GIZ TraCS l Advancing Climate Strategies in Rapidly Motorising Countries

Updated Transport Data in Kenya 2018

An Overview
February 2019

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

of the Federal Republic of Germany

REPUBLIC OF KENYA

Ministry of Transport, Infrastructure, Housing and Urban Development
State Department of Transport

Project context

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 below 2 degrees Celsius.

Under the Advancing Transport Climate Strategies (TraCS) project in Kenya, the State Department for Transport and GIZ are cooperating to develop a sectoral climate change strategy and related transparency framework for the transport sector. In addition, the project closely coordinates with the Climate Change Directorate in the Ministry of Environment and Forestry to ensure coherence with the overarching framework of the Climate Change Act (2016).

For more information see: www.changing-transport.org/country/kenya/

TraCS is funded through the International Climate Initiative (IKI) of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

Disclaimer

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Table of Contents

Glossary

BEV	Battery-electric vehicle
BRT	Bus Rapid Transit
CO2e	CO2 equivalents
LCV	Light commercial vehicle
HGV	Heavy goods vehicle
GHG	Greenhouse gas
MC	Motorcycle
NCCAP	National Climate Change Action Plan (Kenya)
PC	Passenger car
PHEV	Plug-in hybrid electric vehicle
TTW	Tank-to-wheel (emissions from combustion or use of fuel in vehicle)
WTT	Well-to-tank (upstream emissions, e.g. from production and transportation of fuels)
WTW	Well-to-wheel (total emissions, sum of TTW and WTT)

1. Introduction

Under the framework of the Advancing Transport Climate Strategies project, the State Department for Transport in Kenya and GIZ have cooperated to set up a climate change unit, which is now in charge of reporting on transport emissions and climate change-related activities of the state department and its state agencies, who are also represented in the unit.

In order to improve the transport database in Kenya to facilitate more accurate greenhouse gas emissions accounting in the sector and the development of mitigation scenarios, GIZ contracted the INFRAS institute and the University of Nairobi to collect and analyse new data on Kenya's in-use vehicle fleet, average vehicle mileages and country-specific emission factors. In addition, the INFRAS institute reassessed the mitigation potential of four priority mitigation actions of the sector based on the newly collected data: Shift from road to rail, passenger vehicle efficiency, heavy goods vehicle efficiency, and electrification of buses, cars and motorcycles. The underlying data and the assumptions made in the mitigation scenarios are summarised in this document for easy access to the updated transport sector database. The detailed technical reports and supporting Excel files can be accessed online: www.changing-transport.org/publications/?_sft_country=kenya. These reports provide more background information to the data sets summarised here.

2. Overview of updated transport data

2.1. Age distributions and life expectancies

Survival probabilities and age distributions are based on Ogot et al. (2018).

Table 1: Average vehicle age per vehicle segment

Vehicle segment	Average vehicle age
PC petrol < 1.4L	13
PC petrol 1,4-<2L	11
PC petrol >=2L	9
PC diesel <1,4L	19
PC diesel 1,4-<2L	14
PC diesel >=2L	14
LCV (matatu) diesel N1-III	17
LCV (matatu) petrol N1-III	18
LCV (other) diesel M+N1-I	12
LCV (other) diesel N1-II	8
LCV (other) diesel N1-III	8
LCV (other) petrol M+N1-I	19
LCV (other) petrol N1-II	17
MC 4S <=150cc	3
MC 4S 151-250cc	4
MC 4S 251-750cc	1
MC 4S >750cc	2
Coach Midi <=15t	5
RigidTruck <7.5t	7
RigidTruck 7.5-12t	8

The median life expectancy describes the age at which half of the vehicle fleet is not in use anymore. Example: From the passenger car fleet of 2015 (baseline), half of the vehicles are out of service by 2029 (14 years later).

The following values were used in the baseline as well as in all the scenarios except for passenger vehicle efficiency:

Table 2: Median life expectancy per vehicle category (baseline, scenarios except for pass. veh. efficiency)

Vehicle category	Median life expectancy
Passenger car (PC)	14
Light commercial vehicles (LCV)	10
Buses	5
Heavy goods vehicles (HGV)	8
Motorcycles (MC)	9

The following values were used in the passenger vehicle efficiency scenario:

Table 3: Median life expectancy per vehicle category (scenario passenger vehicle efficiency)

Vehicle category	Median life expectancy
Passenger car (PC)	11
Light commercial vehicles (LCV)	7

2.2. Vehicle fleet

The vehicle fleet for the years 2015-16 is based on Ogot et al. (2018). Vehicle stock up to 2050 has been calculated using the HBEFA fleet model[1] based on projections of new registrations per vehicle category up to 2050 (by the University of Nairobi, in turn based on projected population growth) and survival probabilities by vehicle segment (from Ogot et al. 2018).

The following adjustment was made to the data obtained from Ogot et al. (2018):

- All buses were reassigned to the "Standard" size class (up to 18 t) instead of the "Midi Bus" (< 15t) size class. The authors know from their own observations in Kenya that most buses are of this size class. A quick internet web picture research confirmed this. A reason that the "Standard" size class was not registered by the study of Ogot et al. (2018) may be that the survey was based on traffic counting at "normal" public retail petrol stations, while the larger buses may use company outlets.
  Please note that this adaptation does not affect the vehicle stock numbers at vehicle category level shown in Table 4, but only segment (i.e. size class) shares.

[1] The Handbook Emission Factors for Road Transport (HBEFA) provides emission factors for all vehicle categories. With the expert version of HBEFA, the fleet of a country or region can be modelled (based on the current fleet, modelled with parameters such as age distribution and survival probability of the fleet). For further information, see http://www.hbefa.net/e/.

Table 4: Vehicle fleet in Kenya per vehicle category

Vehicle category	2015	2017
Passenger car (PC)	532,406	626,896
Light commercial vehicles (LCV)	119,230	142,922
Buses	57,792	75,202
Heavy goods vehicles (HGV)	10,041	13,070
Motorcycles (MC)	539,768	762,807

2.3. Emission factors

Tank-to-wheel emission factors

The basis for estimating tank-to-wheel (TTW) emission factors for road transport in Kenya is the Handbook of Emission Factors for Road Transport (HBEFA Version 3.3, see INFRAS (2017)). The CO_2 emission factors for Kenya in the year 2015 were estimated in a separate pilot study (INFRAS 2018). In brief, a country-specific fleet composition and distribution of traffic situations for Kenya were derived and applied to the HBEFA base energy/fuel consumption and GHG emission factors (see INFRAS 2018 for technical and methodological details). This is based on the assumption that the same vehicle type will have the same fuel consumption/GHG emissions in the same traffic situation regardless whether in Germany or Kenya.

The CO_2 emission factors from HBEFA are transformed into CO_2 equivalent (CO2e) emission factors by using the ratio between CO_2 and CO_2e from to the EN 16258 standard (EU methodology for calculation and declaration of energy consumption and GHG emissions of transport services, see CEN 2012). These ratios (CO_2e per CO_2) amount to 102.45% for petrol and 101.64% for diesel. Accordingly, the results of the analyses reflect total GHG emissions in CO_2 equivalents.

The following assumptions were made for the development of the emission factors up to 2050 in the baseline:

- Regarding fuel efficiency development: The yearly reduction in fuel consumption of newly registered conventional (non-electric vehicles) is as follows (range of values indicate that the reduction is not linear over time):
  - Light duty vehicles (PC and LCV): 1.2% reduction/a, based on optimization potentials of ICE engines and hybridization (SCCER Mobility 2017)
  - Heavy goods vehicles (HGV): 0.4 to 1.2% reduction/a of FC (based on ifeu and TUG 2015)
  - Buses and MC: no reduction (since no information is available and it is assumed that there will not be legislation for buses and MC similar as is already in force or planned for PC, LCV and HGV e.g. in the European Union)

Well-to-tank emission factors

Well-to-tank (WTT) emission factors of fossil fuels are calculated according to the EN 16258 stand-ard (CEN 2012) by using the ratio given between TTW and WTT emission factors by fuel type. The WTT emission factors amount to 19% of the TTW emission factors in the case of petrol and for 21% in the case of diesel.

Grid emission factors are used for WTT emissions of electric vehicles (i.e., BEV, PHEV, eScooters and electric powered trains). Two different versions of grid emission factors are used (scenario "Basic" and scenario "Alternative").

Emission factors used in the baseline and in the scenarios

This chapter presents the emission factors in gCO_2e/km as they were used for the calculation of the baseline and the mitigation scenarios.

The following tank-to-wheel emission factors were used for the baseline, as well as for the scenarios "shift road rail" (only for road transport) and "passenger vehicle efficiency":

Table 5: TTW emission factors per vehicle category (baseline; scenario shift road rail; scenario passenger vehicle efficiency) [g CO2e/km]

Vehicle category	2015	2017	2020	2030	2040	2050
Passenger car (PC)	189.6	181.1	170.0	137.9	120.5	107.1
Light commercial vehicles (LCV)	220.2	216.8	213.1	195.3	173.9	154.6
Matatus petrol (part of LCV)	*167.9*	*166.0*	*162.3*	*147.7*	*132.0*	*117.6*
Matatus diesel (part of LCV)	*150.7*	*149.8*	*148.1*	*136.4*	*121.7*	*108.3*
Buses	860.1	862.6	864.8	866.6	866.7	866.7
Heavy goods vehicles (HGV)	772.3	761.0	742.5	671.7	608.1	574.7
Motorcycles (MC)	70.1	70.1	69.1	64.2	62.9	62.6

The following emission factors were used for passenger rail transport in the scenario "shift road rail":

Table 6: Emission factors for rail passenger transport (scenario shift road to rail) [g CO2e/pkm]

Vehicle category	2015	2017	2020	2030	2040	2050
Diesel passenger train (WTT)	9.4	9.4	9.4	9.4	9.4	9.4
Diesel passenger train (TTW)	44.1	44.1	44.1	44.1	44.1	44.1
Electric passenger train (WTT); electricity scenario "Basic"	2.7	7.3	7.8	8.4	7.3	7.2
Electric passenger train (WTT); electricity scenario "Alternative"	1.8	2.9	0.4	3.1	3.4	3.4
Electric passenger train (TTW)	0.0	0.0	0.0	0.0	0.0	0.0

The following emission factors were used for freight rail transport in the scenario "shift road rail":

Table 7: Emission factors for rail freight transport (scenario shift road to rail) [g CO2e/tkm]

Vehicle category	2015	2017	2020	2030	2040	2050
Diesel freight train (WTT)	11.9	11.9	11.9	11.9	11.9	11.9
Diesel freight train (TTW)	55.6	55.6	55.6	55.6	55.6	55.6
Electric freight train (WTT); electricity scenario "Basic"	3.4	9.3	9.9	10.6	9.2	9.0
Electric freight train (WTT); electricity scenario "Alternative"	2.3	3.6	0.5	3.9	4.3	4.3
Electric freight train (TTW)	0.0	0.0	0.0	0.0	0.0	0.0

The following tank-to-wheel emission factors were used in the scenario "heavy goods vehicle (HGV) efficiency":

Table 8: TTW emission factors per vehicle category (scenario HGV efficiency) [g CO2e/km]

Vehicle category	2015	2017	2020	2030	2040	2050
Heavy goods vehicles (HGV)	708.7	695.7	674.6	597.8	539.1	481.6

The following tank-to-wheel emission factors were used in the scenario "electrification" for the electricity scenario "Basic":

Table 9: TTW emission factors per vehicle category (scenario electrification, electricity scenario „Basic") [g CO2e/km]

Vehicle category	2015	2017	2020	2030	2040	2050
Passenger car (PC)	189.6	181.1	170.0	134.9	109.3	89.4
Light commercial vehicles (LCV)	220.2	216.8	213.1	193.0	164.2	132.8
Matatus petrol (part of LCV)	*167.9*	*166.0*	*162.3*	*147.8*	*132.2*	*117.9*
Matatus diesel (part of LCV)	*150.7*	*149.8*	*148.1*	*136.5*	*121.9*	*108.6*
Buses	860.1	862.6	864.8	866.6	866.7	866.7
Heavy goods vehicles (HGV)	772.3	761.0	742.5	671.7	608.1	574.7
Motorcycles (MC)	70.1	70.0	68.7	43.7	34.0	31.5

The following tank-to-wheel emission factors were used in the scenario "electrification" for the electricity scenario "Alternative":

Table 10: TTW emission factors per vehicle category (scenario electrification, electricity scenario „Alternative") [g CO2e/km]

Vehicle category	2015	2017	2020	2030	2040	2050
Passenger car (PC)	189.6	181.1	170.0	134.9	109.3	89.4
Light commercial vehicles (LCV)	220.2	216.8	213.1	193.0	164.2	132.8
Matatus petrol (part of LCV)	*150.7*	*149.8*	*148.1*	*136.5*	*121.9*	*108.6*
Matatus diesel (part of LCV)	*860.1*	*862.6*	*864.8*	*866.6*	*866.7*	*866.7*
Buses	860.1	862.6	864.8	866.6	866.7	866.7
Heavy goods vehicles (HGV)	772.3	761.0	742.5	671.7	608.1	574.7
Motorcycles (MC)	70.1	70.0	68.7	43.7	34.0	31.5

The following well-to-tank emission factors were used in the scenario "electrification" for the electricity scenario "Basic":

Table 11: WTT emission factors per vehicle category (scenario electrification, electricity scenario „Basic") [g CO2e/km]

Vehicle category	2015	2017	2020	2030	2040	2050
Passenger car (PC)	36.1	34.5	32.4	28.7	32.0	37.3
Light commercial vehicles (LCV)	46.5	45.8	45.0	41.9	39.4	39.5
Matatus petrol (part of LCV)	*31.7*	*31.4*	*30.7*	*27.9*	*25.0*	*22.3*
Matatus diesel (part of LCV)	*32.2*	*32.0*	*31.6*	*29.1*	*26.0*	*23.2*
Buses	183.6	184.1	184.6	184.9	185.0	185.0
Heavy goods vehicles (HGV)	164.8	162.4	158.5	143.3	129.8	122.7
Motorcycles (MC)	13.2	13.2	13.0	8.8	7.1	6.6

The following well-to-tank emission factors were used in the scenario "electrification" for the electricity scenario "Alternative":

Table 12: WTT emission factors per vehicle category (scenario electrification, electricity scenario „Alternative") [g CO2e/km]

Vehicle category	2015	2017	2020	2030	2040	2050
Passenger car (PC)	36.1	34.5	32.4	26.8	26.0	26.5
Light commercial vehicles (LCV)	46.5	45.8	45.0	41.2	36.8	33.4
Matatus petrol (part of LCV)	*31.7*	*31.4*	*30.7*	*27.9*	*25.0*	*22.3*
Matatus diesel (part of LCV)	*32.2*	*32.0*	*31.6*	*29.1*	*26.0*	*23.2*
Buses	183.6	184.1	184.6	184.9	185.0	185.0
Heavy goods vehicles (HGV)	164.8	162.4	158.5	143.3	129.8	122.7
Motorcycles (MC)	13.2	13.2	13.0	8.4	6.7	6.3

2.4. Fuel/energy consumption

Fuel consumption data (and projections) were calculated in HBEFA Version 3.3 based on the fleet and activity data obtained from Ogot et al. (2018).

Note that fuel consumption values are not available for the HGV efficiency scenario. The reason is that for some of the emission reduction measures in the HGV efficiency scenario (e.g. road roughness and eco-driving), the reduction potential was directly applied to the CO_2e emission factors instead of to the fuel consumption. I.e., the reduction was defined as a relative reduction potential of the emissions per vehicle kilometre; for further details see Notter at al. (2018a). Accordingly, the reduction of fuel consumption in the scenario compared to the baseline is not known.

The following values were used in the baseline as well as in the scenarios "shift road rail" and "HGV efficiency":

Table 13: Fuel consumption per vehicle category (baseline; scenario shift road rail; HGV efficiency) [l/100km]

Vehicle category	2015	2017	2020	2030	2040	2050
Passenger car (PC)	9.2	8.8	8.2	6.7	5.8	5.2
Light commercial vehicles (LCV)	8.0	7.9	7.7	7.0	6.2	5.5
Matatus petrol (part of LCV)	*12.1*	*12.1*	*11.8*	*10.7*	*9.6*	*8.5*
Matatus diesel (part of LCV)	*9.3*	*9.2*	*9.0*	*8.3*	*7.4*	*6.5*
Buses	31.5	31.6	31.6	31.7	31.7	31.7
HGV	27.8	27.4	26.8	24.5	22.5	21.4
Motorcycles (MC)	4.4	4.4	4.3	4.2	4.1	4.1

The following values were used for rail passenger transport in the scenario “shift road rail”:

Table 14: Energy consumption for rail passenger transport (scenario shift road to rail) [MJ/pkm]

Vehicle category	2015	2017	2020	2030	2040	2050
Diesel passenger train	0.220	0.220	0.220	0.220	0.220	0.220
Electric passenger train	0.082	0.082	0.082	0.082	0.082	0.082

The following values were used for rail freight transport in the scenario “shift road rail”:

Table 15: Energy consumption for rail freight transport (scenario shift road to rail) [MJ/tkm]

Vehicle category	2015	2017	2020	2030	2040	2050
Diesel freight train	0.150	0.150	0.150	0.150	0.150	0.150
Electric freight train	0.055	0.055	0.055	0.055	0.055	0.055

The following values were used in the scenario “passenger vehicle efficiency”:

Table 16: Fuel consumption per vehicle category (scenario passenger vehicle efficiency) [l/100 km]

Vehicle category	2015	2017	2020	2030	2040	2050
Passenger car (PC)	9.2	8.7	7.9	6.4	5.6	5.0
Light commercial vehicles (LCV)	8.0	7.9	7.6	6.9	6.1	5.5
Matatus petrol (part of LCV)	*12.1*	*12.0*	*11.7*	*10.6*	*9.5*	*8.4*
Matatus diesel (part of LCV)	*9.3*	*9.2*	*9.0*	*8.2*	*7.3*	*6.5*
Buses	31.5	31.6	31.6	31.7	31.7	31.7
Motorcycles (MC)	4.4	4.4	4.3	4.2	4.1	4.1

The following values were used in the scenario “electrification”. The values are in MJ/km, since they include electric vehicles (BEV and PHEV in the category passenger cars, BEV in the category light commercial vehicles, and e-Scooters).

Table 17: Energy consumption per vehicle category (scenario electrification) [MJ/km]

Vehicle category	2015	2017	2020	2030	2040	2050
Passenger car (PC)	2.7	2.5	2.4	1.9	1.7	1.5
Light commercial vehicles (LCV)	2.9	2.9	2.8	2.6	2.2	1.9
Matatus petrol (part of LCV)	*4.0*	*4.0*	*3.9*	*3.5*	*3.1*	*2.8*
Matatus diesel (part of LCV)	*3.4*	*3.3*	*3.3*	*3.0*	*2.7*	*2.4*
Buses	11.4	11.5	11.5	11.5	11.5	11.5
HGV	10.3	10.1	9.9	8.9	8.1	7.6
Motorcycles (MC)	1.0	1.0	1.0	0.6	0.5	0.5

2.5. Mileage

Specific mileage is based on Ogot et al. (2018). Ogot et al. (2018) conducted a survey at the end of 2017. They then used the collected data on kilometres driven by vehicles (odometer readings and vehicle age) to compute average mileages per vehicle category.

The following adjustment was made to the data obtained from Ogot et al. (2018):

- 20% of the total vehicle kilometres of trucks were reassigned to the size class 34-40 t. In the survey by Ogot et al. (2018), this size class did not occur. However, according to the JKUAT study (Abiero et al. 2015), this is the most frequent size class on the international freight corridors like Mombasa–Nairobi–Malaba or Nairobi–Namanga. A quick web research revealed images from weighbridges and border crossings in Kenya that confirmed this finding. A possible reason that this size class was not registered by the study of Ogot et al. (2018) may be that the survey was conducted at public retail petrol stations, while large trucks may use company outlets.

The following vehicle kilometre data was used for the baseline as well as for the scenarios “passenger vehicle efficiency”, “HGV efficiency”, and “electrification”:

Table 18: Specific mileage per vehicle category (baseline; scenario passenger vehicle efficiency; HGV efficiency; electrification) [vehicle km/vehicle and year]

Vehicle category	2015	2017	2020	2030	2040	2050
Passenger car (PC)	22,223	22,223	22,223	22,223	22,223	22,223
Light commercial vehicles (LCV)	29,862	29,900	29,936	29,907	29,880	29,875
Matatus petrol (part of LCV)	*19,536*	*19,491*	*19,433*	*19,484*	*19,526*	*19,513*
Matatus diesel (part of LCV)	*45,713*	*45,610*	*45,474*	*45,592*	*45,690*	*45,710*
Buses	43,815	43,815	43,815	43,815	43,815	43,815
Heavy goods vehicles (HGV)	63,205	63,205	63,205	63,205	63,205	63,205
Motorcycles (MC)	17,807	17,807	17,807	17,807	17,807	17,807

The following data shows total vehicle kilometres per year for the scenario “shift road rail” (based on specific mileages and number of vehicles)

Table 19: Total mileage per vehicle category (scenario shift road rail) [1000 vehicle km/ year]

Vehicle category	2015	2017	2020	2030	2040	2050
Passenger car (PC)	454,688	462,126	473,283	577,598	672,839	759,005
Buses	284,554	289,203	296,176	361,449	421,040	474,949
Diesel passenger trains	-	-	1,383	1,945	2,354	2,486
Electric passenger trains	-	-	-	389	1,177	2,486
Heavy goods vehicles (HGV)	1,147,653	1,212,513	1,309,802	1,970,754	3,039,233	4,107,713
Diesel freight trains	-	-	3,455	6,033	4,826	3,620
Electric freight trains	-	-	-	1,207	2,413	3,620

2.6. Motorisation rate

The projected increase of the motorization rate in Kenya is based on the in-use vehicle fleet from 2015 and the relative increase of inhabitants (total inhabitants of Kenya). The data and projection of inhabitants stem from the United Nations (United Nations 2015).

Table 20: Motorisation rate in the baseline

	2015	2020	2030	2040	2050
Passenger car (PC) stock [-]	532,406	745,304	1,297,828	2,101,272	3,142,422
Inhabitants [in 1000]	46,050	53,115	67,245	81,375	95,505
Motorisation rate [PC per 1000 inhabitants]	11.56	14.03	19.30	25.82	32.90

2.7. Modal split (scenario “shift road rail”)

The modal split shows the percentage share of rail transport compared to total transport (rail and road). For passenger transport, the modal split is based on passenger kilometres travelled, for freight transport on tonne kilometres.

Note that the capacity of freight transported on railways is expected to remain constant after 2025. Total demand for freight transport, in contrast, is expected to continue it’s increase. As a result, the share of freight transport on rail declines from 2030 on.

Table 21: Modal split in the scenario "shift road rail" (based on pkm and tkm)

	2015	2020	2030	2040	2050
Share of passenger rail [%]	0%	10%	13%	16%	20%
Share of freight rail [%]	0%	22%	28%	20%	16%

List of tables

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Local court (Amtsgericht) Bonn, Germany: HRB 18384
Local court (Amtsgericht) Frankfurt am Main, Germany: HRB 12394

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Management Board

Tanja Gönner (Chair of the Management Board)
Dr Christoph Beier (Vice-Chair of the Management Board)