XLM-TRANSPORT TOOLKIT

User Manual

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Ministry of Social Security, National Solidarity, and Environment and Sustainable Development
(Environment and Sustainable Development Division)
Republic of Mauritius

XL-Mitigation Transport Toolkit User Reference

About this manual

This manual, *XL-Mitigation Transport User Reference*, forms part of a family of toolkits to compute and plot a number of other variables including GHG emissions for Transport sector. The user reference has been written from an application developer's perspective. A fundamental conceptual and operational knowledge of Excel is assumed.

Disclaimer

Data used has been obtained from reliable sources. The Ministry of Social Security, National Solidarity, and Environment and Sustainable Development (Environment and Sustainable Development Division) assumes no responsibility for errors and omissions in the data provided. Users are, however, kindly asked to report any errors or deficiencies in this product to the Ministry. The choices of calculation made in this tool are derived from TNC Report (2016).

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XLM-Transport Toolkit

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XLM-Transport Toolkit

1.0 Introduction

This document refers to a user-friendly toolkit developed to mitigate the Energy: Transport sector of the Republic of Mauritius.

The mitigation for Transport sector was assessed in the Third National Communications (TNC) Report (2016) for a Business-as-Usual (BAU) and 4 other scenarios, after a screening exercise to select the most feasible options. Thus, the first scenario, after the BAU, considered that improvement in the fuel intensity of vehicles. The second scenario consider an improvement in the vehicle inspection as a result of introduction of sophisticated technologies by private vehicle inspection centres. The third scenario entails low-carbon options through the increase of hybrid and electric vehicles and ethanol substitution for gasoline. The last scenario considers substitution of vehicles by a mass transit light rail system.

The XLM-Transport Toolkit performs basic calculations guided by the TNC (2016) with the parameters and assumptions used therein for computing the Greenhouse Gas (GHG) emissions resulting from this sector till 2050. Users of this user-friendly XLM-Transport Toolkit can adjust the scenarios by choosing appropriate parameters/assumptions to suit their needs of the mitigation analysis.

2.0 Overview of the Transport sector

Road transportation, the only mode of land transport in Mauritius, caters for both the passenger and freight transport needs. Mauritius plans to introduce a mass transit system by 2019. Since Mauritius is an important tourist destination, international flights connect the islands of the Republic. In 2013, over 10,300 flights were recorded of which 8,100 were international and 2,200 were domestic. Mauritius also has one port from which domestic and international shipping is operated both for cruise, fishing and freight purposes.

As per the TNC findings, the XLM-Transport Toolkit considers land transportation only.

Facts (2015): Transport sector (TNC Report, 2016)

Mauritius	Rodrigues
Road length: 2275 km • Motorway length: 99 km • Main roads – total length: 1131 km Fleet of Vehicles: 486,144 (5.2% av. growth rate; 9.3% for private motor cars, 11.7% for motorcycles) Motorization rates: 385 vehicles per thousand people	Fleet of vehicles: 11,937 (8.7% av. growth rate)

3.0 GHG Emissions from the Transport sector

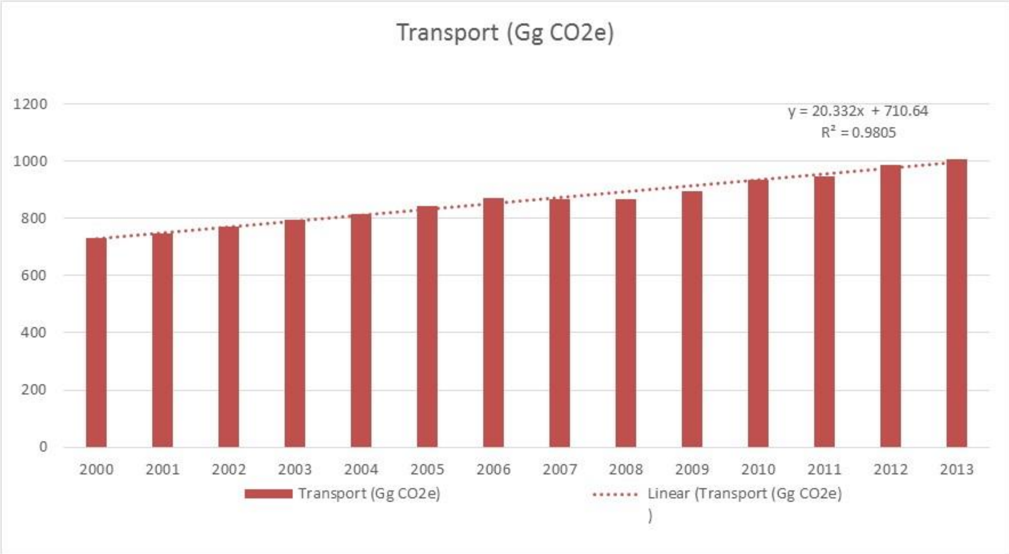

Figure 3.1: Trend of emissions for the energy transport sector (p30 TNC for values)

The transport sector is the second biggest emitter (19.7%) in Mauritius.
Figure 3.1 shows the trend for the Transport sector (which includes land, sea and air transportation). The emission of this sector stands around 1,007.4 Gg CO2e in 2013. Increase at a linear rate of 20.3 Gg in the emission in the transport sector is attributed essentially to changes in lifestyle arising mainly from an increase in number of vehicles.

4.0 Mitigation Actions proposed under TNC for the Transport sector

4.1 Mitigation Scenarios and Assumptions

Relative to the BAU scenario, four mitigation actions were developed by TNC (2016):

- Scenario 1 (SC1) relies improvement of fuel intensity;
- Scenario 2 (SC2) calls for an improvement in the vehicle inspection;
- Scenario 3 (SC3) adopts low carbon options;
- Scenario 4 (SC4) invokes a mass transit light rail system.

The assumptions adopted by TNC for mitigations actions for the Transport sector are summarized in Table 4.1.

The parameters used for the different scenarios appear in section 5.2.

Table: 4.1: Mitigation actions proposed by TNC (2016) and Assumptions used. (Land Transport)

Scenario		TNC Assumptions
BAU	Business-As-Usual	BAU is based on the TNC methodology which projects equivalent GHG emissions after performing a two-layer calibration (see TNC Report for details) using a parametric model for both passenger and freight mobility followed by an energy balance using published fuel consumption data.
SC1	Improvement of fuel intensity	Main Assumption: Improvements in the fuel intensity of vehicles (applied to all vehicles) at the rate of 1% per year pre-2020, and increasing to 1.5% per year post-2020.
SC2	Improvement in the vehicle inspection	Main Assumption: Improved vehicle inspection (privatization of centres starting in 2017) leads to an overall reduction in GHG emission reductions of 5% in 2019.
SC3	Low-carbon options	A low-carbon option has been modelled that combines three technologies: blended bio-ethanol produced in Mauritius, and an increasing penetration of hybrid cars and electric cars. These options are assumed to impact on gasoline-fueled cars. For ethanol, it is assumed that there is a total available potential of 20 ML bio-ethanol per year, the low-carbon scenario accounts for a 25% penetration in 2020, and increasing by increments of 5% in subsequent years until 100% penetration is reached in 2035 (i.e. 50% in 2025 and 75% in 2030).
SC4	Mass transit light rail system	Light Rail System (LRS) generates modal shift away from private cars and buses along the Curepipe – Port Louis corridor. The impact of the LRS on road transport GHG emissions has been modelled (TNC Report, 2016) taking into account the reduction in car and bus annual distance travelled as follows: 2018: cars – 109 540 000 km; buses – 10 547 000 km; 2028: cars – 107 204 000 km; buses – 10 836 000 km; 2038: cars – 115 300 000 km; buses – 11 330 000 km; 2038-2050: the reductions kept constant at their 2038 levels; Also, 90% of the reduction in car passenger mobility is attributed to gasoline-fueled cars, and the remaining 10% to diesel-fueled cars.
SC5	Cumulative	Impact of all scenarios

4.2 TNC Targets under different scenarios

For this sector, the resulting reductions from the TNC studies in GHG emissions over time frames of 2020, 2030, 2040 and 2050 are given in Table 4.5 (see also Figure 4.1).

Table 4.5: 2016 TNC GHG Emissions in Transport sector

Scenario		TARGETS *Expected GHG Emissions/Reductions*	TNC Remarks
BAU	Business-As-Usual	BAU GHG Emissions: 2020: 1093 Gg CO2e; 2030: 1294 Gg CO2e; 2040: 1453 Gg CO2e; 2050: 1645 Gg CO2e;	
SC1	Improvement of fuel intensity	Relative to BAU, emissions reductions of: 11 Gg CO2e in 2020; 19 Gg CO2e in 2030; 22 Gg CO2e in 2040; 25 Gg CO2e in 2050.	
SC2	Improvement in the vehicle inspection	Relative to BAU, emission reductions of: 54 Gg CO2e in 2020; 64 Gg CO2e in 2030; 73 Gg CO2e in 2040; 82 Gg CO2e in 2050.	An intermediate reduction level of 2.5% is achieved in 2018.
SC3	Low-carbon options	Relative to BAU, emission reductions of: 9 Gg CO2e in 2020; 42 Gg CO2e in 2030; 99 Gg CO2e in 2040; 180 Gg CO2e in 2050.	
SC4	Mass transit light rail system	Relative to BAU, emission reductions of: 25 Gg CO2e in 2020; 26 Gg CO2e in 2030; 27 Gg CO2e in 2040; 27 Gg CO2e in 2050.	
SC5	Cumulative	Relative to BAU, emission reductions of: 99 Gg CO2e in 2020; 151 Gg CO2e in 2030; 221 Gg CO2e in 2040; 314 Gg CO2e in 2050.	

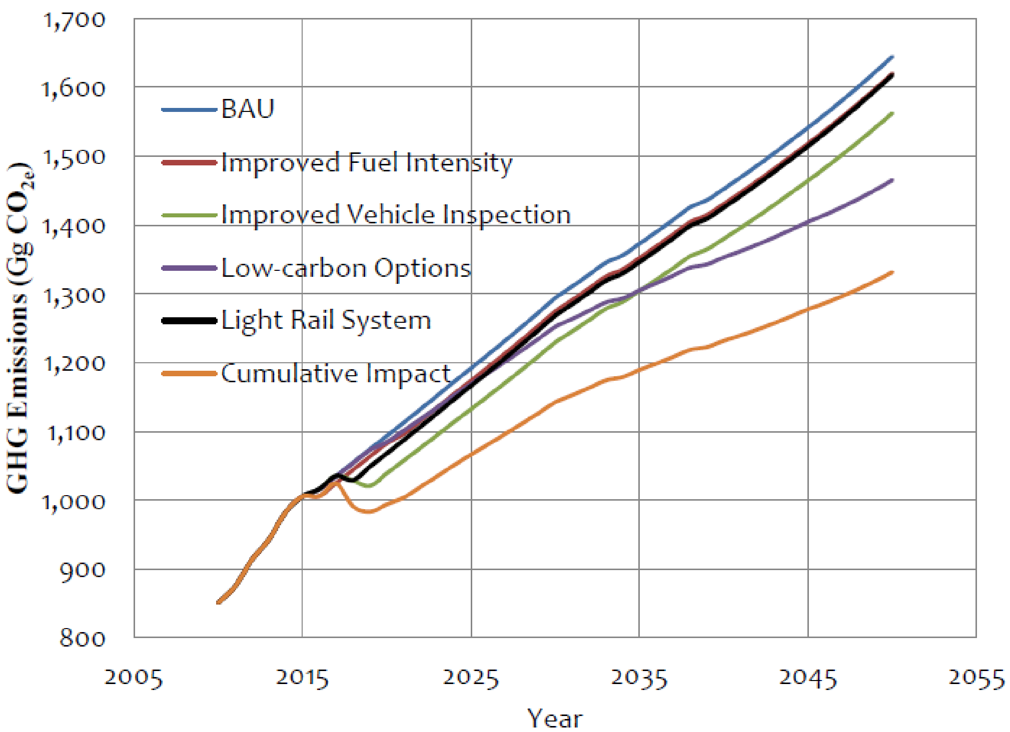

Figure 4.1: GHG emissions scenarios for land transport (source: TNC, 2016)

5.0 XLM– Transport Toolkit

The structure, methodology, and components/modules of the XLM Toolkits has been described in the main User Manual.

5.1 Transport Data

The data used in TNC 2016 appear in the 'Data' worksheet. These data are compiled by Statistics Mauritius.

5.2 Transport Parameters

Table 5.1 defines the major parameters used for the Transport sector (see TNC Report for details).

Table 5.1: List of Parameters for the Transport sector (see TNC Report (2016) for details)

MOBILITY	
Ksat	10000
k	-4.27E-04

Parameters for freight mobility		
% share petrol and diesel		Fuel intensity (L/tonne-km)
Petrol	3%	0.0469
Diesel	97%	0.0368

Residual decreases by 7.1% per annum - 0.071

FUEL EMISSION FACTORS

				NCV	EFCO2	EFCH4	EFN20
Fuel	kgCO2/TJ	kgCH4/TJ	kgN2O/TJ	TJ/Ggfuel	kgCO2/kgfuel	kgCH4/kgfuel	kgN2O/kgfuel
Gasoline	69300	33	3.2	44.8	3.10464	0.0014784	0.00014336
Diesel	74100	3.9	3.9	43.3	3.20853	0.00016887	0.00016887
LPG	63100	62	0.2	52.2	3.29382	0.0032364	0.00001044

GLOBAL WARMING POTENTIAL

GHG	GWP
CO2	1
CH4	25
N2O	298

Ethanol parameters		
Volume		2.00E+07 L
NCV		27 TJ/Gg
Gasoline equivalent		
	Volume	1.21E+07 L
	Weight	8,558 tonne

Model parameters for Fuel Densities, kg/L			
Gasoline			0.710
Diesel			0.850
LPG			0.557

Model parameters for Autocycles			
Parameter	Symbol	Units	Value
Fuel intensity	FI_Ac	L/100km	2.5
Vehicle occupancy	Oc	number of p	1
Days utilised	DU	days/yr	300
Transit distance	TD	km/yr	5,600

Model parameters for Motorcycles			
Fuel intensity	FI_Mc	L/100km	3
Vehicle occupancy	Oc	number of p	1
Days utilised	DU	days/yr	300
Transit distance	TD	km/yr	5,600

Model Parameters			Car
Fuel Intensity (Petrol	FI_X_P	L/100 km	6.5
Occupancy (Petrol)	Oc_X_P	PAX	1.9
Transit distance (Pet	TD_X_P	km/yr	13,500
Fuel Intensity (Diesel	FI_X_D	L/100 km	7
Occupancy (Diesel)	Oc_X_D	PAX	1.9
Transit distance (Die	TD_X_D	km/yr	13,500
Fuel Intensity (LPG)	FI_X_L	L/100 km	8
Occupancy (LPG)	Oc_X_L	PAX	1.9
Transit distance (LPG	TD_X_L	km/yr	13,500
Fuel Intensity (Hybri	FI_X_L	L/100 km	4
Occupancy (Hybrid)	Oc_X_L	PAX	1.9
Transit distance (Hyb	TD_X_L	km/yr	13,500

Model Parameters			DPV
Fuel Intensity (Petrol	FI_X_P	L/100 km	11.5
Occupancy (Petrol)	Oc_X_P	PAX	1.9
Transit distance (Pet	TD_X_P	km/yr	13500
Fuel Intensity (Diesel	FI_X_D	L/100 km	11.3
Occupancy (Diesel)	Oc_X_D	PAX	1.9
Transit distance (Die	TD_X_D	km/yr	13,500
Fuel Intensity (LPG)	FI_X_L	L/100 km	14.1
Occupancy (LPG)	Oc_X_L	PAX	1.9
Transit distance (LPG	TD_X_L	km/yr	13,500
Fuel Intensity (Hybri	FI_X_L	L/100 km	
Occupancy (Hybrid)	Oc_X_L	PAX	
Transit distance (Hyb	TD_X_L	km/yr	

Model Parameters			Good Vehicles
Fuel Intensity (Petrol	FI_X_P	L/100 km	20
Occupancy (Petrol)	Oc_X_P	PAX	
Transit distance (Pet	TD_X_P	km/yr	
Fuel Intensity (Diesel	FI_X_D	L/100 km	30
Occupancy (Diesel)	Oc_X_D	PAX	
Transit distance (Die	TD_X_D	km/yr	
Fuel Intensity (LPG)	FI_X_L	L/100 km	
Occupancy (LPG)	Oc_X_L	PAX	
Transit distance (LPG	TD_X_L	km/yr	
Fuel Intensity (Hybri	FI_X_L	L/100 km	
Occupancy (Hybrid)	Oc_X_L	PAX	
Transit distance (Hyb	TD_X_L	km/yr	

Model Parameters for Buses			
Fuel Intensity	FI_Bus	L/100km	30.3
Occupancy	O_Bus	PAX	35
Transit distance	TD_Bus	km/yr	38,000
Psssenger daily transit distance		PAX km / da	17.9
Days per year			300
Annual bus passengers			2.40E+08

Allocation of total PAX km by fuel type (%)			
Gasoline			54.93
Diesel			45.01
LPG			0.05

Percentage allocation of PAX km by type of vehic			
Petrol	A/cycle		11.31
	Cars		77.79
	M/cycle		7.36
	DPV		2.52
	Hybrid		1.01
TOTAL	*TOTAL*		100
Diesel	Cars		8.46
	DPV		12.20
	Goods Vehicle		
	Buses		79.35
TOTAL	*TOTAL*		100
LPG	Cars		94.51
	DPV		5.49
	Goods Vehicle		
TOTAL	*TOTAL*		100

Scenario 4 LRT			
MLRT Car	Petrol		90.0%
	Diesel		10.0%

Percentage Residual decrease per annum - the 5 year average decline in consumption			7.1%

5.3 Transport Assumptions

Table: 5.2: List of Assumptions for the Transport sector

1	Annual Improvement in Fuel Economy by Fuel Type (%)
2	Improvements through better vehicle maintenance by Fuel Type (%)
3	Percentage allocation of PAX km by type of petrol vehicles
4	Penetration rate of Ethanol
5	MLRT: Reduction in car and bus annual distance travelled

5.4 Graphic Analysis and Reporting

Graphic analysis in the 'Query' worksheet provides the following choices for the type of plots:

Sector	Type of Plot	Plot numbers
Energy: Transport	ALL	1-158;
	Mobility	1-14; 80-85; 115-127;
	Fuel Consumption	15-32; 46-49; 63-66; 86-101; 128-145;
	Total GHG Emissions (TNC)	33-45; 50-62; 67-79; 102-114; 146-158;

The complete set of figures are listed in Table 5.3.

Table 5.3: Complete List of Transport Sector Plots

Plot No.	Scenario	Description
1	BAU	Net Passenger Mobility (PAX km)
2	BAU	Passenger Mobility for All Gasoline Vehicles (PAX km)
3	BAU	Passenger Mobility for All Diesel Vehicles (PAX km)
4	BAU	Passenger Mobility for All LPG Vehicles (PAX km)
5	BAU	Passenger Mobility for Autocycles (PAX km)
6	BAU	Passenger Mobility for Motorcycles (PAX km)
7	BAU	Passenger Mobility for Petrol Cars (PAX km)
8	BAU	Passenger Mobility for Petrol DPVs (PAX km)
9	BAU	Passenger Mobility for Hybrid Cars (PAX km)
10	BAU	Passenger Mobility for Diesel Cars (PAX km)
11	BAU	Passenger Mobility for Diesel DPVs (PAX km)
12	BAU	Passenger Mobility for Buses (PAX km)
13	BAU	Passenger Mobility for LPG Cars (PAX- km)
14	BAU	Passenger Mobility for LPG DPVs (PAX km)
15	BAU	Fuel Consumption for Autocycles (tonne)
16	BAU	Fuel Consumption for Petrol Cars (tonne)
17	BAU	Fuel Consumption for Motorcycles (tonne)
18	BAU	Fuel Consumption for Petrol DPVs (tonne)
19	BAU	Fuel Consumption for Hybrid Cars (tonne)
20	BAU	Fuel Consumption for Petrol Good Vehicles (tonne)

Plot No.	Scenario	Description
21	BAU	Fuel Consumption for All Petrol Vehicles (tonne)
22	BAU	Fuel Consumption for Diesel Cars (tonne)
23	BAU	Fuel Consumption for Diesel DPVs (tonne)
24	BAU	Fuel Consumption for Buses (tonne)
25	BAU	Fuel Consumption for Diesel Freights (tonne)
26	BAU	Fuel Consumption for All Diesel Vehicles (tonne)
27	BAU	Fuel Consumption for LPG Cars (tonne)
28	BAU	Fuel Consumption for LPG DPVs (tonne)
29	BAU	Fuel Consumption- Residual (tonne)
30	BAU	Fuel Consumption for all LPG Vehicles (tonne)
31	BAU	10X Fuel Consumption: LPG (total) (tonne)
32	BAU	Fuel Consumption for ALL Vehicles (tonne)
33	BAU	CO2 Emissions from Petrol Vehicles (Gg/year)
34	BAU	CH4 Emissions from Petrol Vehicles (Gg/year)
35	BAU	N2O Emissions from Petrol Vehicles (Gg/year)
36	BAU	CO2 Emissions from Diesel Vehicles (Gg/year)
37	BAU	CH4 Emissions from Diesel Vehicles (Gg/year)
38	BAU	N2O Emissions from Diesel Vehicles (Gg/year)
39	BAU	CO2 Emissions from LPG Vehicles (Gg/year)
40	BAU	CH4 Emissions from LPG Vehicles (Gg/year)
41	BAU	N2O Emissions from LPG Vehicles (Gg/year)
42	BAU	Total CO2 Emissions from Vehicles (Gg/year)
43	BAU	Total CH4 Emissions from Vehicles (Gg/year)
44	BAU	Total N2O Emissions from Vehicles (Gg/year)
45	BAU	Total GHG (CO2e) Emissions from Vehicles (Gg/year)
46	SC1	Total Gasoline Consumption after Fuel Intensity Improvements (tonne)
47	SC1	Total Diesel Consumption after Fuel Intensity Improvements (tonne)
48	SC1	Total LPG Consumption after Fuel Intensity Improvements (tonne)
49	SC1	Total Fuel Consumption after Fuel Intensity Improvements (tonne)
50	SC1	CO2 Emissions from Petrol Vehicles after Fuel Intensity Improvements (Gg/year)
51	SC1	CH4 Emissions from Petrol Vehicles after Fuel Intensity Improvements (Gg/year)
52	SC1	N2O Emissions from Petrol Vehicles after Fuel Intensity Improvements (Gg/year)
53	SC1	CO2 Emissions from Diesel Vehicles after Fuel Intensity Improvements (Gg/year)
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55	SC1	N2O Emissions from Diesel Vehicles after Fuel Intensity Improvements (Gg/year)
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61	SC1	Total N2O Emissions from Vehicles after Fuel Intensity Improvements (Gg/year)
62	SC1	Total GHG (CO2e) Emissions from Vehicles after Fuel Intensity Improvements (Gg/year)
63	SC2	Total Gasoline Consumption after Improvements in Vehicle Maintenance (tonne)

Plot No.	Scenario	Description
64	SC2	Total Diesel Consumption after Improvements in Vehicle Maintenance (tonne)
65	SC2	Total Fuel Consumption after Improvements in Vehicle Maintenance (tonne)
66	SC2	Total LG Consumption after Improvements in Vehicle Maintenance (tonne)
67	SC2	CO2 Emissions from Petrol Vehicles after Improvements in Vehicle Maintenance (Gg/year)
68	SC2	CH4 Emissions from Petrol Vehicles after Improvements in Vehicle Maintenance (Gg/year)
69	SC2	N2O Emissions from Petrol Vehicles after Improvements in Vehicle Maintenance (Gg/year)
70	SC2	CO2 Emissions from Diesel Vehicles after Improvements in Vehicle Maintenance (Gg/year)
71	SC2	CH4 Emissions from Diesel Vehicles after Improvements in Vehicle Maintenance (Gg/year)
72	SC2	N2O Emissions from Diesel Vehicles after Improvements in Vehicle Maintenance (Gg/year)
73	SC2	CO2 Emissions from LPG Vehicles after Improvements in Vehicle Maintenance (Gg/year)
74	SC2	CH4 Emissions from LPG Vehicles after Improvements in Vehicle Maintenance (Gg/year)
75	SC2	N2O Emissions from LPG Vehicles after Improvements in Vehicle Maintenance (Gg/year)
76	SC2	Total CO2 Emissions from Vehicles after Improvements in Vehicle Maintenance (Gg/year)
77	SC2	Total CH4 Emissions from Vehicles after Improvements in Vehicle Maintenance (Gg/year)
78	SC2	Total N2O Emissions from Vehicles after Improvements in Vehicle Maintenance (Gg/year)
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83	SC3	Passenger Mobility for Petrol DPVs with H/E Vs substitutes (PAX km)
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92	SC3	Total Gasoline Consumption with H/E Vs substitutes (tonne)
93	SC3	Total Diesel Consumption with H/E Vs substitutes (tonne)
94	SC3	Total LPG Consumption with H/E Vs substitutes (tonne)
95	SC3	Total Fuel Consumption with H/E Vs substitutes (tonne)
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102	SC3	CO2 Emissions from Petrol Vehicles under low-carbon options (Gg/year)
103	SC3	CH4 Emissions from Petrol Vehicles under low-carbon options (Gg/year)
104	SC3	N2O Emissions from Petrol Vehicles under low-carbon options (Gg/year)
105	SC3	CO2 Emissions from Diesel Vehicles under low-carbon options (Gg/year)
106	SC3	CH4 Emissions from Diesel Vehicles under low-carbon options (Gg/year)

Plot No.	Scenario	Description
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108	SC3	CO2 Emissions from LPG Vehicles under low-carbon options (Gg/year)
109	SC3	CH4 Emissions from LPG Vehicles under low-carbon options (Gg/year)
110	SC3	N2O Emissions from LPG Vehicles under low-carbon options (Gg/year)
111	SC3	Total CO2 Emissions from Vehicles under low-carbon options (Gg/year)
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122	SC4	Passenger Mobility for Buses with MLRT (PAX km)
123	SC4	Passenger Mobility for Diesel Cars with MLRT (PAX km)
124	SC4	Passenger Mobility for Diesel DPVs with MLRT (PAX km)
125	SC4	Reduction in Passenger Mobility by Buses with MLRT (PAX km)
126	SC4	Passenger Mobility for LG Cars with MLRT (PAX km)
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128	SC4	Fuel Consumption for Autocycles with MRLT (tonne)
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130	SC4	Fuel Consumption for Petrol Cars with MRLT (tonne)
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147	SC4	CH4 Emissions from Petrol Vehicles with MLRT System (Gg/year)
148	SC4	N2O Emissions from Petrol Vehicles with MLRT System (Gg/year)
149	SC4	CO2 Emissions from Diesel Vehicles with MLRT System (Gg/year)

Plot No.	Scenario	Description
150	SC4	CH4 Emissions from Diesel Vehicles with MLRT System (Gg/year)
151	SC4	N2O Emissions from Diesel Vehicles with MLRT System (Gg/year)
152	SC4	CO2 Emissions from LPG Vehicles with MLRT System (Gg/year)
153	SC4	CH4 Emissions from LPG Vehicles with MLRT System (Gg/year)
154	SC4	N2O Emissions from LPG Vehicles with MLRT System (Gg/year)
155	SC4	Total CO2 Emissions from Vehicles with MLRT System (Gg/year)
156	SC4	Total CH4 Emissions from Vehicles with MLRT System (Gg/year)
157	SC4	Total N2O Emissions from Vehicles with MLRT System (Gg/year)
158	SC4	Total GHG (CO2e) Emissions from Vehicles with MLRT System (Gg/year)

6.0 References

- **TNC (2016).** Third National Communication: Report to the United Nations Framework Convention on Climate Change. Republic of Mauritius, Port Louis
- **IPCC (2006).** Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.

7.0 Appendices

A: List of Acronyms and Abbreviations

Toolkit		Others	
BAU	Business-As-Usual	IPCC	International Panel of Climate Change
GUI	Graphics User Interface	TNC	Third National Communications
UD1	User-defined Scenario – Case 1	GHG	Greenhouse Gas
UD2	User-defined Scenario – Case 2	GWP	Global Warming Potential
SC*i*	Scenario *i*		
XLMT	Excel Mitigation Toolkit		

B: Useful Links

Click for access to these links

IPCC

TNC

NTA

Digest transport and others

Digest demography

C: Governing Equations for the Transport sector

The sector derives its GHG emissions and projections from modelled passenger and freight transport. Thus the fuels consumed by type, are derived from vehicle fleet and their uses, which in turn provides the data needed for calculations of GHG emissions.

Passenger Mobility

The passenger transport or mobility, as explained in the TNC, is drawn from the equation (see TNC Report for details):

$$Y = Y_{Sat}\,[\,1 - e^{kx}] \qquad \text{(I)}$$

where:

Y_{sat} = 10 000 km/capita/yr,

k= - 4.27 x 10^{-4}, and

x = GDP (constant 1980 US$) per capita.

Freight Mobility

Freight mobility measured in tonne of freight/goods km per capita, is parametrized as a linear relationship to economic growth as follows:

$$Y = ax + b \qquad \text{(II)}$$

where: a = 0.52, and b = 26.16.

Once the above have been obtained, they are used to calculate the fuel consumed by type such as diesel, petrol, etc.

These fuels are then multiplied by the respective emission factors.

$$\text{Emissions } GHG_i = AD_i \times EF_i$$

where

i = Type of fuel

AD = Fuel consumed, TJ (Can be converted from kg or tonnes)

EF = Emission factor, kg GHG/TJ Fuel

For projections, several assumptions are made, as explained in the TNC Report, 2016.

CO_2 FROM ROAD TRANSPORT

$$Emission = \sum_a [Fuel_a \bullet EF_a]$$

where

Emission = Emissions of CO_2 (kg)

$Fuel_a$ = fuel sold (TJ)

EF_a = emission factor (kg/TJ). This is equal to the carbon content of the fuel multiplied by 44/12.

a = type of fuel (e.g. petrol, diesel, natural gas, LPG etc)

TIER 1 EMISSIONS OF CH_4 AND N_2O

$$Emission = \sum_a [Fuel_a \bullet EF_a]$$

where

Emissions = emission in kg

EF_a = emission factor (kg/TJ)

$Fuel_a$ = fuel consumed, (TJ) (as represented by fuel sold)

a = fuel type a (e.g., diesel, gasoline, natural gas, LPG)

TIER 2 EMISSIONS OF CH_4 AND N_2O

$$Emission = \sum_{a,b,c} [Fuel_{a,b,c} \bullet EF_{a,b,c}]$$

where

Emission = emission in kg.

$EF_{a,b,c}$ = emission factor (kg/TJ)

$Fuel_{a,b,c}$ = fuel consumed (TJ) (as represented by fuel sold) for a given mobile source activity

a = fuel type (e.g., diesel, gasoline, natural gas, LPG)

b = vehicle type

c = emission control technology (such as uncontrolled, catalytic converter, etc)