pipeline to transfer oil internally in Uganda, replacing road freight VKM.	Road freight VKM avoided, emissions associated with pipeline

5 Mitigation scenarios

5.1 Assumptions for the mitigation scenarios

The table below summarises the assumptions made for each transport measure for the two mitigation scenarios (as outlined in Section 4):

Table 52 Full list of measures modelled and key assumptions

Measure	BAU	CDP	WAM
Road transport fuel efficiency	Global Fuel Economy Initiative (GFEI) 50by50 targets,[76] improvement of fuel economy with 20 year time-lag: 2040: **20%** 2050: **-35%** 2070: **-50%**	Global Fuel Economy Initiative (GFEI) 50by50 targets, improvement of fuel economy with 10 year time-lag: 2030: **20%** 2040: **-35%** 2060: **-50%**	Global Fuel Economy Initiative (GFEI) 50by50 targets, improvement of fuel economy with no time-lag: 2030: **-35%** 2050: **-50%**
Alternative fuel switch	**Road:** Assumes no switching to alternative fuels (LNG, ethanol or LNG). All traditional fuels (petrol/gasoline and diesel).	**1% per year increase** in alternative fuel use for all road vehicles.[3] - 60% of the increase comes from natural gas. - 20% from ethanol (E10). - 20% from biodiesel. Introduction of at least 200 e-buses in GKMA by 2030.[77]	**2% per year increase** in alternative fuel use for all road vehicles.[3] - 60% of the increase comes from natural gas. - 20% from ethanol (E10). - 20% from biodiesel. Introduction of at least 200 e-buses in GKMA by 2030.[78]

[76] https://www.globalfueleconomy.org/media/46127/50by50-report-2009-lr.pdf
[77] Transformative Urban Mobility Initiative (TUMI) E-bus Mission.
[78] Transformative Urban Mobility Initiative (TUMI) E-bus Mission.

Development of NMT infrastructure	**Road:** Walking accounts for 46% of daily trips.[79] 2015 passenger KM (PKM) Motorised: 66,715 million Non-motorised: 78,318 million Total road PKM: 145,033 million	100 km of complete streets or dedicated NMT corridors, constructed in greater Kampala area by 2030 leading to 10% shift in PKM by mode from other passenger modes. Construct 100 km of NMT facilities in secondary cities by 2030. Policies introduced to manage the use of personal motor vehicles to reduce congestion and encourage a shift to public transport, walking, and cycling. Including parking management and secure cycle parking.	407 km of complete streets or dedicated NMT corridors, constructed in greater Kampala area by 2030 leading to shift in PKM by mode from other passenger modes. Construct 200 km of NMT facilities in secondary cities by 2030. Policies introduced to manage the use of personal motor vehicles to reduce congestion and encourage a shift to public transport, walking, and cycling. Including parking management and secure cycle parking.
Efficient operation of public transportation	Standard growth rate of PKM of 7% to 2025 and 6% to 2050. No change in load factor.	Work with the taxi industry to achieve service quality improvements and operator consolidation. Introduce 1,000 high-quality city buses in GKMA80 together with bus shelters, terminals, and depots.[81] Introduce ITS systems, automatic fare collection, and control centre for public transport in GKMA 2025.[82]	Work with the taxi industry to achieve service quality improvements and operator consolidation. Introduce 1,000 high-quality city buses in GKMA together with bus shelters, terminals, and depots. [83] Introduce ITS systems, automatic fare collection, and control centre for public transport in GKMA 2025.

[79] Kampala Capital City Authority (KCCA). (2018). Multi-Modal Urban Transport Master Plan for Greater Kampala Metropolitan Area (GKMA): Final Report. Section 2.3.
[80] Bus system planned by KCCA in collaboration with Metu Zhongtong.
[81] Kampala Capital City Authority (KCCA). (2018). Multi-Modal Urban Transport Master Plan for Greater Kampala Metropolitan Area (GKMA): Final Report. Section C-3.
[82] Kampala Capital City Authority (KCCA). (2018). Multi-Modal Urban Transport Master Plan for Greater Kampala Metropolitan Area (GKMA): Final Report. Section C-5.
[83] Kampala Capital City Authority (KCCA). (2018). Multi-Modal Urban Transport Master Plan for Greater Kampala Metropolitan Area (GKMA): Final Report. Section C-3.

		5% reduction in VKM and 5% increase in load factor from improved organisation of urban public transport.	10% reduction in VKM and 10% increase in load factor from improved organisation of urban public transport.
Efficient operation of freight through planning and best practice	Standard growth rate of VKM of 7% to 2025 and 6% to 2050 for road freight. No change in load factor.	N/A	**10% reduction*** in PKM of mode
Residential trip avoidance through town planning and transport orientated development	Standard growth rate of PKM of 7% to 2025 and 6% to 2050. No change in load factor.	Develop land use and transport master plans incorporating transit-oriented land use and measures to incentivise well-located affordable housing along planned mass rapid transit lines. Adopt TOD friendly building control rules by 2025. TOD reduces motorised travel demand by 5% in 2050.	Develop land use and transport master plans incorporating transit-oriented land use and measures to incentivise well-located affordable housing along planned mass rapid transit lines. Adopt TOD friendly building control rules by 2025. TOD reduces motorised travel demand by 10% in 2050[84]
BRT – Bus Rapid Transit	**Road:** Standard growth rate of PKM of 7% to 2025 and 6% to 2050. No change in load factor. Minimal policies to encourage mass transit uptake over private vehicles.	Implement 101 km of BRT in GKMA by 2030.[85] Policies introduced to manage the use of personal motor vehicles to reduce congestion and encourage a shift to public transport, walking, and cycling. Including parking management and secure cycle parking.	N/A
GKMA Passenger service	**Rail:** Historical growth rate continues across period. 12% fuel economy improvement of diesel locomotives achieved by 2030 relative to 2015.	Implement 61km of passenger MGR rail by 2030. 22% fuel economy improvement of diesel locomotives achieved by 2030 relative to 2015.	Fuel economy improvement of diesel locomotives achieved 10 years sooner.

[84] https://www.climate-transparency.org/wp-content/uploads/2020/08/CT-Low-Carbon-Transport-SA-DIGITAL.pdf
[85] Four corridors identified in the MMUTMP. Section 10.5.

	Minimal policies to encourage mass transit uptake over private vehicles.	Policies introduced to manage the use of personal motor vehicles to reduce congestion and encourage a shift to public transport, walking, and cycling. Including parking management and secure cycle parking.	
Metro	**Rail:** Historical growth rate continues across period. 12% fuel economy improvement of diesel locomotives achieved by 2030 relative to 2015. Minimal policies to encourage mass transit uptake over private vehicles.	Implement 75km of fully electrified passenger metro rail by 2040. Policies introduced to manage the use of personal motor vehicles to reduce congestion and encourage a shift to public transport, walking, and cycling. Including parking management and secure cycle parking.	N/A
LRT – Light Rail Transit	**Rail:** Historical growth rate continues across period. 12% fuel economy improvement of diesel locomotives achieved by 2030 relative to 2015. Minimal policies to encourage mass transit uptake over private vehicles.	Implement 100km of fully electrified passenger LRT rail by 2040. Policies introduced to manage the use of personal motor vehicles to reduce congestion and encourage a shift to public transport, walking, and cycling. Including parking management and secure cycle parking.	N/A
MGR – Meter Gauge Railway rehabilitation for freight transit	**Rail:** Historical growth rate continues across period. 12% fuel economy improvement of diesel locomotives achieved by 2030 relative to 2015.	Rehabilitation of 634km of meter gauge railway by 2026 to facilitate modal shift of freight from road to rail. 22% fuel economy improvement of diesel locomotives achieved by 2030 relative to 2015.	Fuel economy improvement of diesel locomotives achieved 10 years sooner. [86]

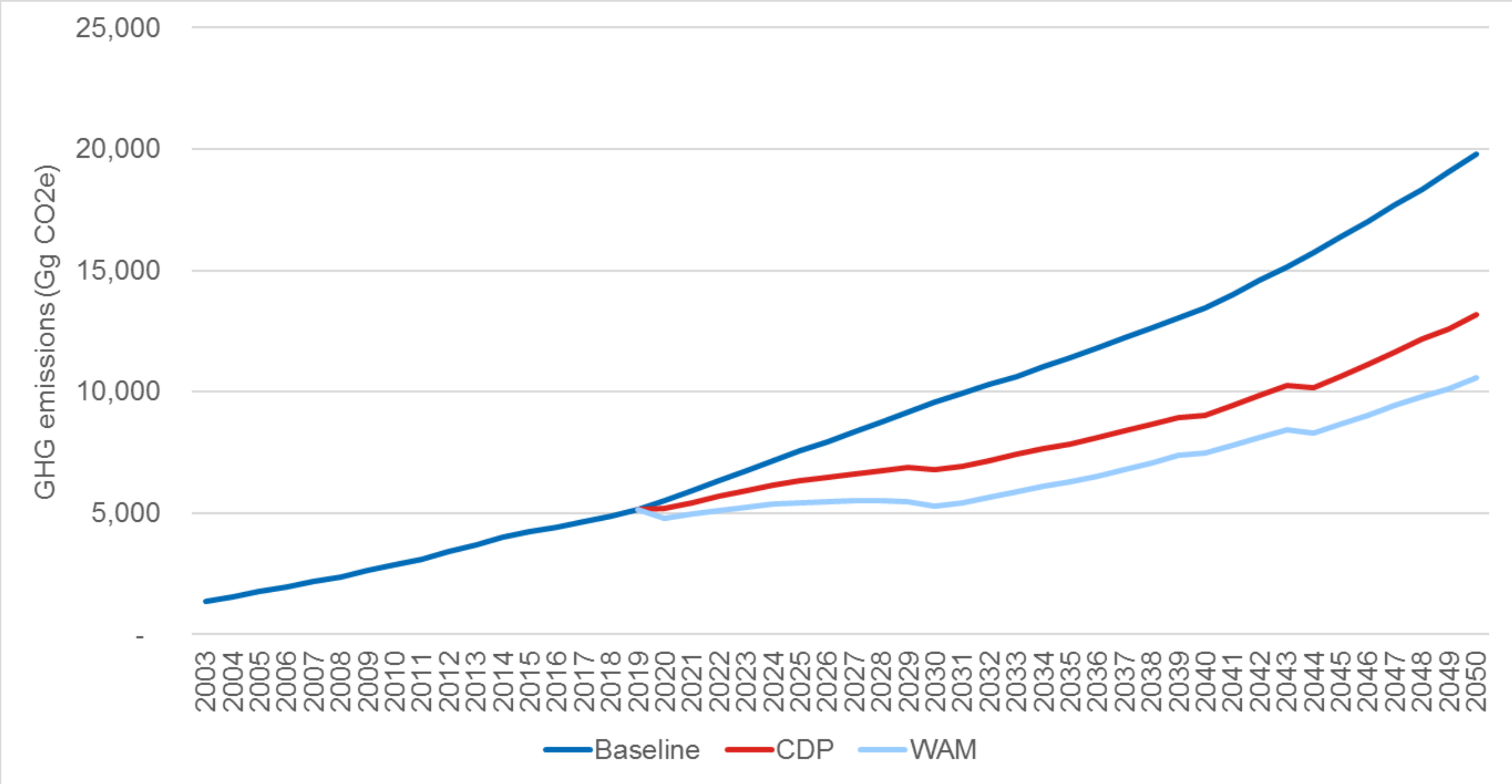
[86] Diesel traction assumed currently due to lack of data availability on electric vehicle energy consumption.

SGR – Standard Gauge Railway	**Rail:** Historical growth rate continues across period. 12% fuel economy improvement of diesel locomotives achieved by 2030 relative to 2015.	Implement 1412km of fully electrified standard gauge rail by 2050.	N/A
Bukasa Port Development	**Rail:** Historical growth rate continues across period **Waterborne**: Growth rate of 7% until 2025 and 6% until 2050 **Road:** Growth rate of 7% until 2025 and 6% until 2050 for VHDV.	Full implementation of Bukasa Port development, modal shift away from road to rail and waterborne of: 2030: 8.11 Mil TKM 2040: 14.61 Mil TKM 2050: 23.63 Mil TKM	N/A

5.2 Mitigation scenario GHG mitigation projections

Figure 27 presents the output of the mitigation potential analysis, the projections of GHG emissions up to 2050 across the three scenarios: baseline, CDP and WAM for all subsectors.

Figure 27 Total GHG emissions for transport in all scenarios



By 2050 in the CDP scenario, there is a 33% reduction in emissions against the baseline scenario in the transport sector, this rises to a 47% reduction in the WAM scenario, as shown in Table 53, Figure 28 and Figure 29. The sudden changes in the curves for the CDP and WAM scenarios result from the introduction of mass transit and rail infrastructure and the associated increase in rail and bus activity as well as the resulting decrease in road transport from the associated modal shift.

Table 53 Total GHG emissions by mode including avoided emissions

Scenario	2003	2010	2019	2020	2030	2040	2050
Baseline	1,368.2	2,865.7	5,137.6	5,519.6	9,585.5	13,471.1	19,771.3
CDP	1,368.2	2,865.7	5,137.6	5,186.2	6,812.6	9,019.1	13,174.7
CDP avoided vs baseline	-	-	-	*333.5*	*2,772.9*	*4,452.0*	*6,596.6*
% reduction vs baseline	-	-	-	6%	29%	33%	33%
WAM	1,368.2	2,865.7	5,137.6	4,772.8	5,300.0	7,467.3	10,568.3
WAM avoided vs baseline	-	-	-	*746.8*	*4,285.6*	*6,003.8*	*9,203.0*
% reduction vs baseline	-	-	-	14%	45%	45%	47%

Figure 28 Total GHG emissions by mode for transport in CDP scenario including avoided emissions

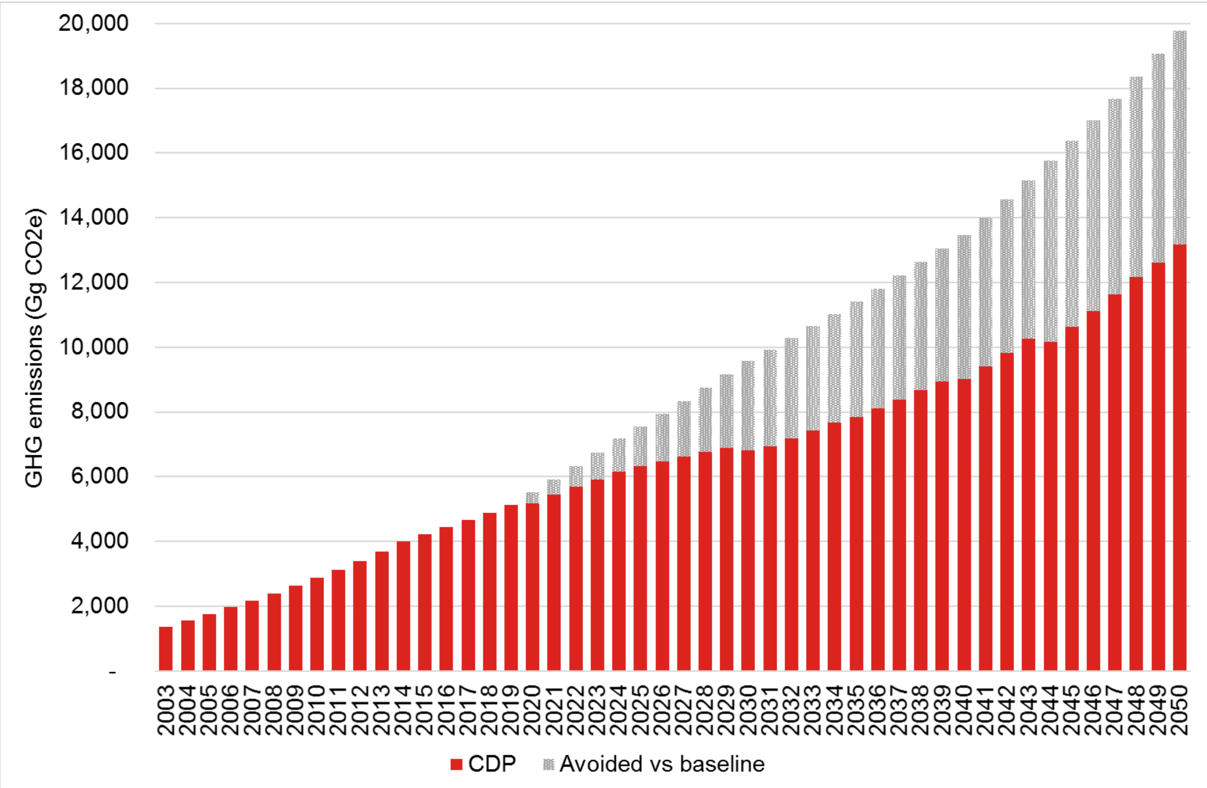


Figure 29 Total GHG emissions by mode for transport in WAM scenario including avoided emissions

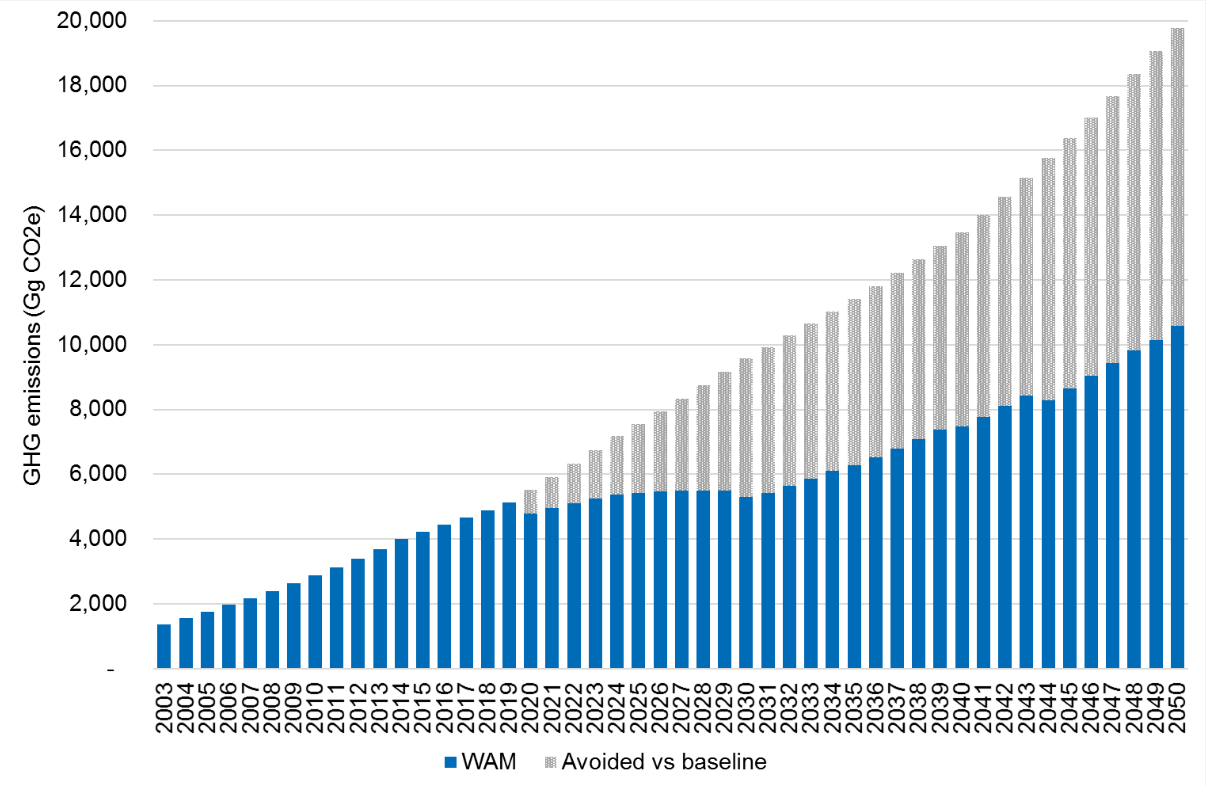


Table 54 and Table 55 present the emission reductions from each of the measures individually and also aggregated into a scenario for both of the mitigation scenarios, CDP and WAM.

Within the CDP scenario, by 2050 the most significant emissions reduction comes from the introduction of alternative fuels and electrification (16% reduction as shown in Table 54), followed by the fuel efficiency measure (11% reduction), then modal shift to mass public transit (9% reduction) and modal shift to freight (3%).

Within the WAM scenario, by 2050 the most significant emissions reduction comes from the fuel efficiency measure (21% reduction as shown in Table 55), followed by the introduction of alternative fuels and electrification (17% reduction), then modal shift to mass public transit (15% reduction) and modal shift to freight (8%).

Table 54 GHG emission reductions by measure in CDP scenario

GHG emissions (Gg CO2e)	2003	2010	2019	2020	2030	2040	2050
Baseline	1,368	2,866	5,138	5,520	9,586	13,471	19,771
CDP	1,368	2,866	5,138	5,186	6,813	9,019	13,175
Total scenario percentage reduction	**-**	**-**	**-**	**6%**	**29%**	**33%**	**33%**
Individual measure emissions reductions							
CDP Alternative fuels and electrification	-	-	-	-27	-537	-1,446	-3,171
% reduction vs baseline	-	-	-	0%	6%	11%	16%

CDP Freight modal shift	-	-	-	-0	2	6	-672
	-	-	-	0%	0%	0%	3%
CDP Fuel efficiency	-	-	-	-85	-1,860	-2,332	-2,137
	-	-	-	2%	19%	17%	11%
CDP Passenger modal shift	-	-	-	-288	-777	-1,481	-1,831
	-	-	-	5%	8%	11%	9%
Sum of measure percentage reduction[87]	**-**	**-**	**-**	**7%**	**33%**	**39%**	**40%**

Table 55 GHG emission reductions by measure in WAM scenario

GHG emissions (Gg CO2e)	2003	2010	2019	2020	2030	2040	2050
Baseline	1,368	2,866	5,138	5,520	9,586	13,471	19,771
WAM	1,368	2,866	5,138	4,773	5,300	7,467	10,568
Total scenario percentage reduction	**-**	**-**	**-**	**14%**	**45%**	**45%**	**47%**
Individual measure emissions reductions							
WAM Alternative fuels and electrification	-	-	-	-31	-568	-1,551	-3,447
% reduction vs baseline	-	-	-	1%	6%	12%	17%
WAM Freight modal shift	-	-	-	-271	-435	-605	-1,491
	-	-	-	5%	5%	4%	8%
WAM Fuel efficiency	-	-	-	-142	-3,110	-3,445	-4,225
	-	-	-	3%	32%	26%	21%
WAM Passenger modal shift	-	-	-	-552	-1,279	-2,175	-2,868
	-	-	-	10%	13%	16%	15%
Sum of measure percentage reduction	**-**	**-**	**-**	**18%**	**56%**	**58%**	**61%**

5.3 Key uncertainties

The mitigation measures that make the most significant contribution to the GHG reductions in the transport sector are those that focus directly on the road transport

[87] The sum of the individual measure percentage reductions does NOT equal the total scenario percentage reduction due to the way in which scenarios are inherited within LEAP, as explained in Chapter 1.2.2. Each measure in a scenario will alter the baseline for the next measure, therefore the aggregate scenario output will be different than the total sum of each measure.

sector, as this is where the vast majority of emissions come from in the sector. In particular, the key measures include:

- Road transport fuel efficiency
- Alternative fuel switch
- Transit Oriented Development (TOD)

The key uncertainties are therefore the assumptions underpinning these measures:

- Feasible fuel economy improvements
- Timeline
- Rate of penetration of alternative fuels
- Uganda specific assumptions about the impact of TOD and freight and public transport on transport activity (efficiency, distance travelled etc).

Whilst the measures listed above have the most significant impact on emissions, the infrastructure project-based modal shift measures are also key as they are critically important for Uganda's national and regional development and will come with very high costs. These measures are:

- Mass transit
- Modal shift to rail

Additional important uncertainties are therefore the assumptions that underpin these measures, in particular:

- Total expected capacity (passenger/freight)
- Assumed potential modal shift from other modes to rail/mass transit
- Fuel used for traction (diesel or electric)
- Energy intensity (fuel economy) of vehicles

Other uncertainties include the impact of NMT infrastructure on modal shift.

Conclusion

Successful policymaking is grounded on evidence-based decisions. Using the data compiled in this report and the mitigation scenario analysis conducted empowers decision makers to make such evidence-based and informed decisions.

This project funded by the German Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) aims to support the Government of Uganda (represented by CCD) in systematically assessing the country's GHG emissions from transport, analysing the sector's emission reduction potentials and optimising its contribution to the mitigation targets in the country's NDC.

This report illustrates the mitigation analysis of the transport sector that has been carried out, detailing the data that have been gathered, the projected future GHG emissions under a business-as-usual scenario, the options for mitigating these emissions and possible mitigation scenarios.

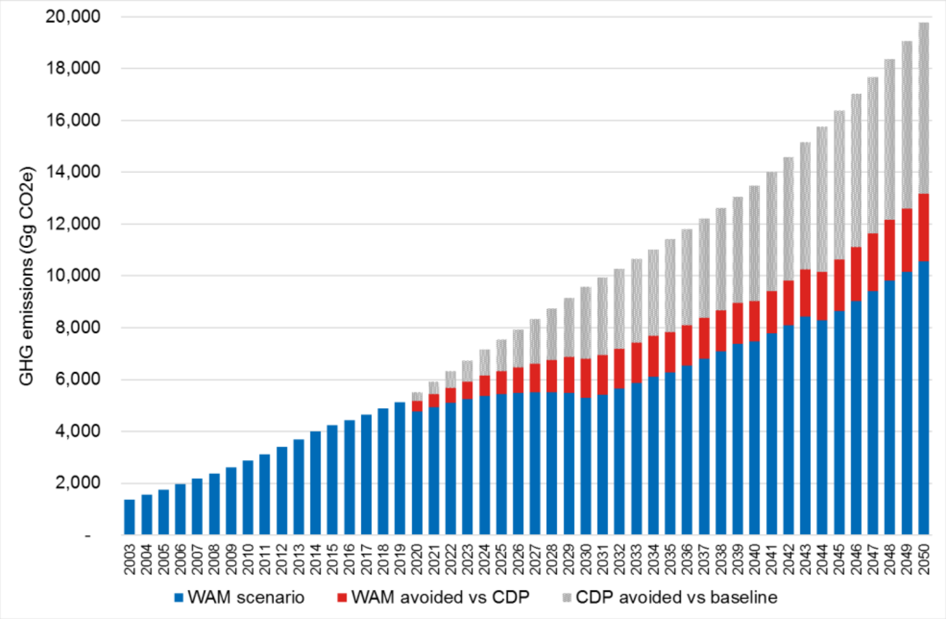
Three scenarios were developed: the business-as-usual scenario serves as baseline and demonstrates the emission growth in the transport sector when we assume that no measures intended to mitigate transport GHG emissions are being introduced in Uganda in the coming years until 2050.

The second scenario is the current development plan (CDP) scenario. It includes both current mitigation measures that have been introduced since 2015 as included in the baseline, and any further commitments, targets or policies that are already planned by the Ugandan government. The third scenario that was calculcated was a scenario with additional measures (WAM). "Additional" here means that the included measures go beyond the ones from the CDP scenario and/or the same measures are included but at a greater level of ambition, e.g., a modal shift of 100% for freight from road to rail as envisioned in *Uganda's Vision 2040* already achieved by 2035 in the WAM in comparison to the same modal shift of 100% achieved five years later by 2035 in the CDP scenario.

The underlying assumptions for the mitigation scenarios can be looked up in Chapter 5.1.

Figure 30 shows the development of GHG emissions from transport from 2003 until 2050 for all three scenarios.

Figure 30 Total GHG emissions by mode for transport in WAM scenario including avoided emissions



From the analysis, it becomes clear that the emissions savings potential for Uganda's transport sector is immense: according to the modelling exercises almost half of emissions of the business-as-usual scenario can be avoided when implementing the measures underlying the WAM scenario.

If only currently planned measures of the CDP scenario are being implemented a 33% reduction in emissions against the baseline scenario by 2050 could be possible.

Both scenarios offer significant potential for avoiding future GHG emissions in the transport sector of Uganda. The most impactful measures in terms of emissions would be the introduction of alternative fuels and electrification (16% reduction by 2050 within the CDP scenario, and 17% reduction by 2050 within the WAM scenario) as well as the implementation of the fuel efficiency measure (11% reduction by 2050 within the CDP scenario, and 21% reduction by 2050 within the WAM scenario).

Measures intending to shift from energy-intense consuming and polluting transport modes towards less-carbon intense modes lead to smaller reductions of GHG emissions than measures aimed at improving fuel and vehicle efficiency. However, shifting to mass public transit systems, for example, still leads to considerable reductions of 9% and 15% respectively for the CDP and WAM scenarios and brings about important additional benefits, such as less congestion, improved air quality, and consequently, increased public health.

Uncertainties in the data and assumptions are considerable and need to be taken into account when applying the findings from this report. Still, this report provides a great wealth of information on the Ugandan transport sector, even beyond the analysis of the emission reduction and avoidance potential for certain transport measures, that we are sure decision makers will put to good use.

Published by:
Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn, Germany
T +49 228 44 60-0 (Bonn)
T +49 61 96 79-0 (Eschborn)

Friedrich-Ebert-Allee 32+36
53113 Bonn, Germany
T +49 228 44 60-0
F +49 228 44 60-17 66

Dag-Hammarskjöld-Weg 1-5
65760 Eschborn, Germany
T +49 61 96 79-0
F +49 61 96 79-11 15

E info@giz.de
I www.giz.de
I www.transferproject.org

Authors
Dominic Sheldon, Ian Skinner (Ricardo Energy and Environment)
Nadja Taeger (GIZ)
Seith Mugume (MEIR Engineering)

Editor
Ritah Rukundo (GIZ)

Photo credits
Cover photo by Ninno JackJr on Unsplash

Printed and distributed by:
GIZ Project Advancing Transport Climate Strategies in Rapidly Motorising Countries
Kampala, Uganda on April 21, 2022