INDIA GHG PROGRAM

Promoting profitable, sustainable and competitive businesses.

VERSION 1.0

# India Specific Road Transport Emission Factors

2015

For Stakeholder Consultation

INDIA GHG PROGRAM

Promoting profitable, sustainable and competitive businesses.

VERSION 1.0

# India Specific Road Transport Emission Factors

2015

For Stakeholder Consultation

## Disclaimer



While every care has been taken in writing the technical paper, India GHG Program and supporting organizations accept no claim for compensation with respect to any wrong, abbreviated, omitted or incorrectly inserted content in the book. The paper is only an attempt to estimate the emission factor.

The technical paper has been compiled based upon the publicly available data.

The paper is open for stakeholder consultation and you are invited to share your views and comments to Mr Chirag Gajjar (cgajjar@wri.org) / Mr Atik Sheikh (atik.sheikh@cii.in).

Published By:
**India GHG Program**
India GHG Program Secretariat
1st Floor, WRI India
Godrej and Boyce Premises,
Gasworks Lane, Lalbaug,
Parel, Mumbai-400012
Tel: +91 (22) 2471 3565

# Table of Contents

## 1. Executive Summary

The India GHG Program acts as a 'Center of Excellence' by disseminating regional, sectoral and global best practices, to create a culture of inventorisation and benchmarking of GHG emissions in India. Based on experiences in the area of GHG accounting & management and interaction with various stakeholders, we have been able to identify the gaps in GHG inventory and management process owing to limited Indian specific data.

The Program Secretariat, managed by WRI India, TERI and CII, is extensively guided in its objectives and strategic direction by an Advisory Board comprising of senior business representatives and program partners.

The IGHG program strives to address issues that are common and widespread with all its stakeholders and one such area is the transport sector. All business units are dependent on transport relatively higher than other sectors. In the present scenario, Indian companies are using internationally available data (by IPCC) for passenger and material transport by road. We propose to arrive at India specific emission factors. This is an important activity and will substantially increase the accuracy in GHG emissions Inventorization and add credibility to the inventory system. This activity will contribute significantly to standardizing measurement and management of GHG emissions in India.

These emission factors will facilitate direct calculation of GHG emissions resulting from material transport and passenger commute, depending on the mode of transport. For the transport sector emission factors, the secretariat has adopted an innovative approach, where the key stakeholders are a part of the working group and the emissions factors is calculated by collaborative means among all the members.

Transport sector accounts for 6.4 per cent share of India's Gross Domestic Product (GDP). Road transport has emerged as the dominant segment in India's transportation sector contributing to a 5.4 per cent share in India's GDP.[1] Of the three major modes of transport in India, road transport is the dominant form of transport for both passenger and freight. Road transport carries almost 90% of country's passenger traffic and 65% of the country's freight . Road transport also utilizes 78% of the energy share used for transport, while rail and air each utilize 11% of the energy share.[2]

Indian road transport sector has witnessed a remarkable growth and is expected to grow at a significant rate in the coming years. The current projection suggests that the road transport traffic will grow more than 5 times current (2011-12) 1385 billion tones-km (freight traffic) and 9329 billion passenger km to 6559 billion tones-km (freight traffic) and 163,109 billion passenger km (2031-32).

Currently, the transport sector emissions fall under the Scope 3 categories for organisations accounting their corporate GHG emissions. These organisations either use internationally available emission factors or use the emission factors calculated based on assumptions. These approaches could have significant errors and may not be relevant to Indian conditions.

With the objective of facilitating a uniform accounting basis for Indian organisations, the India GHG Program has initiated activities to determine India Specific Road Transport Emission factors.

[1] Indian Road Congress

[2] India Transport Report : Moving India to 2032 –Volume III

The two major fuels used by the transport sector are gasoline and diesel. These fuels are carbon intensive as they contain 80-85% of carbon by weight. On combustion, these fuels release greenhouse gases along with other pollutants thus contributing to the GHG effect. Based on the projected increase in road transport, it is imperative that the consumption of fossil fuels will also increase in the near future. Most organizations undertaking GHG inventorization include emission categories from material transport and employee commute in their scope 3 emissions. Presently only international factors are available for use by accounting organisations. These, however, are not representative of the Indian scenario. Alternatively, indigenous emission factors based on assumptions are largely prone to error. **Thus, this study aims to arrive at a methodology to estimate India specific road transport emission factors to aid the Indian corporate strengthen its GHG accounting process.**

The methodology has been arrived with detailed consultation from the Working Group formed for the *India Specific Road Transport Emission Factors.* The working group comprised of key stakeholders from the sector. The working group participated in various meetings, tele-conferences and discussions to provide their valuable inputs to establish and refine the methodology to arrive at emission factors.

India GHG Program acknowledges with thanks the co-operation extended by the working group members in providing their inputs for devising a methodology to arrive at India specific air transport emission factor.

**Working Group Members**:

- ACC Limited
- Tata Motors
- Bajaj Limited
- Hero MotoCorp
- Ashok Leyland
- Mahindra Logistics
- Mahindra & Mahindra
- National Thermal Power Plant Corporation Limited (NTPC)
- Indian Oil Corporation Limited (IOCL)

**Summary of activities by working group:**

- Review of the existing international and national methodologies and emission factors
- Identify the methodology to arrive at country specific emission factors
- Identify stakeholder & their level of involvement

Based on the inputs of the working group, the emission factor estimated by using the proposed methodology and currently available data in public domain are as shown below

**Summary of Emission Factors:**

**Two Wheelers:**

| Particulars | | | Emission Factor | |
|---|---|---|---|---|
| Sr.No | Category | Engine CC | kg $CO_2$/km | kg $CO_2$/km @10 uplift factor |
| 1 | Scooter | <110 CC | 0.0334 | 0.0368 |
| 2 | Scooter | <150 CC | 0.0351 | 0.0387 |
| 3 | Motorcycle | <100 CC | 0.0325 | 0.0358 |
| 4 | Motorcycle | <125 CC | 0.0290 | 0.0319 |
| 5 | Motorcycle | <135 CC | 0.0324 | 0.0356 |
| 5 | Motorcycle | <200 CC | 0.0417 | 0.0458 |
| 6 | Motorcycle | <300 CC | 0.0540 | 0.0595 |
| 7 | Motorcycle | <500 CC | 0.0542 | 0.0597 |

**Three Wheelers:**

| Sr.No | Category | kg $CO_2$/km |
|---|---|---|
| 1 | Petrol | 0.1135 |
| 2 | Diesel | 0.1322 |
| 3 | CNG | 0.10768 |

**Passenger Car**

| Sr. No | Type of Car | Category | Fuel | Emisssion Factor (kg CO2/km) | Emisssion Factor (kg CO2/km) with uplift factor |
|---|---|---|---|---|---|
| 1 | Small | <800 CC | Gasoline | 0.103 | 0.111 |
| 2 | Small | <800 CC | CNG | 0.063 | 0.068 |
| 3 | Small | <800 CC | LPG | 0.138 | 0.149 |
| 4 | Hatchback | <1000 CC | Gasoline | 0.117 | 0.127 |
| 5 | Hatchback | <1400 CC | Gasoline | 0.130 | 0.140 |
| 6 | Premium Hatchback | <1600 CC | Gasoline | 0.150 | 0.162 |
| 7 | Compact SUV | <1600 CC | Gasoline | 0.153 | 0.166 |
| 8 | Gypsy | 1298 CC | Gasoline | 0.189 | 0.204 |
| 9 | Sedan | <1400CC | Gasoline | 0.142 | 0.153 |
| 10 | Sedan | <1600 CC | Gasoline | 0.142 | 0.153 |
| 11 | Sedan | <2000 CC | Gasoline | 0.149 | 0.161 |
| 12 | Sedan | <2500 CC | Gasoline | 0.163 | 0.176 |
| 13 | SUV | <3000 CC | Gasoline | 0.197 | 0.213 |
| 14 | MUV | <2000 CC | Gasoline | 0.213 | 0.230 |
| 15 | Premium SUV | <2000 CC | Gasoline | 0.193 | 0.208 |
| 16 | Premium SUV | <3000 CC | Gasoline | 0.258 | 0.279 |
| 17 | Premium SUV | >3000 CC | Gasoline | 0.267 | 0.289 |
| 18 | Premium Sedan | <2000 CC | Gasoline | 0.191 | 0.207 |
| 19 | Premium Sedan | <3000 CC | Gasoline | 0.194 | 0.209 |
| 20 | Premium Sedan | >3000 CC | Gasoline | 0.250 | 0.270 |
| 21 | Hybrid | <2000 CC | Gasoline | 0.095 | 0.103 |

| | | | | | |
|---|---|---|---|---|---|
| 22 | Hatchback | <1000 CC | Diesel | 0.105 | 0.113 |
| 23 | Hatchback | <1400 CC | Diesel | 0.117 | 0.126 |
| 24 | Hatchback | <1600 CC | Diesel | 0.136 | 0.147 |
| 25 | Sedan | <1400 CC | Diesel | 0.121 | 0.131 |
| 26 | Sedan | <1600 CC | Diesel | 0.131 | 0.141 |
| 27 | Sedan | <2000 CC | Diesel | 0.148 | 0.160 |
| 28 | Premium Sedan | <2000 CC | Diesel | 0.164 | 0.177 |
| 29 | Premium Sedan | <2500 CC | Diesel | 0.151 | 0.163 |
| 30 | Premium Sedan | <3000 CC | Diesel | 0.230 | 0.248 |
| 31 | MUV | <1400 CC | Diesel | 0.145 | 0.157 |
| 32 | MUV | <2500 CC | Diesel | 0.200 | 0.216 |
| 33 | Maxi Van | - | Diesel | 0.209 | 0.226 |
| 34 | SUV | <2000 CC | Diesel | 0.186 | 0.201 |
| 35 | SUV | <2500 CC | Diesel | 0.195 | 0.210 |
| 36 | SUV | <3000 CC | Diesel | 0.203 | 0.220 |
| 37 | Premium SUV | <2000 CC | Diesel | 0.167 | 0.180 |
| 38 | Premium SUV | <2500 CC | Diesel | 0.199 | 0.215 |
| 39 | Premium SUV | <3000 CC | Diesel | 0.222 | 0.240 |
| 40 | Premium SUV | >3000CC | Diesel | 0.269 | 0.290 |

**Bus:**

The calculated emission factor for bus transport is 0.015161 kg $CO_2$/pax-km. The emission factor is not applicable to Bus Rapid Transport System (BRTS) and intercity transport, as the loading and passenger-km will differ significantly from intracity transport.

**Freight Vehicles**

| S.No. | Category | kg $CO_2$/km |
|---|---|---|
| 1 | LDV (<3.5T) | 0.3070 |
| 2 | MDV (<12T) | 0.5928 |
| 3 | HDV (>12 T) | 0.7375 |

This paper includes the following:

1) Summary of methodologies that have been followed internationally to arrive at emission factors.
2) A proposed methodology for arriving at India specific road transport emission factors. The methodology adopts certain aspects from each of the different methods. It relies mostly on publicly available data. This is to ensure that the emission factors can be re-assessed periodically. Data requirement, inherent challenges, assumptions, inclusions and exclusions pertinent to this methodology have also been discussed in detail in this paper.

## 2. Introduction

### *2.1 GHG emission from road transport sector*

India is the 4th largest GHG contributor in the world. With the 2nd largest population, the per capita emissions of the country are very low as compared to other developed and developing countries. In 2009, Ministry of Environment and Forest, Government of India launched a report on National GHG Emission for the year 2007. The report highlighted the GHG emissions from various sources situated within the geographical boundary of the country.

This report inventorized emissions from different sectors such as power, transport, commercial, industries, agriculture, waste and Land Use – Land Use Change and Forestry (LULUCF). The transport sector was one of the major contributors to the National GHG emission (2nd largest contributor) and emitted 142 million tonnes of $CO_2$ in the year 2007. The transport sector covered the emissions from road transport, air transport, rail transport and water transport.

Road transport, being the dominant mode of transport in the country, emitted 87% of the total $CO_2$ equivalent emissions from the transport sector. The aviation sector in comparison only emitted 7% of the total $CO_2$ eq. emissions. The remaining were from railways (5%) and navigation (1%) sectors.

The National Transport Development Policy Committee (NTDPC) reports that there will be a five fold growth in the use of road transport for passenger and freight by 2030-31. This growth will have a significant bearing on the overall GHG emissions of the country. Recognizing the need of decoupling the GHG growth from the transport growth, the Government of India has already taken several initiatives to promote the sustainable mode of transport in the country. The National Action Plan on Climate Change (NAPCC) launched in 2008, recognizes the importance of reducing the GHG emissions from and has included sustainable transport under the National Mission on Sustainable Habitat.

For a company inventorizing GHG emissions from their operations, emissions from transport will fall under two categories.

1. Emissions from company owned vehicles (Scope 1 category)
2. Emissions from material transport/employee commute in vehicles other than owned by the company (Scope 3 category)
    a. Employee Commute
    b. Business Commute
    c. Material Transport (both upstream and downstream)

### *2.2 Need for India specific Emission Factors for Road transport*

The number of Indian organizations accounting their GHG emissions has seen a steady rise in the last decade. Rising awareness has led to organizations including scope 3 emissions in their inventories. Sources of scope 3 emissions include employee commute and material transports. Emission factors utilized usually include either globally available emission factors or calculated emissions factors based on several assumptions.

Globally available internationally appropriate emissions factors may not be applicable in the Indian conditions which are relatively different to the conditions in the developed nations. When organizations rely on developing indigenous emission factors, the final GHG inventory is prone to having errors. This is because the emission factors are determined based on many assumptions, which could vary from organization to organization. This poses a threat to consistency in the inventorized emissions.

The emission sources for road transportation includes all types of light-duty vehicles such as automobiles and light trucks, heavy-duty vehicles such as tractor trailers and buses and on-road motorcycles (including mopeds, scooters and three-wheelers).

The methodology to determine emission factors needs to be comprehensive and should address all the variables involved in determining the emissions from road transport. However, the re are multiple challenges in determining these emission factors including utilization of many types of gaseous and liquid fuels. In addition to that, for each of the vehicles, the fuel consumption depends on various conditions such as age of vehicle, road conditions, maintenance, fuel type, weather conditions, etc.

### *2.3 Objective of study*

This study aims to arrive at India specific road transport emission factors to aid the Indian corporate strengthen its GHG accounting process. At the end of this study, emissions factors specific to the Indian environment will be estimated. The emission factors will be determined for passenger transport and material transport specific to the type of vehicle

- Passenger Transport
    - Kg $CO_2$/Passenger-km
- Material Transport
    - Kg $CO_2$/Ton-km

### *2.4 Scope of the study*

This study covers emissions factors for passenger transport from

- Cars
- Motorcycles
- Three Wheelers
- Bus

Emissions from material transport are captured as kg $CO_2$/ Ton-km for freight based vehicles.

The current study is a very basic study which involves publicly available data for calculations; the methodology defined will be refined in subsequent revisions considering more variables and inputs from the stakeholders.

## 3. Methodology for Calculating Road Emission Factors

Greenhouse Gas emissions are generated due to combustion of fuels in engines used for propelling the vehicles. There are different classes of vehicles use in road transport such as motor cycles, cars, 3-wheelers, trucks, etc. and these classes are further sub-classified based on the engine capacity. For vehicle classification, the IPCC guidelines for common reporting framework (1. A. 3) will be referred to.

The emissions from a vehicle will depend on many different factors including, but not limited to, engine efficiency, type of fuel, driving habit, vehicle maintenance, traffic, adulterated fuel, aging fleet, routes, passenger load, cargo load, management, urban planning, weather condition, etc.

Presently three internationally accepted approaches are used by reporting companies to estimate emissions from their road transport i.e. Tier I, Tier II & Tier III (as per IPCC).

Estimated emissions from road transport can be based on two independent sets of data: fuel consumed or the vehicle –ton/passenger kilometer. The calculation of emissions in each of the three approaches is based on the relation:

***Emissions = Activity data X Emission Factor***

**Tier I Approach**: Tier 1 approach is purely based on aggregate quantities of fuel consumption data for road transport multiplied by average emission factors. These emissions factors are directly based on the carbon content of the fuel, and are globally available from various emission factor databases. For the carbon content of the fuel, the globally available factors are used. The activity data for Tier 1 Approach is fuel consumed.

GHG Emissions = Fuel Consumed (TJ) x Emission factor (kg $CO_2$/TJ)

This method will be more applicable when scope 1 emissions for the corporate are calculated. For scope 3 there are varied factors which needs to be considered.

**Tier II Approach:**

The only difference in the tier II approach is that, instead of considering the globally available carbon content of the fuel, the nationally available values carbon content of the fuels are used.

**Tier III Approach:**
Tier III approach is based on use of more detailed data such as vehicle kilometers. The approach requires detailed, country-specific data to generate activity-based emission factors for vehicle subcategories and may involve national models. Tier 3 calculates emissions by multiplying emission factors by vehicle activity levels (e.g., VKT) for each vehicle subcategory and possible road type. Vehicle subcategories are based on vehicle type, fuel, age, etc.

For scope 3 emissions the Tier 3 approach will be more relevant since the activity data available to companies are in form of Passenger-km and Ton-km. Nations like UK (DEFRA) and USA (EPA) use tier 3 approach for calculating the emissions from road transport.

### *3.1 Methodology used for Road Transport Emission factors*

Globally, there are multiple methodologies followed to determine country specific emissions factors. One important data input to these methodologies is using g$CO_2$/km for the vehicle. Many countries have adopted the fuel emission standard for the vehicles which includes Carbon Dioxide ($CO_2$), however in India the fuel emission standard does not cover Carbon Dioxide emissions. This necessitates the modification of this methodology to suit the Indian scenario. For all methodologies, the basic data used to arrive at the emissions factors include:

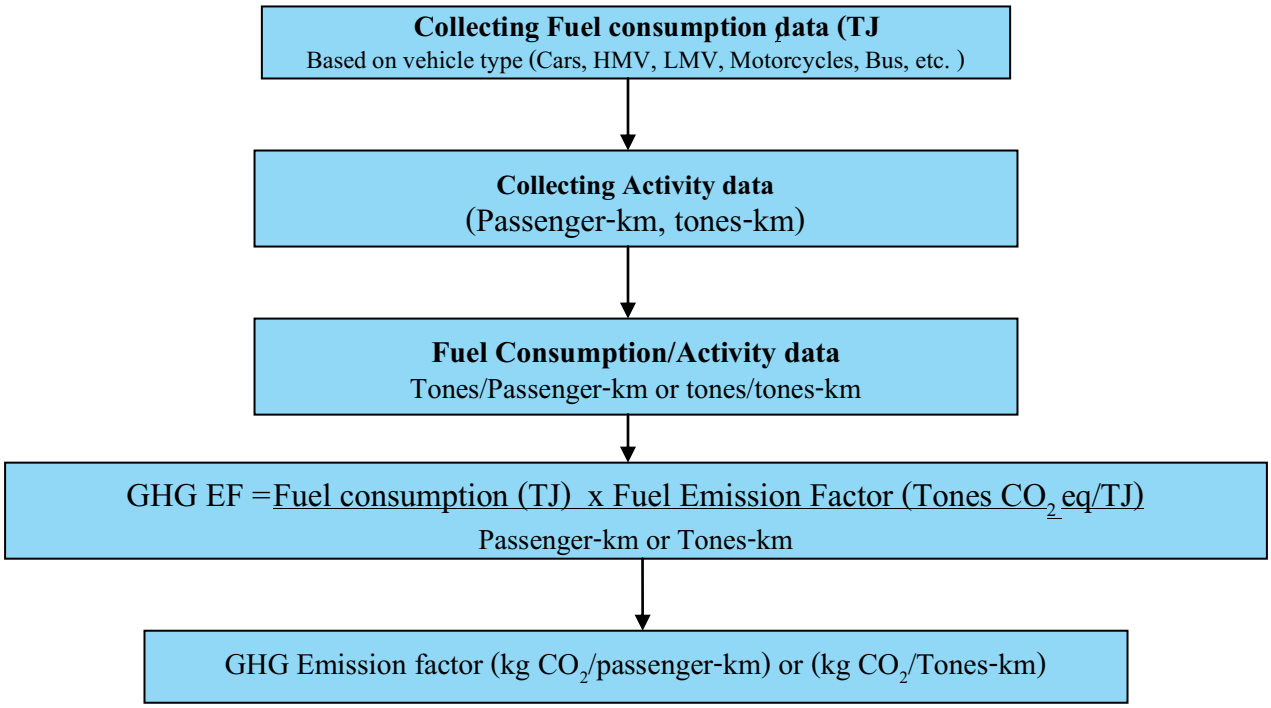
1. Fuel type (gasoline, diesel, natural gas)
2. Vehicle type (passenger cars, LMV, HMVs, 3 wheelers and 2 wheelers)
3. Consideration of operating conditions (speed, road, driving cycles, etc.)
4. Activity data (passenger-km, ton-km)
5. Calorific value of fuel and emission factors of fuel
6. Fuel emission standard (g $CO_2$/km, where applicable)

The following sections describe two methodologies that can be used to determine the emission factors from the transport sector. For each methodology the respective limitations are also discussed.

### *3.1.1 Methodology 1: Using National Fuel consumption data and passenger –km/tones-km*

The first methodology involves using the aggregate available data at the national level for the calculation of the emission factors. The methodology uses the aggregate fuel consumption (based on the vehicle type) and the activity data i.e. passenger-km and ton-km for each vehicle type.
The data required to calculate emission factors via this method include:

1. Fuel consumption data (based on vehicle type)
2. Activity data - Passenger-km and tonnes-km (vehicle type)
3. Emission factor for fuel (Ton $CO_2$/TJ)



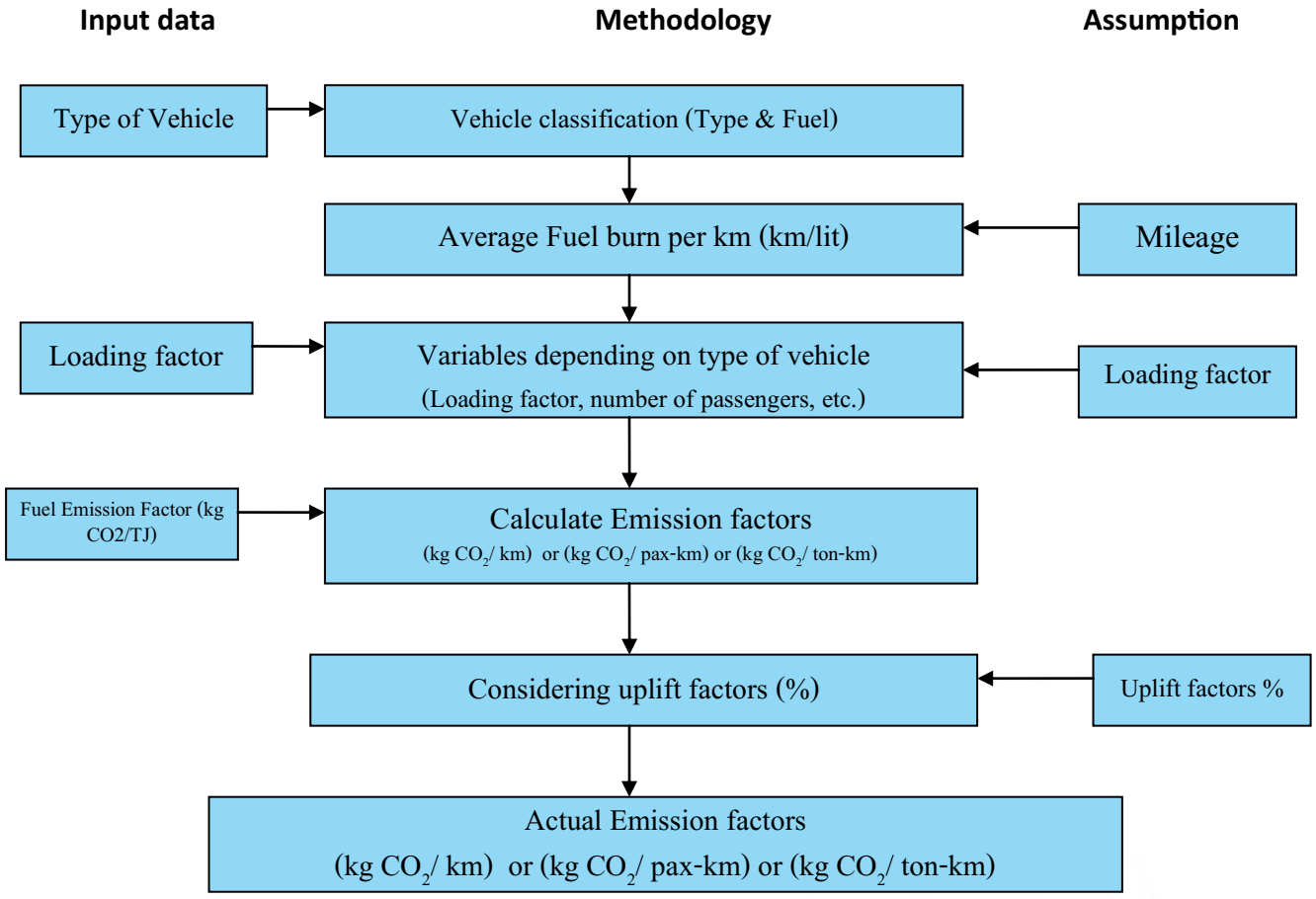

Implementing this methodology in the Indian scenario has certain limitations including

- The data availability for the fuel consumption is available as aggregate and there is no break-up of consumption for vehicles such as fuel consumption by cars, HMVs, LMVs, 2 wheelers.
- For activity data (passenger-km or ton-km) there is no data available, specifically with break-up for passenger-km by car, bus, etc.
- The methodology will give only a single value for road transport, which cannot be applied to all forms of road transport. Clearly, this requires a more elaborate and in-detail analysis.

### *3.1.2 Methodology 2: Using fuel efficiency and loading factors*

The second methodology involves the fuel mileage values, various datasets and realistic assumptions for determining the emission factors. For this method, the major input for the calculation is vehicular efficiency. Described below are the major inputs/data requirements for the emissions factors. Also given is a schematic representation of the generalized methodology. This methodology may vary for different types of vehicles.

The methodology will differ to some extent for freight transport and passenger commute as there will be certain variables which need to be accounted at the emission factors for freight transport and passenger commute.




Implementing this methodology in the Indian scenario has certain limitations as described below-

- The classification of vehicles needs to be considered for accurate emission factors
- The assumptions made for vehicle mileage needs to be carefully considered as this will have significant bearing on the final emission factors values
- The methodology will require inputs specific to variable factors like % occupancy, routes, etc. for passenger travel and % loading, gross capacity, etc. for material transport
- Lack of certain data inputs would necessitate assumptions and with time and availability of the data this methodology can be refined further

## 4. Proposed Methodology

Based on the assessment of the two methodologies, it is proposed that this study align its methodology to the methodology based on fuel efficiencies (second methodology). As described earlier, the limitations pertaining to availability of data at the national level for specific vehicle types has necessitated the use of the second methodology. However, the methodology based on fuel efficiencies have been modified to consider various conditions and assumptions, based on the mode of transport. The modes of transport covered in the scope of this technical paper include

Passenger travel:

1. Two Wheelers (Motorcycles)- kg $CO_2$/km
2. Three Wheelers (Auto rickshaws)- kg $CO_2$/km
3. Four Wheeler (Passenger cars) – kg $CO_2$/km
4. Public transport (Intra city Buses)- kg $CO_2$/passenger-km

Material Transport

1. Freight vehicles (Light and heave trucks)- kg $CO_2$/km

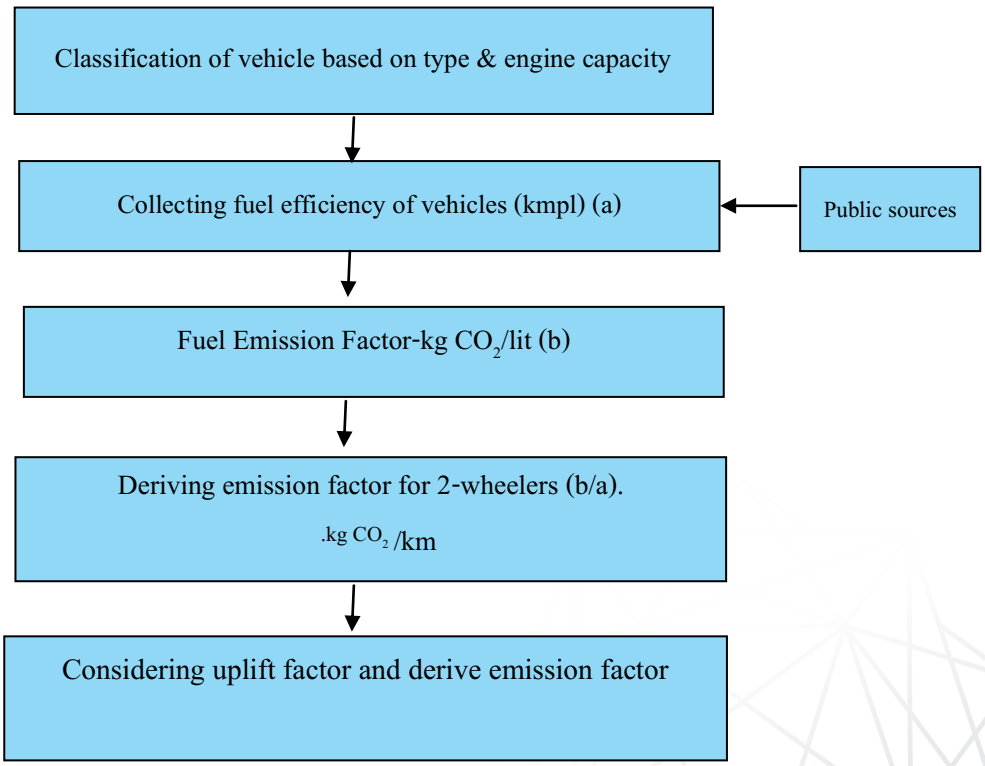
### *4.1 Methodology-Two Wheeler*

Employee commute comprises of commute through either individually or through a combination of cars, bus, motorcycles or cycling. For many organisations, employee commute by motorcycles could be a major source of GHG emissions.

For calculating emission factors for motorcycles commute, the average fuel efficiency is utilized. However, this methodology has not considered any classification for the motorcycles.

For the methodology, the main input is the fuel efficiency of the vehicle. The Indian two wheeler market has various types of motorcycle models and most of the motorcycles (including scooters) have a reported fuel efficiency range of 35-60 KMPL. This methodology refers to fuel efficiency values reported by the companies on public platform. The National Transport Development Policy Committee (Government of India) in “Moving India to 2032”. The reported value for fuel efficiency of motorcycles is 44.5 KMPL, however with reference to the values declared by the automobile companies, there is significant deviation between scooters, motorcycles. Hence based on the input from the working group, the 2-wheelers are categorized into scooters and motorcycles and further classified based on engine capacity. Following is the categorization adopted for two-wheelers:

| Sr.No | Category | CC | Example Models |
|---|---|---|---|
| 1 | Scooter | <110 CC | Pep Plus, Streak, Scooty Teenz, Pleasure. Pleasure IBS, Aviator, Maestro, Activa, Dio, Jupiter, Scooty, Zest, Wego, Gusto, etc. |
| 2 | Scooter | <150 CC | Alpha, Fascino, Ray-Z, Activa, Rodeo, etc. |
| 3 | Motorcycle | <100 CC | Discover DTSI, Splendour 100, HF Dawn, HF Deluxe, HF deluxe Eco, Passion Pro ,Passion Pro 100. Ismart, Splendour Plus, Splendour Classic, Splendour Pro, Splendour Pro, CT 100, etc. |
| 4 | Motorcycle | <125 CC | Platina, Discover 100, CB Twister, Dream Neo ,Dream Yug. Livo, Twister, Passion Pro TR, Passion X Pro , CD Dream 110, Jive, Max R, Star, Centuro , etc. |
| 5 | Motorcycle | <135 CC | Glamour, Glamour I, Ignitor, Super Splendour, CBF Stunner, Shine, Stunner, Discover, Flame, Phenoix, Pulsar 135 |
| 5 | Motorcycle | <200 CC | Achiver, Hunk, Extreme, Extreme Sports, CB Trigger, CBR 150 R , Discover 150 S, Discover F150, Pulsar 150, Pulsar AS 150, F, FZ-S, Fazer, R15, CB Hornet, Apache, CB Unicorn, Pulsar 180, Apache |
| 6 | Motorcycle | <300 CC | Duke, RC , Avenger, Pulsar 200, Pulsar 200 NS, Pulsar AS 200, Pulsar RS 200, Pulsar 220, Karizma ZMR, Karizma R, CBR 250 R |
| 7 | Motorcycle | <500 CC | Twin Spark, Classic 350, Bullet Electra 350, Thunderbird 35, Bullet Electra 350, Duke RC , Classic 500 |

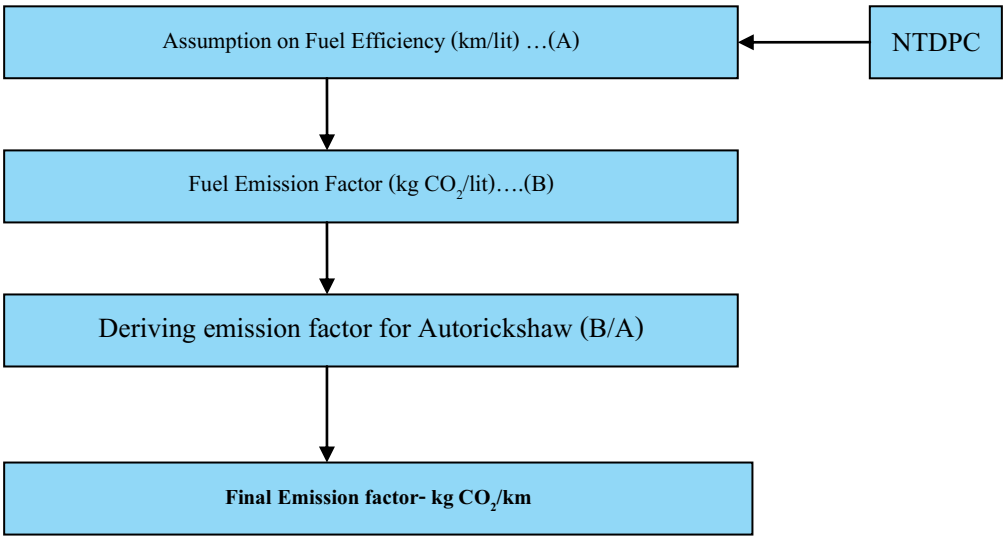


### *4.2 Methodology- Three Wheeler*

In the Indian scenario, three-wheeler travel is an important mode for passenger commute for shorter distance and is an essential form of urban transport. It is noted that the share of emissions from auto-rickshaw may be marginal when compared to other modes of transport for an organization, but can be accounted for when doing a GHG Inventorization.

These rickshaws rely on petrol, CNG and diesel as fuel sources. The seating capacity of a rickshaw is four including the driver's seat. There are very few auto-manufacturers in India and the market is dominated by Bajaj auto, Piaggio and TVS motors. The efficiency of the rickshaw does not vary significantly for petrol, diesel or CNG. The National Transport Development Policy Committee reports a fuel efficiency value of 20-25 km/l or km/kg.

The methodology for calculating the emission factor is described below:




### *4.3 Methodology- Four Wheeler (Passenger Cars)*

The Indian car market has grown substantially and at present is the 6$^{th}$ largest passenger and commercial vehicle producer in the world. The total number of registered vehicles in the year 2012-13 were 2.6 million vehicle units.[3]

The Indian car market caters to many types of cars with varying fuel efficiencies. Hence it becomes imperative to classify this section and ascertain relevant emission factors for each category. Society of Indian Automobile Manufacturers (SIAM) is a premier industry body representing 46 leading vehicle and vehicular engine manufacturers in India. SIAM works closely with all the concerned stakeholders and actively participates in formulation of rules, regulations and policies related to the automobile industry. SIAM has formulated certain parameters for segmentation of passenger cars. Initially, the segmentation was on the basis of length of the car, but recent change in segmentation methodology classifies the passenger car based on engines, length and price of models.

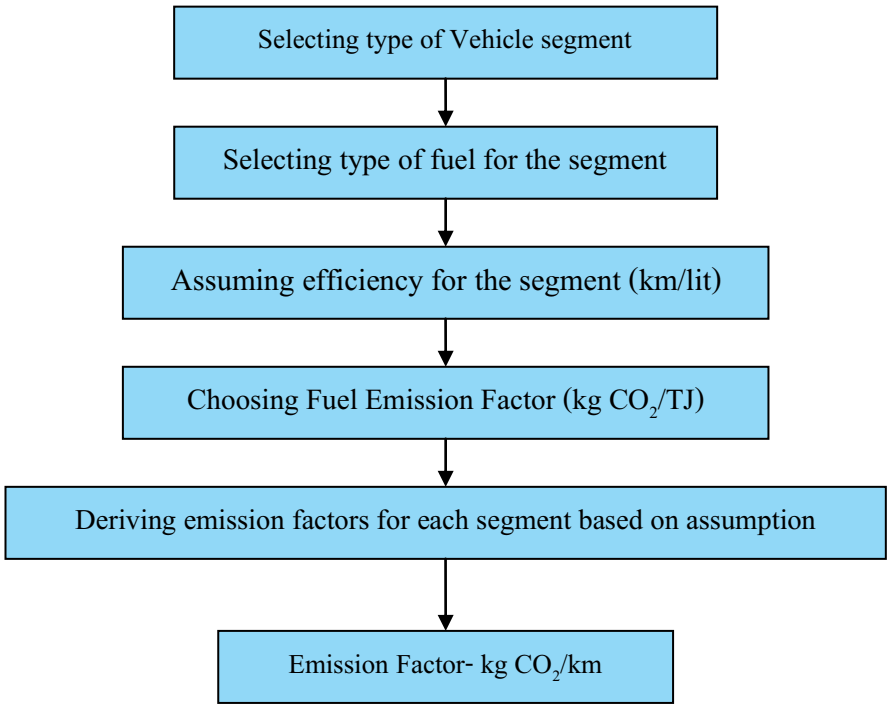
For ease of calculation and ease of uptake and utilization of thus derived emission factors, this methodology broadly classifies cars into three categories - hatchbacks, sedans and SUVs/MUVs and sub-classification based on engine capacity and type of fuel.

| | | | |
|---|---|---|---|
| 1 | Small | <800 CC | Nano, Nano, Alto 800, etc. |
| 2 | Hatchback | <1000 CC | EON, Spark ,Alto k10, Celerio, Wagon R, Ecosport |
| 3 | Hatchback | <1400 CC | Santro, i10, Punto, Indica, Figo, Etios, Swift, i10, Ritz, i20, Polo, Datsun, Micra, Pulse, Brio, Beat, Sail, Punto ,etc. |
| 4 | Premium Hatchback | <1600 CC | Mini Cooper, A180, 1Series Etc |
| 5 | Compact SUV | <1600 CC | Ecosports, Duster, Terrano, Etc. |
| 6 | Gypsy | 1298 CC | Gypsy |
| 7 | Sedan | <1400CC | Amaze, Swift Dzire, Indigo, Xcent, Manza, Amaze, Linea, Jetta, Octavia, Verna, etc. |
| 8 | Sedan | <1600 CC | City, Scala, Sunny, SX4, Verna, Fiesta, Polo, Rapid, Verito, etc. |
| 9 | Sedan | <2000 CC | Elantara, Altis, Octavia, Superb, Passat, etc. |
| 10 | Sedan | <2500 CC | Sonata, Kizashi, Camry, Verna, Etc. |
| 11 | SUV | <2000 CC | Sumo, Yeti, MUV-7, etc. |
| 12 | SUV | <2500 CC | Scorpio, Aria, Safari, Xenon, Captiva, Pajero, Thar |
| 13 | SUV | <3000 CC | Fortuner, CRV, Endevaour, Sumo, XUV 500, rexton, etc. |
| 14 | MUV | <2000 CC | Innova, Tavera, Enjoy, etc. |
| 15 | MUV | <1400 CC | Eritga, Mobilio, enjoy etc. |
| 16 | MUV | <2500 CC | Enjoy, Innova, etc. |
| 17 | Premium SUV | <2000 CC | Evoque, X1, b180, etc. |
| 18 | Premium SUV | <3000 CC | Range Rover, etc. |
| 19 | Premium SUV | >3000 CC | CLS, ML, G63 AMG, etc. |
| 20 | Premium Sedan | <2000 CC | C200, 3 series, jaguar, XF2L, etc. |
| 21 | Premium Sedan | <3000 CC | 7 Series, XF 3L, F Type, z4, etc. |
| 22 | Premium Sedan | >3000 CC | SLK 360, SLS AMG, etc. |
| 23 | Hybrid | <2000 CC | Prius |
| 24 | Maxi Van | - | Winger, Traveller, etc. |



[3] SIAM-Domestic Sale Trends

The methodology involves utilizing the fuel efficiencies as reported by manufacturers and adding a conservative reduction value (uplift factors) to account for change in test driving and real driving conditions. The following is schematic representation of the methodology for calculating the emissions.




### *4.4 Methodology- Public Transport (Buses)*

Employee and business commute from bus travel is a source of GHG emissions for many organizations and is generally accounted in Scope 3. The bus transport in India is dominated by State Transport Utilities (STUs). These STUs operate the fleet of buses both inter-state and intra-state.

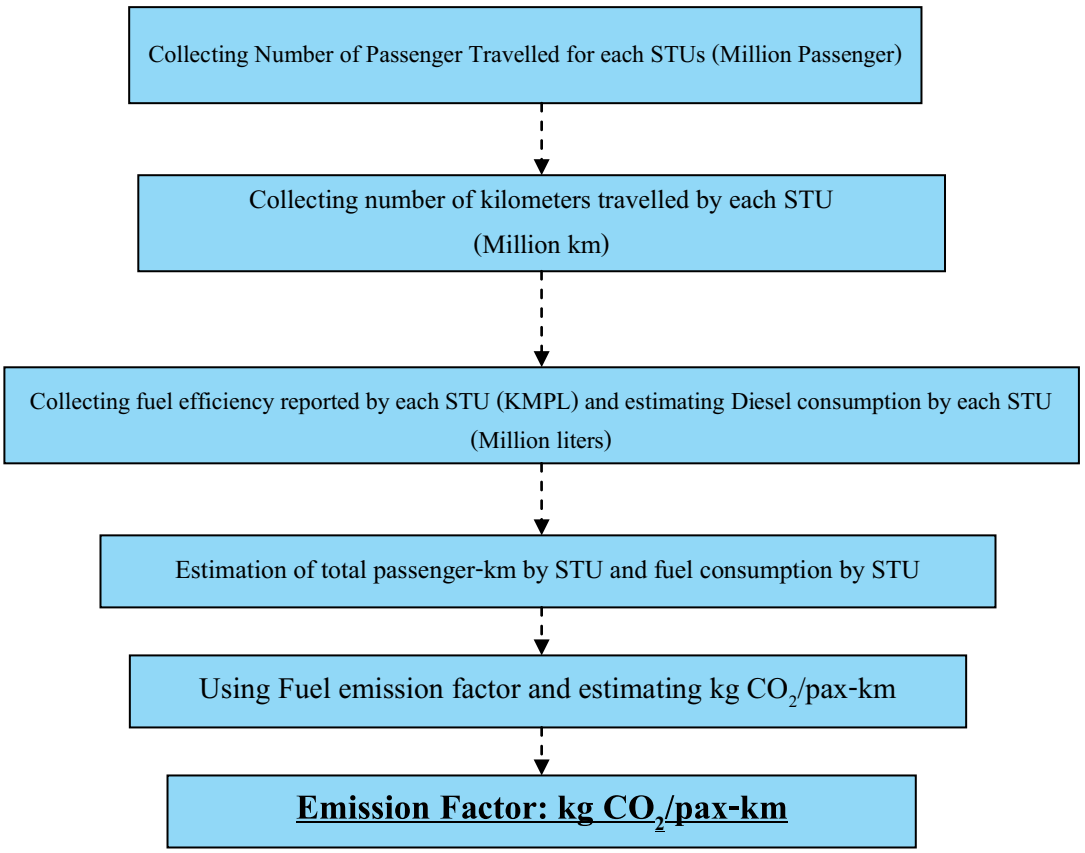
For the estimation of GHG emission factors from bus transport the basic data input for the methodology include

1. Average mileage of the fleets
2. Passenger travelled in a year (or daily passenger commute)
3. Effective kilometers travelled by utiliti es in a year (or daily kilometers)
4. Fuel consumption data (yearly)
5. Distribution of buses (fleet) between different types of fuels (Diesel/CNG)

The STUs monitor the parameters mentioned above, as this data constitute operational/physical performance of the utilities. Each STU, on a yearly basis is directed to submit the operational and financial performance data to Central Institute of Road Transport (CIRT) under the Association of State Road Transport. The operational data and financial data is then combine d and published on a yearly basis and is made publicly available.

The methodology will directly use publicly available data from CIRT to derive the emissions factors from bus transport under State Transport Utilities. These emission factors can also be used for private buses as the situation or conditions in which they operate are relatively similar to the STUs.

The methodology for estimating the emission factors from bus transport is explained as follows:




### *4.5 Methodology- Freight Vehicles (Light and Heavy Trucks)*

Freight by Light Duty Vehicles (LDV) and Heavy Duty vehicles (HDV) is one of the major emission sources for an organization. The LDVs and HDVs also constitute a major share (50%) of GHG emissions from the transport sector in the country[4]. Usually, the organization uses the vehicles for raw material, fuel, product, etc. transport. For a manufacturing industry, the emission from logistics can be major scope 3 emission sources.

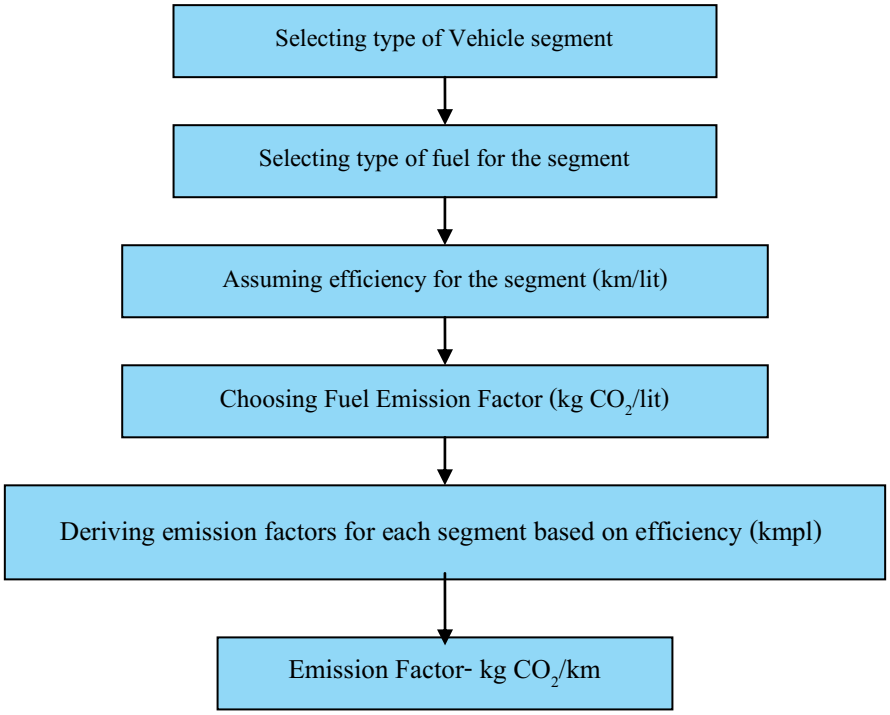
For transportation of goods, there are different categories of vehicles, these vehicles are classified as per the Central Motor Vehicle Rules, 1989 and are as follows:

| Category | Criteria |
|---|---|
| N 1 | Means a vehicle used for carriage of goods and having a GVW not exceeding 3.5 ton. |
| N 2 | A vehicle used for the carriage of goods and having a GVW exceeding 3.5 ton but not exceeding 12 ton. |
| N 3 | Means a vehicle used for the carriage of goods and having a GVW exceeding 12 ton |

The methodology for estimation of emission factor from freight transport cannot be done on the basis of overall fuel consumption since currently the accurate data is not available.

The methodology adopted for the estimation of emission factor for freight transport is on the basis of fuel efficiency and gross weight. In India, currently there are no regulations pertaining to mandatory disclosure of vehicular efficiency and is still voluntary. For fuel efficiency the methodology rely on fuel efficiency studies by other institutions. Following is the method adopted for estimation of emission factor from freight transport. The emission factor derived by this methodology will be in kg $CO_2$/km. The organization using the data in form of Tonnes-km, need to divide the number with the gross capacity of the vehicle and the emission factor should be in kg CO2/ton-km.

Following is the methodology adopted for freight transport by LDV and HDVs:

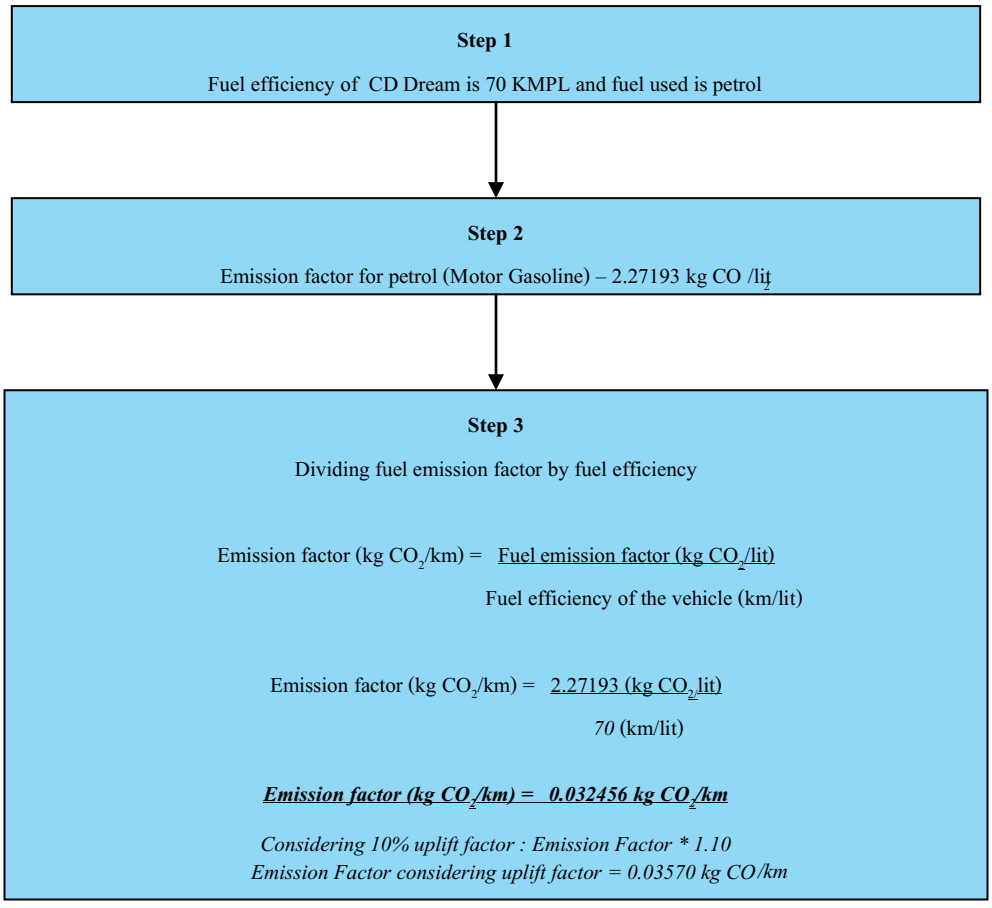



[4] *Fuel Efficiency Standards of Heavy Duty Vehicles in India, Shakti Foundation (2013)*

## 5. Calculation of Emission Factors

### *5.1 Two Wheeler Emission Factor*

The emission factor for two-wheelers is calculated using the methodology discussed in the previous section. The methodology followed for estimation of emission factor for motorcycles and scooters is as show below. The methodology uses the published fuel efficiency and fuel emission factor for the calculation of the emission factor. The emission factor calculation is as shown below:




Based on the above method, the emission factor is calculated for more than 100 motorcycles and scooters available in India and averaged for motorcycles based on engine capacity and type. The data inputs for the emission factor have been referred from publicly available sources.

Following are the sources referred for the data inputs:

1. Fuel efficiency: National Transport Development Policy Committee (Government of India), Automotive Research Association of India, publicly available sources, manufacturers' website, etc.

2. Fuel emission factor: Intergovernmental Panel on Climate Change (IPCC)

### 5.1.1 Summary of Emission Factor calculated for two wheelers

| Particulars | | | Emission Factor | |
|---|---|---|---|---|
| Sr.No | Category | Engine CC | kg $CO_2$/km | kg $CO_2$/km @10 uplift factor |
| 1 | Scooter | <110 CC | 0.0334 | 0.0368 |
| 2 | Scooter | <150 CC | 0.0351 | 0.0387 |
| 3 | Motorcycle | <100 CC | 0.0325 | 0.0358 |
| 4 | Motorcycle | <125 CC | 0.0290 | 0.0319 |
| 5 | Motorcycle | <135 CC | 0.0324 | 0.0356 |
| 5 | Motorcycle | <200 CC | 0.0417 | 0.0458 |
| 6 | Motorcycle | <300 CC | 0.0540 | 0.0595 |
| 7 | Motorcycle | <500 CC | 0.0542 | 0.0597 |

### *5.2 Three Wheeler Emission Factor*

The emission factor for three-wheelers is calculated using the methodology discussed in the previous section. The emission factor for two-wheelers is 0.05163 kg $CO_2$/km. The methodology uses the published fuel efficiency and fuel emission factor for the calculation of the emission factor. The emission factor calculation is as below:

**Step 1**

Fuel efficiency of three-wheelers is 20 KMPL and 25 KM/kg fuel used is petrol/diesel and CNG

**Step 2**

Emission factor for petrol (Motor Gasoline) – 2.27193 kg $CO_2$/lit

Emission factor for Diesel – 2.6444 kg $CO_2$/lit

Emission factor for CNG – 2.692 kg CO2/kg

**Step 3**

Dividing fuel emission factor by fuel efficiency

$$\text{Emission factor (kg } CO_2\text{/km)} = \frac{\text{Fuel emission factor (kg } CO_2\text{/lit)}}{\text{Fuel efficiency of the vehicle (km/lit)}}$$

$$\text{Emission factor (kg } CO_2\text{/km)} = \frac{2.27193 \text{ (kg } CO_2\text{lit)}}{20 \text{ (km/lit)}} \text{ ….. (Petrol)}$$

$$\text{Emission factor (kg } CO_2\text{/km)} = \frac{2.6444 \text{(kg } CO_2\text{lit)}}{20 \text{ (km/lit)}} \text{ ….. (Diesel)}$$

$$\text{Emission factor (kg CO2/km)} = \frac{2.692 \text{(kg } CO_2\text{lit)}}{25 \text{ (km/lit)}} \text{ ….. (Diesel)}$$

***Emission factor (kg $CO_2$/km) = 0.1135 kg $CO_2$/km ….(Petrol)***

***Emission factor (kg $CO_2$/km) = 0.13222 kg $CO_2$/km ….(Diesel)***

***Emission factor (kg $CO_2$/km) = 0.10768 kg $CO_2$/km ….(CNG)***

### 5.2.1 Summary of Emission Factor calculated for three wheelers

| S.No. | Category | kg $CO_2$/km |
|---|---|---|
| 1 | Petrol | 0.1135 |
| 2 | Diesel | 0.1322 |
| 3 | CNG | 0.10768 |

### 5.3 Four-Wheeler Emission Factor

The first step in determining emission factors for each of the three categories specified for cars, is determining a fuel efficiency value for each category.

The vehicles are classified based on type and further sub-classified based on engine size and fuel used in vehicles. The fuel efficiency of vehicles are collected from ARAI and other publicly available sources. For more than 350 vehicles, the declared efficiency and other details were referred from public sources and then combined.

One of the assumptions made in the emission factor calculation is on uplift factor as the declared efficiency are based on Indian Driving Cycle and is not representative of actual efficiency achieved by the users. Thus, the uplift factor is an assumption on how much the efficiency is deteriorated based on actual conditions. As the fuel efficiency of vehicle is dependent on a variety of factors such as driving habits, maintenance of vehicles, weather, terrain, road conditions, kerb weight, etc., the calculating uplift factor is an uphill task. Hence for a single uplift factor, consultation and deliberations were made to arrive at. Based on consensus it was decided to refer a research study or to conduct a survey. For considering the uplift factor, publicly available sources were referred to and the deviation was between 4-20%.

A conservative uplift factor of 8%[5] was applied to arrive at actual emission factor. The number is referred from a study by research scholars from Central Road Research Institute, (CRRI).



[5] Evaluation of variability in on-road vehicle fuel consumption under controlled conditions, Central Road Research Institute

**Step 1**

Average Fuel Efficiencies

Hatchbacks: 16.42 KMPL (Petrol), 18.8 KMPL (Diesel)

Sedans: 14.9 KMPL (Petrol), 19.6 KMPL (Diesel)

MUVs/SUVs – 11.6 KMPL (Petrol), 13.6 KMPL (Diesel)

**Step 2**

Emission factor for petrol (Motor Gasoline) – 2.27193 kg $CO_2$/lit

Emission factor for petrol (Diesel) – 2.6444 kg $CO_2$/lit

**Step 3**

Dividing fuel emission factor by fuel efficiency

$$\text{Emission factor (kg } CO_2\text{/km)} = \frac{\text{Fuel emission factor (kg } CO_2\text{/lit)}}{\text{Fuel efficiency of the vehicle (km/lit)}}$$

**Hatchback**

Emission factor (kg $CO_2$/km) = 2.27193(kg $CO_2$lit) ….. (Petrol)

*16.42* (km/lit)

Emission factor (kg $CO_2$/km) = 2.6444(kg $CO_2$lit) ….. (Diesel)

*18.8* (km/lit)

**Sedans**

Emission factor (kg $CO_2$/km) = 2.27193(kg $CO_2$lit) ….. (Petrol)

*14.9* (km/lit)

Emission factor (kg $CO_2$/km) = 2.6444(kg $CO_2$lit) ….. (Diesel)

*19.6* (km/lit)

**MUVs/SUVs**

Emission factor (kg $CO_2$/km) = 2.27193(kg $CO_2$lit) ….. (Petrol)

*11.60* (km/lit)

Emission factor (kg $CO_2$/km) = 2.6444(kg $CO_2$lit) ….. (Diesel)

*13.6* (km/lit)

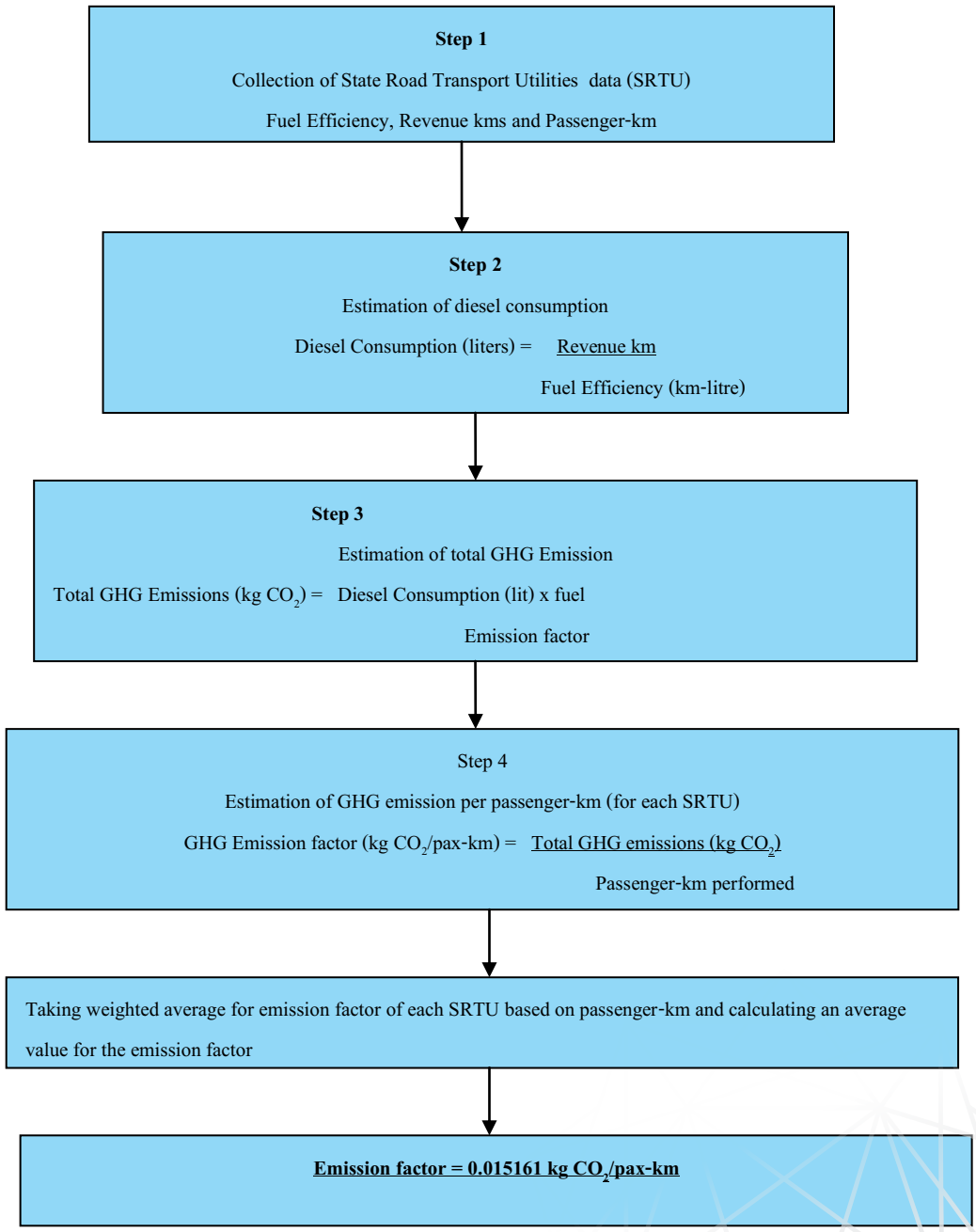
### 5.3.1 Summary of Emission Factor calculated for four wheelers

Based on the above calculations, the estimated India specific emission factors for passenger cars and considering uplift factor of 8% are:

| Sr. No | Type of Car | Category | Fuel | Emission Factor (kg CO2/km) | Emission Factor (kg CO2/km) with uplift factor |
|---|---|---|---|---|---|
| 1 | Small | <800 CC | Gasoline | 0.103 | 0.111 |
| 2 | Small | <800 CC | CNG | 0.063 | 0.068 |
| 3 | Small | <800 CC | LPG | 0.138 | 0.149 |
| 4 | Hatchback | <1000 CC | Gasoline | 0.117 | 0.127 |
| 5 | Hatchback | <1400 CC | Gasoline | 0.130 | 0.140 |
| 6 | Premium Hatchback | <1600 CC | Gasoline | 0.150 | 0.162 |
| 7 | Compact SUV | <1600 CC | Gasoline | 0.153 | 0.166 |
| 8 | Gypsy | 1298 CC | Gasoline | 0.189 | 0.204 |
| 9 | Sedan | <1400CC | Gasoline | 0.142 | 0.153 |
| 10 | Sedan | <1600 CC | Gasoline | 0.142 | 0.153 |
| 11 | Sedan | <2000 CC | Gasoline | 0.149 | 0.161 |
| 12 | Sedan | <2500 CC | Gasoline | 0.163 | 0.176 |
| 13 | SUV | <3000 CC | Gasoline | 0.197 | 0.213 |
| 14 | MUV | <2000 CC | Gasoline | 0.213 | 0.230 |
| 15 | Premium SUV | <2000 CC | Gasoline | 0.193 | 0.208 |
| 16 | Premium SUV | <3000 CC | Gasoline | 0.258 | 0.279 |
| 17 | Premium SUV | >3000 CC | Gasoline | 0.267 | 0.289 |
| 18 | Premium Sedan | <2000 CC | Gasoline | 0.191 | 0.207 |
| 19 | Premium Sedan | <3000 CC | Gasoline | 0.194 | 0.209 |
| 20 | Premium Sedan | >3000 CC | Gasoline | 0.250 | 0.270 |
| 21 | Hybrid | <2000 CC | Gasoline | 0.095 | 0.103 |
| 22 | Hatchback | <1000 CC | Diesel | 0.105 | 0.113 |
| 23 | Hatchback | <1400 CC | Diesel | 0.117 | 0.126 |
| 24 | Hatchback | <1600 CC | Diesel | 0.136 | 0.147 |
| 25 | Sedan | <1400 CC | Diesel | 0.121 | 0.131 |
| 26 | Sedan | <1600 CC | Diesel | 0.131 | 0.141 |
| 27 | Sedan | <2000 CC | Diesel | 0.148 | 0.160 |
| 28 | Premium Sedan | <2000 CC | Diesel | 0.164 | 0.177 |
| 29 | Premium Sedan | <2500 CC | Diesel | 0.151 | 0.163 |
| 30 | Premium Sedan | <3000 CC | Diesel | 0.230 | 0.248 |
| 31 | MUV | <1400 CC | Diesel | 0.145 | 0.157 |
| 32 | MUV | <2500 CC | Diesel | 0.200 | 0.216 |
| 33 | Maxi Van | - | Diesel | 0.209 | 0.226 |
| 34 | SUV | <2000 CC | Diesel | 0.186 | 0.201 |
| 35 | SUV | <2500 CC | Diesel | 0.195 | 0.210 |
| 36 | SUV | <3000 CC | Diesel | 0.203 | 0.220 |
| 37 | Premium SUV | <2000 CC | Diesel | 0.167 | 0.180 |
| 38 | Premium SUV | <2500 CC | Diesel | 0.199 | 0.215 |
| 39 | Premium SUV | <3000 CC | Diesel | 0.222 | 0.240 |
| 40 | Premium SUV | >3000CC | Diesel | 0.269 | 0.290 |

### *5.4 Bus Emission Factor*

The emission factor for bus commute is calculated using the methodology discussed in the previous section. The methodology uses the published fuel efficiency (based on real/operating conditions) and fuel emission factor for the calculation of the emission factor. The emission factor calculation is as below:




The data inputs for the emission factor have been referred from publically available sources. Following are the sources referred for the data inputs:

1. Fuel efficiency : State SRTUS (Open Government Data Platform India)
2. Passenger-km – State SRTUS (Open Government Data Platform India)
3. Revenue-km – State SRTUS (Open Government Data Platform India)

Fuel emission factor: Intergovernmental Panel on Climate Change (IPCC) & India GHG Report 2007

### 5.4.1 Summary of Emission Factor calculated for Bus (Intracity)

The calculated emission factor for bus transport is 0.015161 kg $CO_2$/pax-km. The emission factor is not applicable to Bus Rapid Transport System (BRTS) and intercity transport, as the loading and passenger-km will differ significantly from intracity transport.

## *5.5 Freight Transport Emission Factor*

The emission factor for LDVs and HDVs is calculated using the methodology discussed in the previous section. The methodology followed for estimation of emission factor for LDVs and HDVs is as below and the methodology uses the published fuel efficiency (by third party) and fuel emission factor for the calculation.

Following are the sources referred for the data inputs:

1. Fuel efficiency: National Transport Development Policy Committee (Government of India), Automotive Research Association of India, publicly available sources, manufacturers' website, etc.
2. Fuel emission factor: Intergovernmental Panel on Climate Change (IPCC)

The emission factor calculation is as below:

**Step 1**

Average Fuel Efficiencies

LDVs: 8.58 KMPL (Diesel)

MDVs: 4.46 KMPL (Diesel)

HDVs, 3.59 KMPL (Diesel)

**Step 2**

Emission factor for petrol (Diesel) – 2.6444 kg $CO_2$/lit

**Step 3**

Dividing fuel emission factor by fuel efficiency

$$\text{Emission factor (kg } CO_2\text{/km)} = \frac{\text{Fuel emission factor (kg } CO_2\text{/lit)}}{\text{Fuel efficiency of the vehicle (km/lit)}}$$

**LDVs**

$$\text{Emission factor (kg } CO_2\text{/km)} = \frac{2.6444 \text{ (kg } CO_2\text{ lit)}}{8.58 \text{ (km/lit)}} \text{ ….. (Diesel)}$$

**MDVs**

$$\text{Emission factor (kg } CO_2\text{/km)} = \frac{2.6444 \text{ (kg } CO_2\text{ lit)}}{4.46 \text{ (km/lit)}} \text{ ….. (Diesel)}$$

**HDVs**

$$\text{Emission factor (kg } CO_2\text{/km)} = \frac{2.6444 \text{ (kg } CO_2\text{ lit)}}{3.59 \text{ (km/lit)}} \text{ ….. (Diesel)}$$

***LDV Emission factor (kg $CO_2$/km) = 0.3070 kg $CO_2$/km ….(Diesel)***

***MDV Emission factor (kg $CO_2$/km) = 0.5928 kg $CO_2$/km ….(Diesel)***

***HDV Emission factor (kg $CO_2$/km) = 0.7353 kg $CO_2$/km ….(Diesel)***

### 5.3.1 Summary of Emission Factor calculated for freight vehicles

| Sr.No | Category | kg $CO_2$/km |
|---|---|---|
| 1 | LDV (<3.5T) | 0.3070 |
| 2 | MDV (<12T) | 0.5928 |
| 3 | HDV (>12 T) | 0.7375 |

The organization can use this data directly, if the activity data is in form of kilometers travell ed and in case the data is in form of tones-km, the emission factor is to be divided by the gross capacity of the vehicle based on the category.

INDIA GHG PROGRAM

Promoting profitable, sustainable and competitive businesses.

# India GHG Program:

The India GHG Program acts as a 'Center of Excellence' by disseminating regional, sectoral and global best practices to create a culture of inventorisation and benchmarking of GHG emissions in India. To accomplish this, the primary objective of the India GHG Program will be to build institutional capabilities in Indian businesses and organizations. The India GHG Program brings together internationally recognized GHG accounting and measurement tools and methodologies that serve to create a key platform that facilitates national level benchmarking of GHG emissions and incentivises and rewards sustainable business initiatives. India GHG Program seeks a multi-stakeholder approach through effective representation of stakeholders (such as other industry associations, sector associations, ministries and government agencies, civil society organisations, and experts) in promoting a standardised approach to GHG accounting.

Indian businesses recognise the incentives of sustainable business practices but are challenged by a lack of uniformity in GHG measurement guidelines and a national benchmarking system. The lack of clear policy and regulatory directives, limited access to clean technology, absence of methods for footprinting data and inadequate institutional capacity act as constraints on the ability of middle managerial level business leaders to manage and measure GHG emissions. The India GHG Program will address the needs and expectations of industry in building capacity to mitigate economic, social and environmental risks while helping businesses remain profitable, competitive and sustainable.

The program offers a unique threefold proposition – expertise and recognition from three renowned organisations - WRI India, TERI and CII. It is a voluntary and flexible program influenced by and aligned to business expectations as compared to others that have a clearly defined agenda and methodology. It offers a value proposition to businesses in incorporating mitigation of carbon related risks into the overall business strategy – starting with capacity building, measurement and management of GHG Emissions, reporting and target setting, identifying reduction opportunities and ending with exploration of further avenues in carbon neutrality. The India GHG Program offers businesses public visibility and specialised incentives through improved efficiency and profitability. The India GHG Program also offers businesses opportunities to engage with industry, sectorial and regional peers on a single platform and access to policy makers and civil society to initiate dialog on actions businesses take and challenges they face in reducing GHG emissions.

For more details and membership :
India GHG Program Secretariat
1st Floor, WRI India, Godrej and Boyce Premises, Gasworks Lane, Lalbaug,
Parel, Mumbai-400012. Tel: +91 (22) 2471 3565 / indiaghgpsecretariat@wri-india.org

http://indiaghgp.org

Partners

teri

CII

WRI INDIA

Supported by

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

SHAKTI SUSTAINABLE ENERGY FOUNDATION

PIROJSHA GODREJ FOUNDATION