GHG Inventory – Mobile combustion-

Road Transportation

Training on 2006 IPCC Guidelines for preparing National GHG Inventory:

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Organized by the Capacity Building Initiative for Transparency
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INTERGOVERNMENTAL PANEL ON climate change

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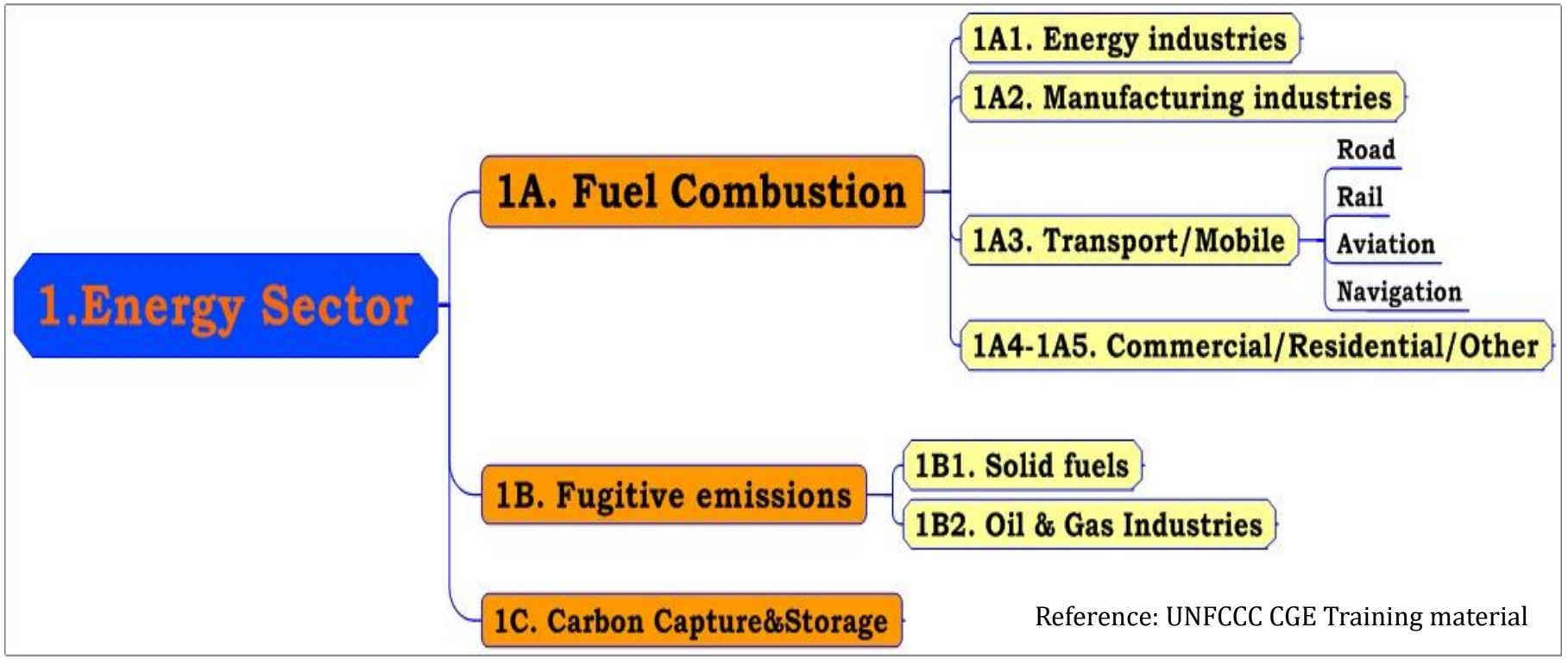
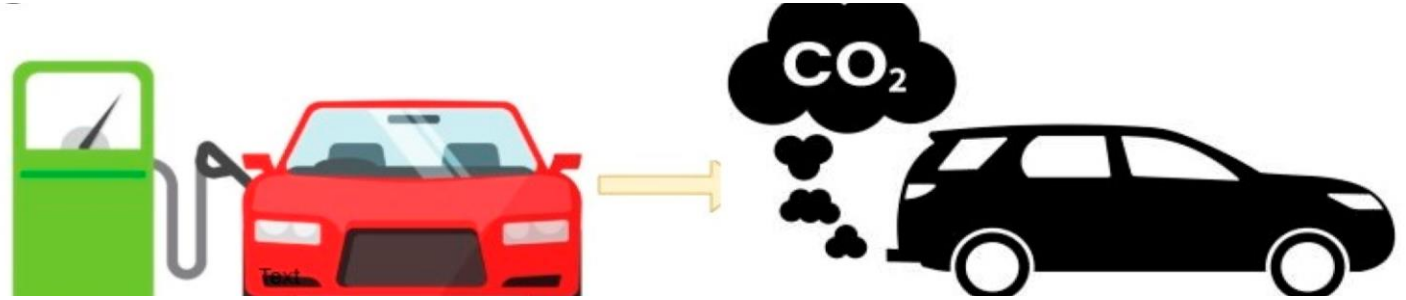
- Road transportation coverage in 2006 IPCC guideline
- Road transportation in Philippine GHGI, 2010
- Calculation examples and exercises – Manually & using IPCC inventory tool

Introduction

Energy Sector



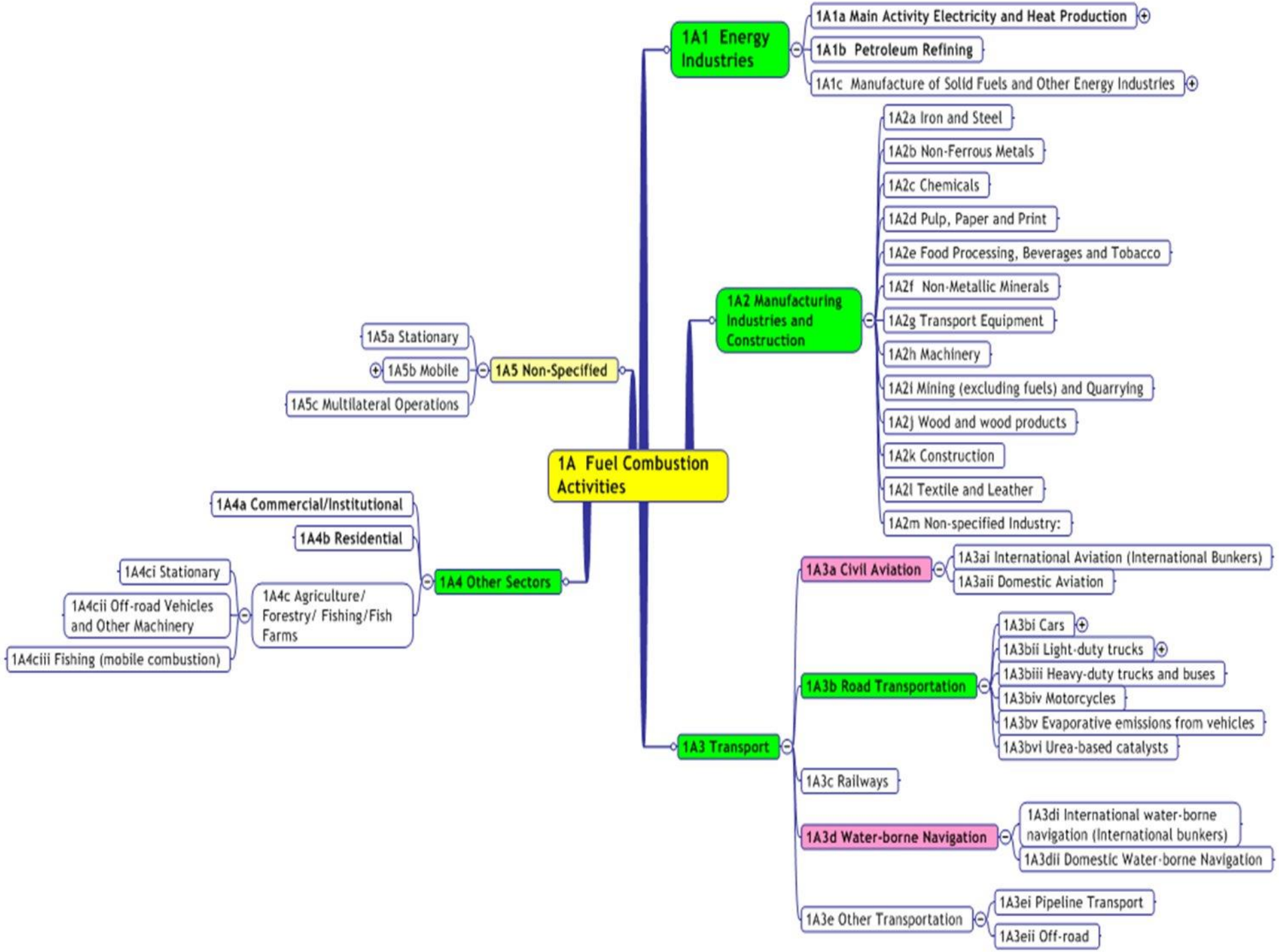
Reference: UNFCCC CGE Training material



Total GHG emissions-2010 in the Philippines (Million tons of CO_2e)

	CO_2	CH_4	N_2O	HFCs	Total
Energy	50.698	1.888	0.519	-	53.105
Agriculture	0.696	33.853	8.604	-	43.152
Transport	23.718	0.125	0.331	-	24.174
Waste	0.015	14.527	1.017	-	15.559
IPPU	7.564	0.009	0.019	0.771	8.363
FOLU	(37.016)	0.007	0.002	-	(37.007)
	TOTAL				107.345

GHG Inventory Report-2010
Philippines


1A Fuel Combustion Activities
1A1 Energy Industries
1A1a Main Activity Electricity and Heat Production
1A1b Petroleum Refining
1A1c Manufacture of Solid Fuels and Other Energy Industries
1A2 Manufacturing Industries and Construction
1A2a Iron and Steel
1A2b Non-Ferrous Metals
1A2c Chemicals
1A2d Pulp, Paper and Print
1A2e Food Processing, Beverages and Tobacco
1A2f Non-Metallic Minerals
1A2g Transport Equipment
1A2h Machinery
1A2i Mining (excluding fuels) and Quarrying
1A2j Wood and wood products
1A2k Construction
1A2l Textile and Leather
1A2m Non-specified Industry:
1A3 Transport
1A3a Civil Aviation
1A3ai International Aviation (International Bunkers)
1A3aii Domestic Aviation
1A3b Road Transportation
1A3bi Cars
1A3bii Light-duty trucks
1A3biii Heavy-duty trucks and buses
1A3biv Motorcycles
1A3bv Evaporative emissions from vehicles
1A3bvi Urea-based catalysts
1A3c Railways
1A3d Water-borne Navigation
1A3di International water-borne navigation (International bunkers)
1A3dii Domestic Water-borne Navigation
1A3e Other Transportation
1A3ei Pipeline Transport
1A3eii Off-road
1A4 Other Sectors
1A4a Commercial/Institutional
1A4b Residential
1A4c Agriculture/ Forestry/ Fishing/Fish Farms
1A4ci Stationary
1A4cii Off-road Vehicles and Other Machinery
1A4ciii Fishing (mobile combustion)
1A5 Non-Specified
1A5a Stationary
1A5b Mobile
1A5c Multilateral Operations

1A. Fuel Combustion: CO_2

- **CO_2 emissions depend almost entirely on the carbon content of the fuel, though a small amount of carbon is un-oxidized (less than 1%).**

- **During the combustion process, most carbon is immediately emitted as CO2 regardless combustion technology**

- **By default *the 2006 IPCC Guidelines* assume a complete combustion process (100% carbon conversion or oxidation fraction is 1)**

C + O2 = CO2

1 tonne C => 3.667 tonne CO2

(44/12)

Reference: UNFCCC CGE Training material

1A. Fuel Combustion: Fuels

- **SOLID** (Coal and Coal Products)
  - including Coal, Coke and Derived Gases
- **LIQUID** (Crude Oil and Petroleum Products)
  - Including Fuel Oil, Gasoline, LPG, Ethane and Petroleum Coke
- **GAS** (Natural Gas)
- **OTHER FOSSIL FUELS** (Non-biomass municipal & Industrial wastes, waste oils)
- **PEAT**
  - treated as fossil fuel
- **BIOMASS** (Wood, Charcoal, Biofuels, Biomass fraction of MSW)
  - CO_2 emissions not included in total Energy emissions

✓ ***See definition of fuel types in Table 1.1, Volume 2, 2006 IPCC Guidelines***

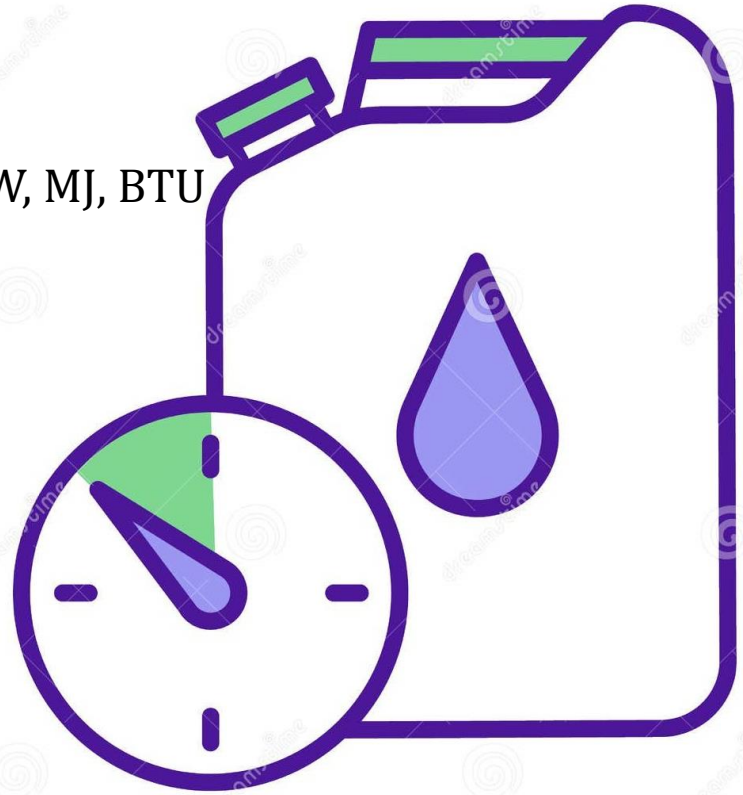
Reference: UNFCCC CGE Training material

1A. Fuel Combustion: Units

The carbon content may vary considerably both among and within primary fuel types on a per mass or per volume basis. By converting to energy units this variability is reduced.

<u>Fuel units:</u>

- **Volume:** barrels (gallons), cubic feet, cubic meters, litres
- **Mass:** tonnes, kg
- **Energy (*expressed as either NCV or GCV*):** oil/coal-equivalent, calories, kW, MJ, BTU



<u>The 2006 IPCC Guidelines - SI units :</u>

1. Fuel – Gg (TJ)
2. NCV – TJ/Gg
3. Carbon content – kg/GJ
4. CO_2 EF – kg/TJ (*per energy basis*)

Reference: UNFCCC CGE Training material

IPCC Energy Units

	NCV, TJ/Gg	Carbon Content, kg/GJ	Default CO_2 EF, kg/TJ
Biomass (Wood)	15.6	30.5	112 000
Peat	9.76	28.9	106 000
Lignite	8.9	27.6	101 000
Anthracite	26.7	26.8	98 300
Coking Coal	28.2	25.8	94 600
Residual Fuel Oil	40.4	21.1	77 400
Diesel Oil	43	20.2	74 100
Motor Gasoline	44.3	18.9	69 300
Natural Gas	48	15.3	56 100

Reference: UNFCCC CGE Training material

NCV vs. GCV

- **Some statistical offices use gross calorific values (GCV)**

- **The difference between NCV and GCV is the latent heat of vaporisation of the water produced during combustion of the fuel:**
  - for coal and oil, the NCV is about 5 % less than the GCV
  - for most natural and manufactured gas, the NCV is about 10 % less

- **Where fuel characteristics (**moisture, hydrogen and oxygen contents**) are known, the 2006 IPCC Guidelines give a more precise method to convert GCV to NCV data:**

$$NCV = GCV - 0.212H - 0.0245M - 0.008Y$$

M – Moisture, H – Hydrogen, Y – Oxygen, %

Reference: UNFCCC CGE Training material

Exercise 2: CO_2 emissions - ?

1. Diesel burnt by:

- **Stationary source – a diesel-generator**
- **Mobile source – a car**

2. Amount of diesel burnt - 1 Giga-gram (or 1 201 923 litres, or 317 561 gallons)*

3. Assuming complete combustion

$$CO_2 \text{ emissions} = \text{Amount of Fuel} * NCV * EF$$

$$CO_2 \text{ emissions} = 1 * 43 * 74\,100 = 3\,186\,300 \text{ kg } CO_2$$

$$= 3.19 \text{ Gg } CO_2$$

Reference: UNFCCC CGE Training material

Non-CO_2: CH_4 and N_2O

- **Emission factors for non-CO_2 gases from fuel combustion are dependent on fuel and technology used** (operating conditions, control technologies, quality of maintenance, age of equipment)

- **Since the set of technologies, applied in each sector varies considerably, so do the emission factors**

- **Therefore it is not useful to provide default emission factors for these gases on the basis of fuels only**

Reference: UNFCCC CGE Training material

Non-CO_2: CH_4 and N_2O

TABLE 2.7
INDUSTRIAL SOURCE EMISSION FACTORS

		Emission factors[1] (kg/TJ energy input)	
Basic technology	**Configuration**	**CH_4**	**N_2O**
Liquid Fuels			
Residual Fuel Oil Boilers		3	0.3
Gas/Diesel Oil Boilers		0.2	0.4
Large Stationary Diesel Oil Engines >600hp (447 kW)		r 4	NA
Liquefied Petroleum Gases Boilers		n 0.9	n 4
Solid Fuels			
Other Bituminous/Sub-bit. Overfeed Stoker Boilers		1	r 0.7
Other Bituminous/Sub-bit. Underfeed Stoker Boilers		14	r 0.7
Other Bituminous/Sub-bituminous Pulverised	Dry Bottom, wall fired	0.7	r 0.5
	Dry Bottom, tangentially fired	0.7	r 1.4
	Wet Bottom	0.9	r 1.4
Other Bituminous Spreader Stokers		1	r 0.7
Other Bituminous/Sub-bit. Fluidised Bed Combustor	Circulating Bed	1	r 61
	Bubbling Bed	1	r 61
Natural Gas			
Boilers		r 1	n 1
Gas-Fired Gas Turbines[2] >3MW		4	1
Natural Gas-fired Reciprocating Engines[3]	2-Stroke Lean Burn	r 693	NA
	4-Stroke Lean Burn	r 597	NA
	4-Stroke Rich Burn	r 110	NA
Biomass			
Wood/Wood Waste Boilers[4]		n 11	n 7

Reference: UNFCCC CGE Training material

Non-CO_2: CH_4 and N_2O

TABLE 3.2.2
ROAD TRANSPORT N_2O AND CH_4 DEFAULT EMISSION FACTORS AND UNCERTAINTY RANGES [a]

Fuel Type/Representative Vehicle Category	CH_4 (kg /TJ)			N_2O (kg /TJ)		
	Default	Lower	Upper	Default	Lower	Upper
Motor Gasoline -Uncontrolled [b]	33	9.6	110	3.2	0.96	11
Motor Gasoline –Oxidation Catalyst [c]	25	7.5	86	8.0	2.6	24
Motor Gasoline –Low Mileage Light Duty Vehicle Vintage 1995 or Later [d]	3.8	1.1	13	5.7	1.9	17
Gas / Diesel Oil [e]	3.9	1.6	9.5	3.9	1.3	12
Natural Gas [f]	92	50	1 540	3	1	77
Liquified petroleum gas [g]	62	na	na	0.2	na	na
Ethanol, trucks, US [h]	260	77	880	41	13	123
Ethanol, cars, Brazil [i]	18	13	84	na	na	na

Reference: UNFCCC CGE Training material

Combustion Emissions – Higher Tiers

Tier 1

Amount of fuel combusted, default NCV, carbon content, CO_2 EF (complete combustion)

Emissions = AD * EF

Tier 2

Amount of fuel, country-specific NCV, carbon content and CO_2 EF (oxidation rate), N_2O EF, CH_4 EF

Tier 3

Emissions depend on fuel type used, combustion technology, operating conditions, control technology, quality of maintenance, age of the equipment used to burn the fuel – plant-specific EFs (measurements)

Reference: UNFCCC CGE Training material

Road Transport

- **All fuel sold in a country is included in national estimates even if a vehicle crosses a border or fuel exported in fuel tanks of vehicles**

- **Bio-fuels carbon removed from total and reported separately**

- **Carbon is also emitted from urea based catalysts and included here** (not strictly combustion)

- **CH_4 and N_2O strongly technology related. At higher tiers need to know technologies in fleet** (especially type and proportion of catalysts)

- **Caution with "fuel sold" data:**
  - overlaps with off-road and potentially other sectors (e.g. agriculture)
  - blended fuels (e.g. bio-ethanol) and lubricants
  - smuggling

Reference: UNFCCC CGE Training material

International bunker

Aviation and Shipping (water-borne navigation):

- **Domestic emissions included in National Total**
- **International emissions reported separately as *"Bunker Fuels"***

- **Domestic trips are journeys between points in one country**
- **International trips - between countries**

Reference: UNFCCC CGE Training material

Waste as a Fuel

- **Some waste incinerators also produce heat or power**
- **In such cases the waste stream will show up in national energy statistics and it is good practice to report these emissions under the energy sector**
- **This could lead to double counting when in the waste sector the total volume of waste is used to estimate emissions**
- **Only the fossil fuel derived fraction of CO_2 from waste is included in national total emissions**

Reference: UNFCCC CGE Training material

Reference Approach

Reference Approach is a top-down approach, using a country's energy supply data to calculate the emissions of CO_2 from fuel combustion:

CO2 emissions = (Apparent Consumption - Excluded Carbon) * EF

Apparent consumption = Production + Import - Export - International bunker - Stock change

- ✓ ***CO_2 only***
- ✓ ***used as a check for Sectoral Approach***

Reference: UNFCCC CGE Training material

Excluded Carbon / Non-Energy Use of Fuels

TABLE 1.2
TYPES OF USE AND EXAMPLES OF FUELS USED FOR NON-ENERGY APPLICATIONS

Type of use	Example of fuel types	Product/process	Chapter
Feedstock	natural gas, oils, coal	ammonia	3.2
	naphtha, natural gas, ethane, propane, butane, gas oil, fuel oils	methanol, olefins (ethylene, propylene), carbon black	3.9
Reductant	petroleum coke	carbides	3.6
	coal, petroleum coke	titanium dioxide	3.7
	metallurgical cokes, pulverised coal, natural gas	iron and steel (primary)	4.2
	metallurgical cokes	ferroalloys	4.3
	petroleum coke, pitch (anodes)	aluminium [1]	4.4
	metallurgical coke, coal	lead	4.6
	metallurgical coke, coal	zinc	4.7
Non-energy product	lubricants	lubricating properties	5.2
	paraffin waxes	misc. (e.g., candles, coating)	5.3
	bitumen (asphalt)	road paving and roofing	5.4
	white spirit[2], some aromatics	as solvent (paint, dry cleaning)	5.5

1. Also used in secondary steel production (in electric arc furnaces) (see Chapter 4.2).
2. Also known as mineral turpentine, petroleum spirits, industrial spirit ('SBP').

Reference: UNFCCC CGE Training material

Summary

- **Energy Sector = Fuel combustion (mobile and stationary) + Fugitive emissions + CCS**
- **Energy emissions are usually the most important**
  - CO_2 from fuel combustion is major source
  - CH_4 mainly comes from fugitive emissions
- **CO_2 emission factor depends on carbon content of fuel, non-CO_2 – on the technology used**
- **Methodological issues** (biomass, international bunker, excluded carbon/fuels in other sectors)
- **Reference approach is used for checking** (CO_2)

Reference: UNFCCC CGE Training material

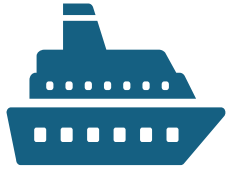
❑ Sources of mobile combustion in Philippines

- Road transportation

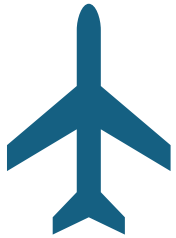
  Examples

  - Jeepneys – Diesel
  - Tricycles – Diesel/ kerosene
  - Buses

- Water transportation



- Civil aviation



- Railways

Road transportation coverage in 2006 IPCC guideline

- According to the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, no refinements has occurred in mobile combustion

Emission source coverage for road transportation

All combustion and evaporative emissions arising from fuels used in road vehicles, including the use of agricultural vehicles on paved roads

- According to the 2006 IPCC Guidelines it may include emissions from,
  - Cars
    - Automobiles use for transport of persons having capacity of 12 persons or fewer
  - Light-duty trucks
    - Emissions from vehicles do transportation of light-weight cargo or which are equipped with special features such as four-wheel drive for off-road operation.
    - Gross vehicle weight ranges up to 3500-3900 kg or less

- Heavy-duty trucks and buses
  - Gross vehicle weight ranges from 3500-3900 kg or more for heavy duty trucks
  - Buses are rated to carry more than 12 persons
- Motorcycles

  - Emissions from any motor vehicle designated to travel not more than 3 wheels in contact with the ground
  - Weight < 680 kg
- Evaporate emissions from vehicles
  - Evaporative emissions from vehicles
  - Exclude emissions from loading fuel into vehicles
- Urea-based catalysts
  - CO_2 emissions from use of urea-based additives in catalytic converters (non-combustive emissions)

Road transportation in Philippine GHGI, 2010

2010 Philippine Greenhouse Gas Inventory Report

Executive Summary

Approaches used for data collection

❑ For GHGI, 2010 in Philippines

Screening of available data

Literature sources

- Overall energy balance sheet - Department of Energy (DoE)
- Natural gas activity data – Natural Gas Management Division of DoE
- Oil activity data – The Petroleum Resources Development Division

- IPCC

Activity data

- Fuel types used for Inventory calculation in GHGI, 2010
  - Premium gasoline
  - Regular gasoline
  - Diesel
  - LPG

Activity data used for road transportation in GHGI, 2010

	Coal	Natgas	Crude	PremGas	RegGas	Kero	Diesel	Fuel Oil	LPG	Jet	Avgas	Naphtha
Road Transport	-	-	-	2,150.05	599.47	-	4,083.94	-	0.01	-	-	-

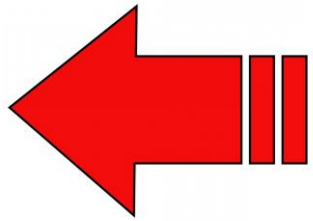
Source: https://climate.emb.gov.ph/wp-content/uploads/2016/06/GHG-Manual.pdf

Emission factors

- Emission factors used for Inventory calculation in GHGI, 2010
  - IPCC, 1997

Example for CH_4 emission factors used for road transportation (marked in red) in GHGI, 2010

ACTIVITY			COAL	NATURAL GAS	OIL		WOOD/ WOOD WASTE	CHARCOAL	OTHER BIOMASS & WASTES
Energy Industries			1	1	3		30	200	30
Manufacturing Industries & Construction			10	5	2		30	200	30
Transport	Domestic Aviation					0.5			
	Road				Gasoline	Diesel			
				50	20	5			
	Railways		10		5				
	National Navigation		10		5				
Other Sectors	Commercial/Institutional		10	5	10		300	200	300
	Residential		300	5	10		300	200	300
	Agriculture/Forestry/Fishing	Stationary	300	5	10		300	200	300
		Mobile		5	5				

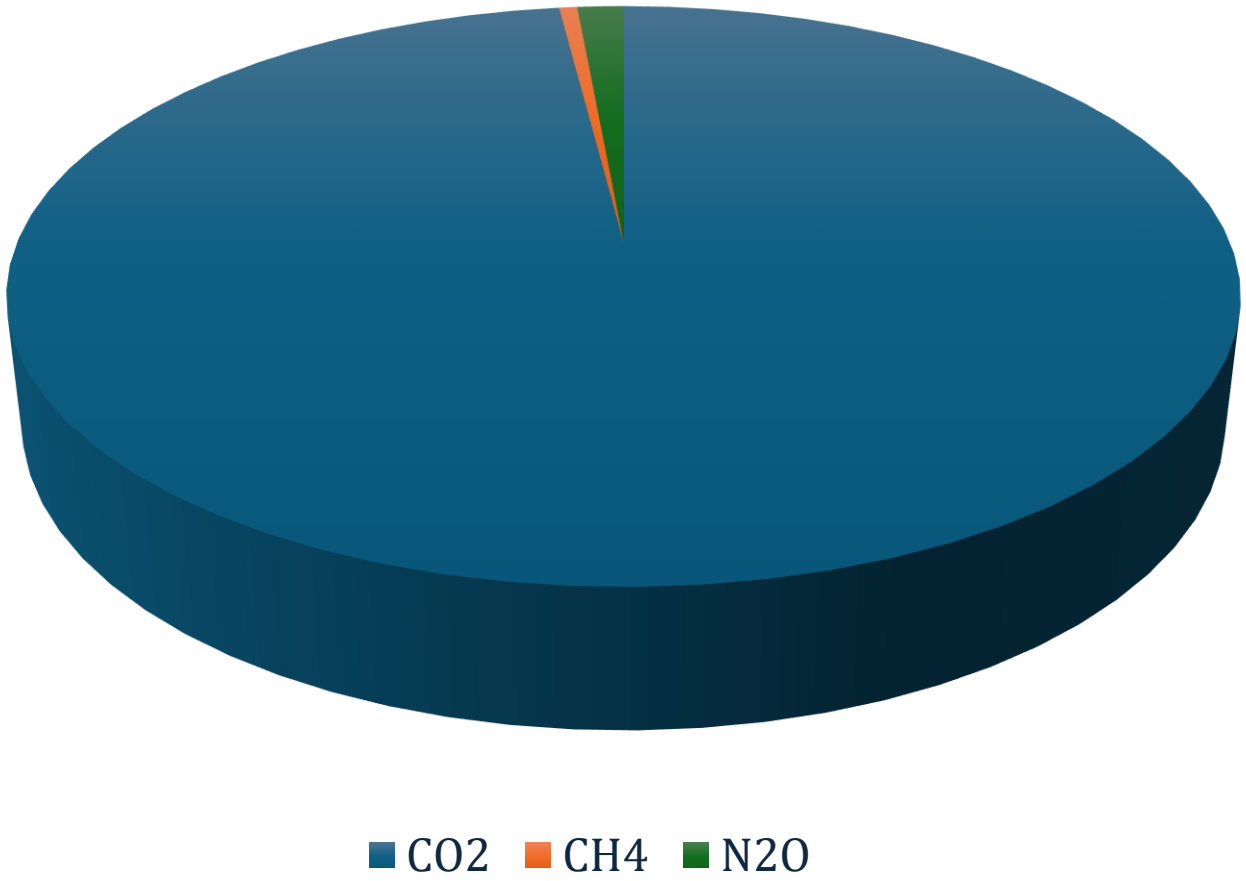


Source: IPCC (1997)

Emissions

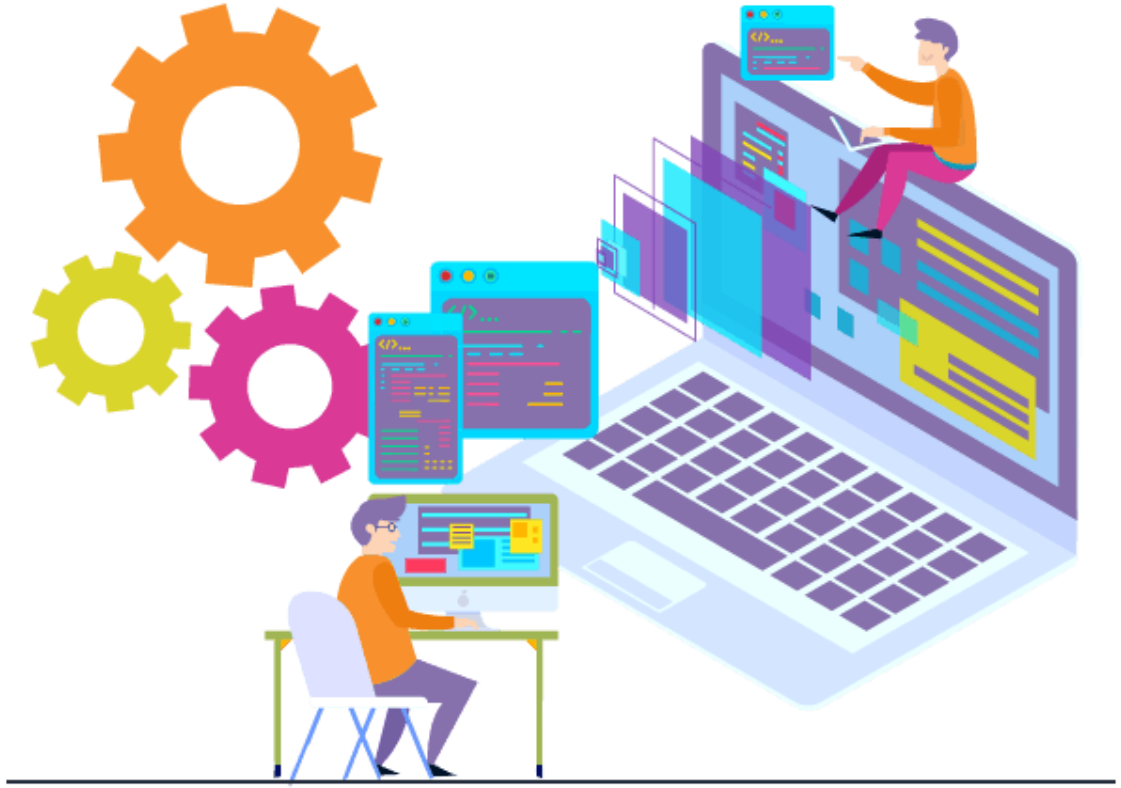
Gas	Emissions (Mt CO_2e)
CO_2	20.816
CH_4	0.120
N_2O	0.308
Total	21.243

GHG emissions in Road transportation



Source: Executive Summary_2010 National GHGI Report.pdf (climate.gov.ph)

Calculation examples and exercises – Manually & using IPCC inventory tool



ROAD TRANSPORTATION

Tier 1 approach to calculate CO_2 emissions		
Emission = $\sum_a$ [fuel $_a$ * EF $_a$]		
Parameter	Description	Unit
Emission	Emissions of CO_2	kg
fuel $_a$	Fuel sold	TJ
EF $_a$	Emission factor . This is equal to the carbon content of the fuel multiplied by 44/12.	kg/TJ
a	Fuel type	N/A

- Tier 1 approach use default, fuel based CO_2 emission factor

Default EF values for Tier 1 calculations are available in IPCC guideline >> Volume 2 >> Chapter 3

Calculation example to find CO_2 emissions from road vehicles in Philippines 2010, using tier 1 approach

Fuel type	Consumption (ktoe)	2006, IPCC default CO_2 emission factor (kg/TJ)	Conversion factor (TJ/ ktoe)
PremGas	2,150.05	69,300	41.87
RegGas	599.47	69,300	41.87
Diesel	4,083.94	74,100	41.87
LPG	0.01	63,100	41.87

conversion factor is used in here because activity data is present in ktoe (kilo tonne of oil equivalents)

2006, IPCC default EF

TABLE 3.2.1
ROAD TRANSPORT DEFAULT CO_2 EMISSION FACTORS AND UNCERTAINTY RANGES [a]

Fuel Type	Default (kg/TJ)	Lower	Upper
Motor Gasoline	69 300	67 500	73 000
Gas/ Diesel Oil	74 100	72 600	74 800
Liquefied Petroleum Gases	63 100	61 600	65 600
Kerosene	71 900	70 800	73 700
Lubricants [b]	73 300	71 900	75 200
Compressed Natural Gas	56 100	54 300	58 300
Liquefied Natural Gas	56 100	54 300	58 300

Fuel type	Emission = [fuel consumption * EF]
PremGas	Fuel consumption = 2,150.05 ktoe* 41.87 TJ/ktoe = 90,022.5935 TJ E_{CO2} =90,022.5935 TJ *69,300 kg/TJ = 6,238,565,730 kg or 6,238.57 Gg
RegGas	1,739,416,757 kg
Diesel	12,670,697,470 kg
LPG	26,419.97 kg

Source of activity data: https://climate.emb.gov.ph/wp-content/uploads/2016/06/GHG-Manual.pdf

This result is correct only if any CO_2 is not recovered!

If CO_2 has captured, it should subtract from the total CO_2 emissions

Tier 1 approach to calculate CH_4 and N_2O emissions		
Emission = $\sum_a$ [fuel $_a$ * EF $_a$]		
Parameter	Description	Unit
Emission	Emissions of CO_2	kg
fuel $_a$	Fuel sold	TJ
EF $_a$	Emission factor	kg/TJ
a	Fuel type (e.g., diesel, gasoline, natural gas, LPG)	N/A

- Tier 1 approach use default, fuel based CH_4 and N_2O emission factors

Calculation example to find CH_4 emissions from road vehicles in Philippines 2010, using tier 1 approach

Fuel type	Consumption (ktoe)	2006, IPCC default CH_4 emission factor (kg/TJ)	Conversion factor (TJ/ ktoe)
PremGas	2,150.05	33 (uncontrolled)	41.87
RegGas	599.47	33 (uncontrolled)	41.87
Diesel	4,083.94	3.9	41.87
LPG	0.01	62	41.87

2006, IPCC default EF

TABLE 3.2.2
ROAD TRANSPORT N_2O AND CH_4 DEFAULT EMISSION FACTORS AND UNCERTAINTY RANGES [a]

Fuel Type/Representative Vehicle Category	CH_4 (kg /TJ)			N_2O (kg /TJ)		
	Default	Lower	Upper	Default	Lower	Upper
Motor Gasoline -Uncontrolled [b]	33	9.6	110	3.2	0.96	11
Motor Gasoline –Oxidation Catalyst [c]	25	7.5	86	8.0	2.6	24
Motor Gasoline –Low Mileage Light Duty Vehicle Vintage 1995 or Later [d]	3.8	1.1	13	5.7	1.9	17
Gas / Diesel Oil [e]	3.9	1.6	9.5	3.9	1.3	12
Natural Gas [f]	92	50	1 540	3	1	77
Liquified petroleum gas [g]	62	na	na	0.2	na	na
Ethanol, trucks, US [h]	260	77	880	41	13	123
Ethanol, cars, Brazil [i]	18	13	84	na	na	na

a conversion factor is used in here because activity data was present in ktoe (kilo tonne of oil equivalents)

Fuel type	Emission = [fuel a * EF a]
PremGas	Fuel consumption = 2,150.05 ktoe * 41.87 TJ/ktoe = 90,022.5935 TJ E_{CH4} = 90,022.5935 TJ * 33 kg/TJ = 2,970,745.586 kg or 2.98 Gg
RegGas	828293.6937 kg
Diesel	666878.8144 kg
LPG	25.9594 kg

Source of activity data: https://climate.emb.gov.ph/wp-content/uploads/2016/06/GHG-Manual.pdf

Calculation example to find N_2O emissions from road vehicles in Philippines 2010, using tier 1 approach

Fuel type	Consumption (ktoe)	2006 IPCC default N_2O emission factor (kg/TJ)	Conversion factor (TJ/ ktoe)	Emission = [fuel consumption * EF]
PremGas	2,150.05	3.2	41.87	Fuel consumption = 2,150.05 ktoe * 41.87 TJ/ktoe = 90,022.5935 TJ E_{N2O}= 90,022.5935 TJ * 3.2 kg/TJ = 288,072.2992 kg or 0.29 Gg
RegGas	599.47	3.2	41.87	80319.38848 kg
Diesel	4,083.94	3.9	41.87	666878.8144 kg
LPG	0.01	0.2	41.87	0.08374 kg

TABLE 3.2.2
ROAD TRANSPORT N_2O AND CH_4 DEFAULT EMISSION FACTORS AND UNCERTAINTY RANGES [a]

Fuel Type/Representative Vehicle Category	CH_4 (kg /TJ)			N_2O (kg /TJ)		
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Motor Gasoline –Low Mileage Light Duty Vehicle Vintage 1995 or Later [d]	3.8	1.1	13	5.7	1.9	17
Gas / Diesel Oil [e]	3.9	1.6	9.5	3.9	1.3	12
Natural Gas [f]	92	50	1 540	3	1	77
Liquified petroleum gas [g]	62	na	na	0.2	na	na
Ethanol, trucks, US [h]	260	77	880	41	13	123
Ethanol, cars, Brazil [i]	18	13	84	na	na	na

2006, IPCC default EF

**a conversion factor is used in here because activity data was present in ktoe (kilo tonne of oil equivalents)*

Source of activity data: https://climate.emb.gov.ph/wp-content/uploads/2016/06/GHG-Manual.pdf

Let's start working with the software

Dive into the Inventory tool together and explore its features firsthand

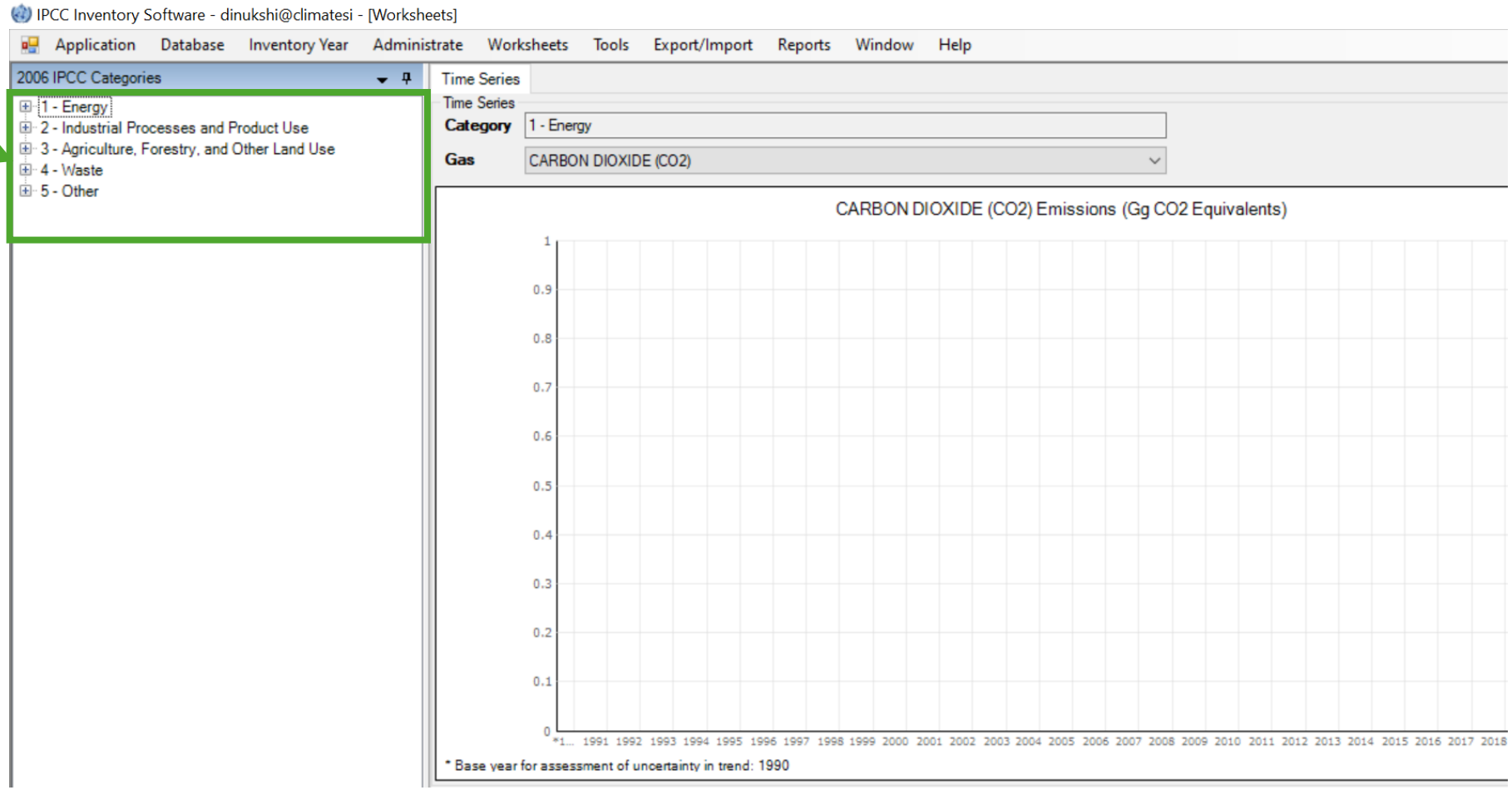
Open the software and go to worksheets!

Select the sector that you want to enter data

In here select the sector as ‘Energy’

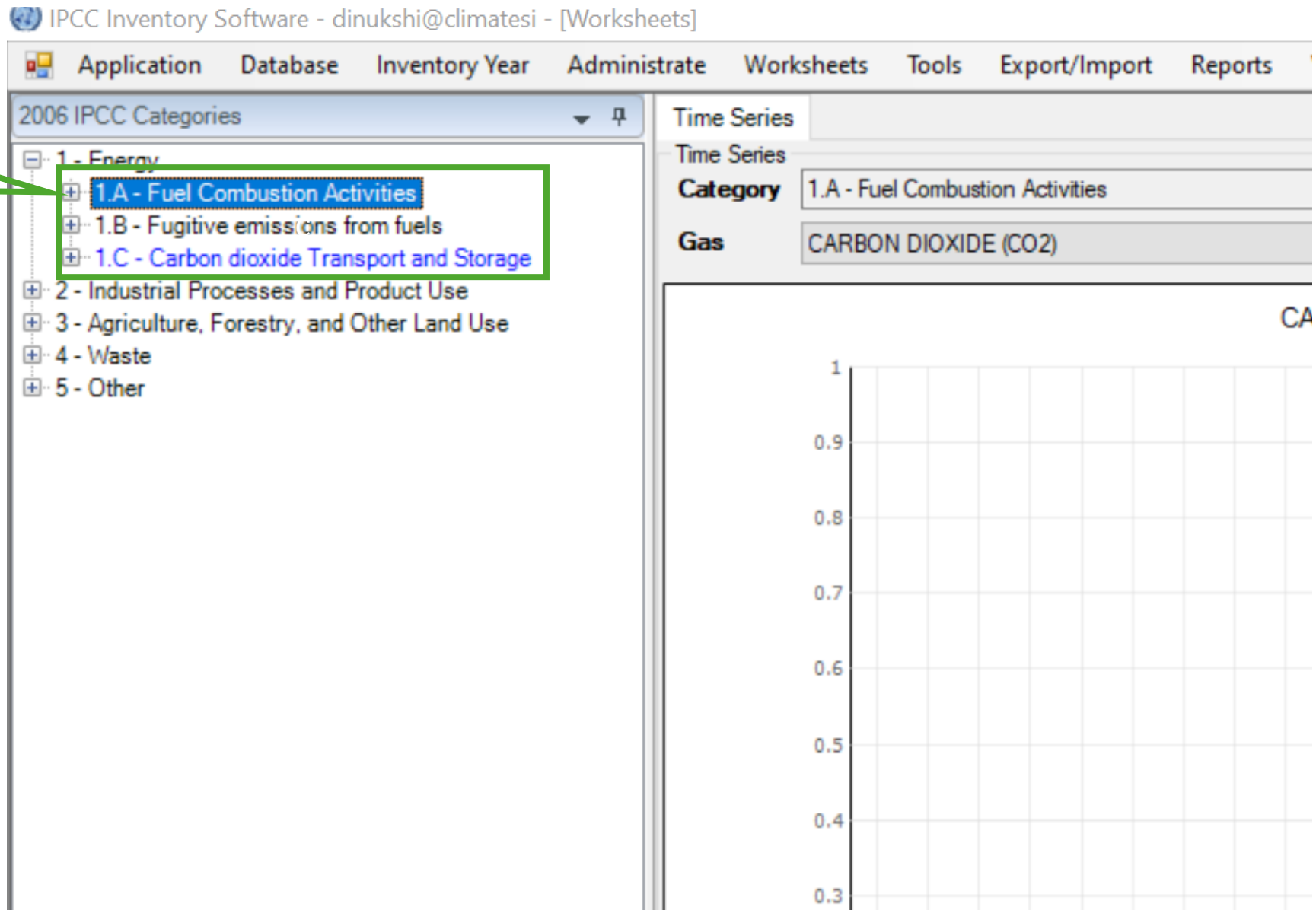
Then, click on the ‘+’ mark in front of the Energy sector

You will be getting categories of Energy sector

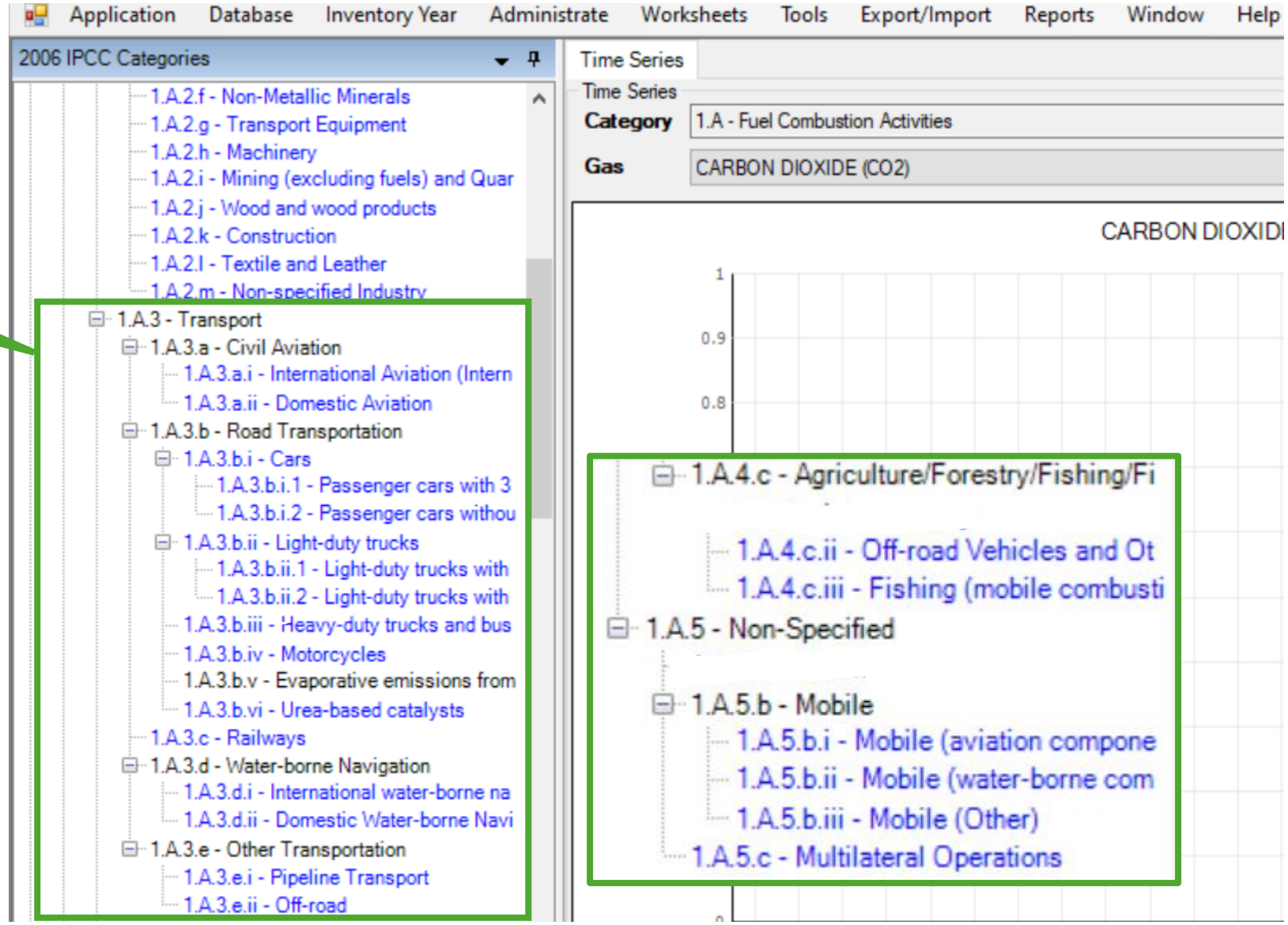


There are 3 categories of Energy sector

To enter mobile combustion data, click on '+' mark in front of '1.A – Fuel combustion activities' and proceed

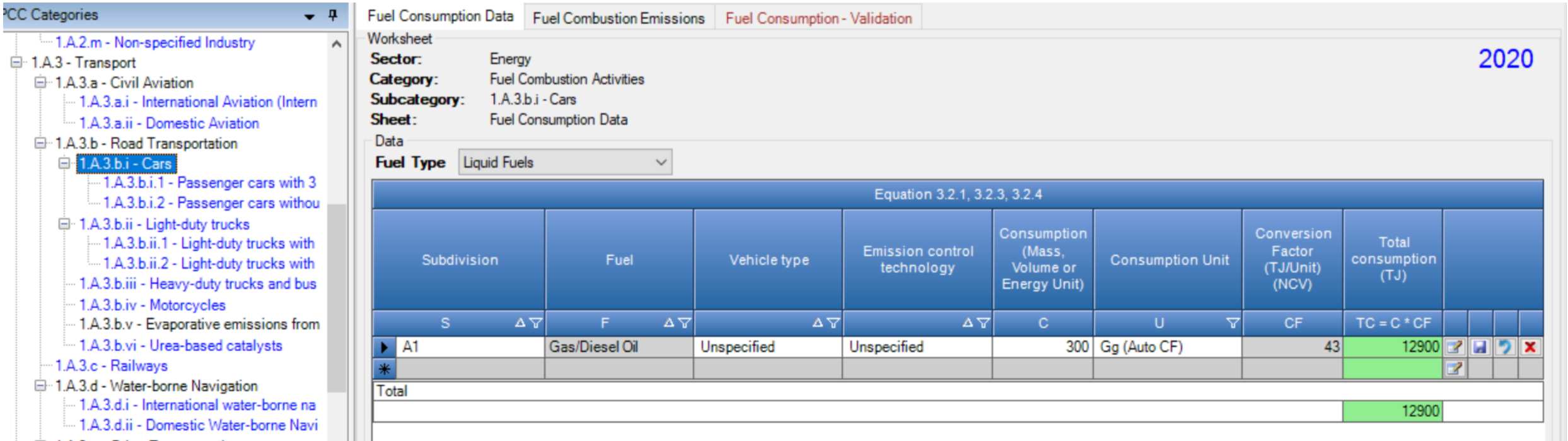


Mobile combustion related categories and sub-categories



1.A.3.b – Road transportation

- In IPCC inventory tool, worksheets for sub-categories *1.A.3.b.i – Cars* and *1.A.3.b.ii – Light-duty vehicles* have common formats
  - There are 3 worksheets for each
    1. Fuel consumption data
    2. Fuel combustion emissions
    3. Fuel consumption – validation



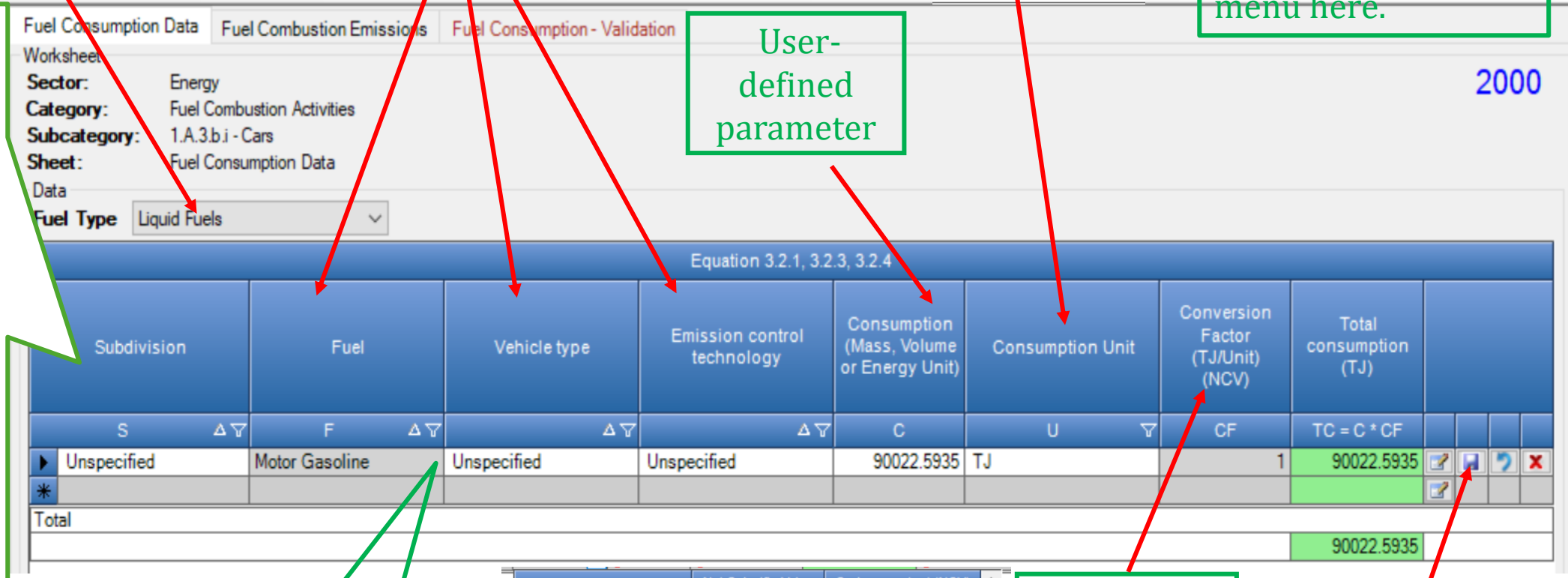
1. Fuel consumption data

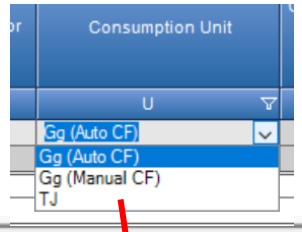
Select the 'fuel type '

The user must enter these information accordingly

Select the 'consumption unit' using drop down menu here.

Data may be entered either within a single nation-wide aggregate (i.e. "country name" subdivision or "unspecified") or within a national disaggregation such as administrative units (e.g. provinces, regions, states) or production units (e.g. companies, facilities, or any other aggregation according to which the user collects AD).





User-defined parameter

Select the 'fuel' using drop down menu here

Fuel Name	Net Calorific Value (TJ / Gg)	Carbon content (NCV) (kg C / GJ)
Aviation Gasoline	44.3	19.1
Bitumen	40.2	22
Crude Oil	42.3	20
Ethane	46.4	16.8
Gas/Diesel Oil	43	20.2
Jet Gasoline	44.3	19.1
Jet Kerosene	44.1	19.5
Liquefied Petroleum Gases	47.3	17.2

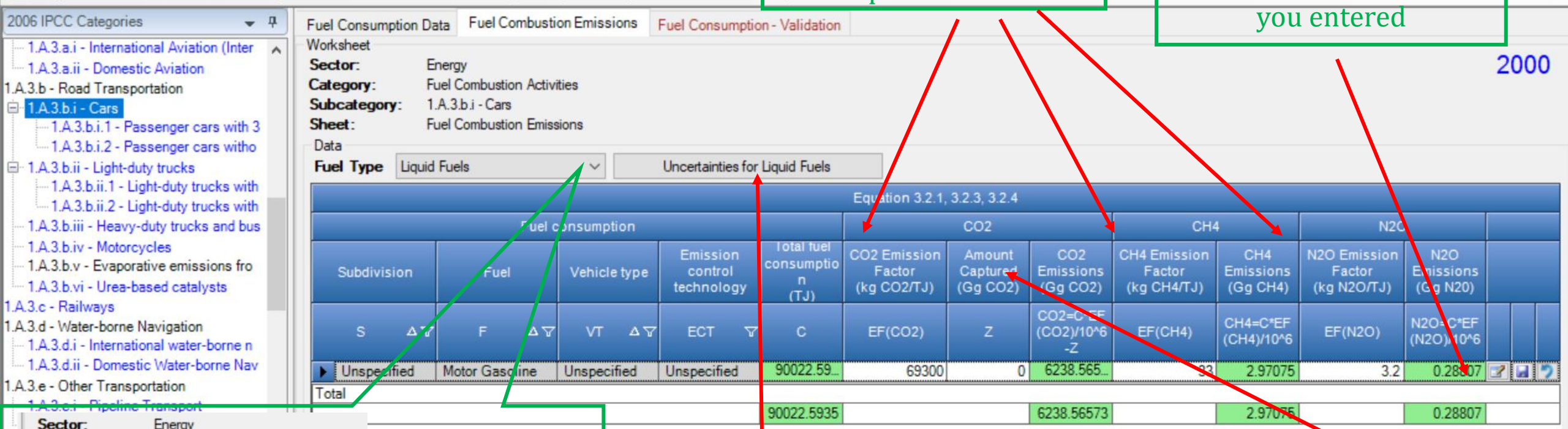
Default or user-defined parameter

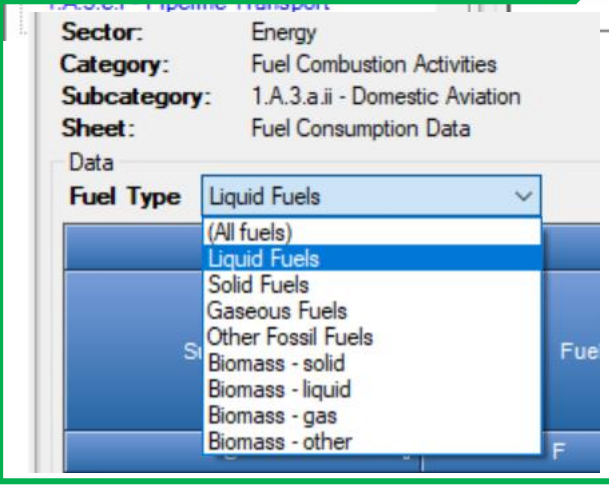
Click 'save' button finally to save the entries you entered

2. Fuel combustion emissions

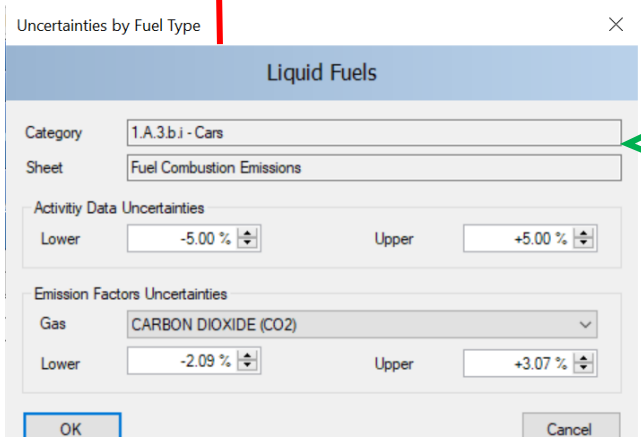
Default or User-defined parameter

Click 'save' button finally to save the information you entered





select the 'fuel type' from drop-down menu



Add uncertainties for activity data and emission factors

User-defined parameter

3. Fuel consumption – validation

- It is good practice to compare the fuel sold statistics used in the Tier 1 approach with the result of this
- This provides an important quality check.
- Significant differences between the results of two approaches may indicate that one or both sets of statistics may have errors, and that there is need for further analysis.
- It is good practice to consider any differences and determine which data is of higher quality. (Except in rare cases like when large quantities of fuel sold for off-road uses etc.)

- Calculated quantities in this worksheet are not reported.

3. Fuel consumption validation

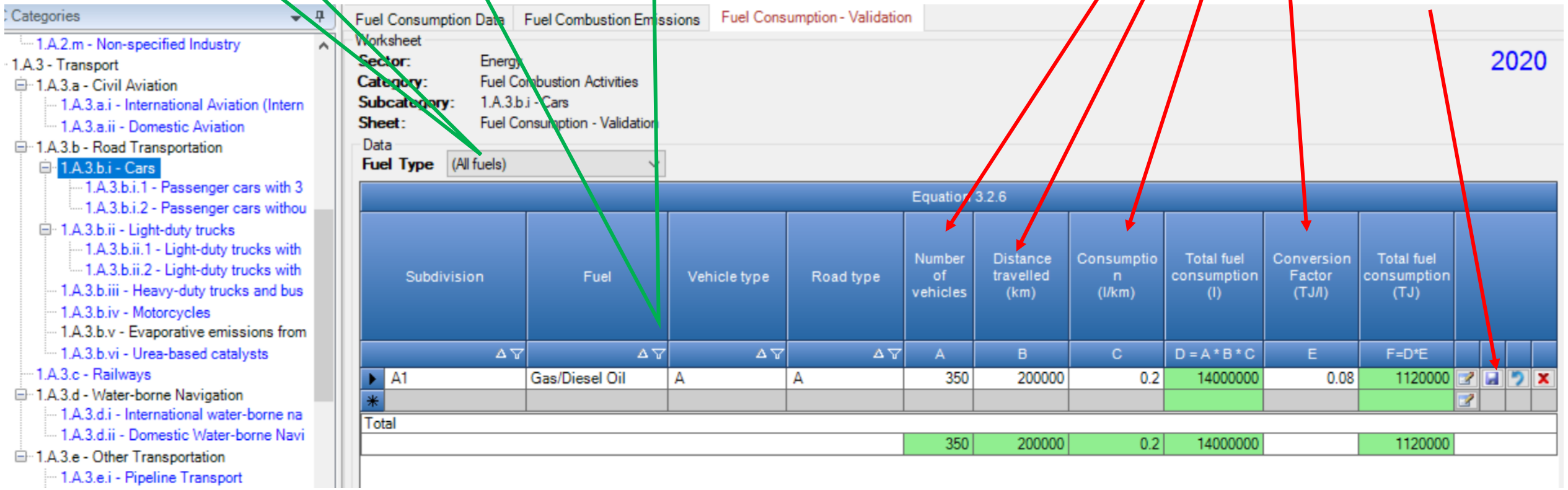
Fuel Name	Net Calorific Value (TJ / Gg)	Carbon content (NCV) (kg C / GJ)
Aviation Gasoline	44.3	19.1
Bitumen	40.2	22
Crude Oil	42.3	20
Ethane	46.4	16.8
Gas/Diesel Oil	43	20.2
Jet Gasoline	44.3	19.1
Jet Kerosene	44.1	19.5
Liquefied Petroleum Gases	47.3	17.2

Select the fuel type using drop down menu here

User-defined parameter

Select the fuel type

Click 'save' button finally to save the information you entered



Let’s do an example with the inventory tool!

Activity 03

Step 01: Open the worksheet fuel consumption data of either 1.A.3.b.i.1 – Passenger cars with 3-way catalysts, 1.A.3.b.i.2 – Passenger cars without 3-way catalysts, 1.A.3.b.ii.1 – Light-duty trucks with 3-way catalysts, 1.A.3.b.ii.2 – Light-duty trucks without 3-way catalysts, 1.A.3.b.iii – Heavy-duty trucks and buses or 1.A.3.b.iv – Motorcycles

Step 02: Select the fuel type as liquid fuels

Step 03: Enter following data accordingly

Input parameter	Entry	Note
Subdivision	District A	
Fuel	Gas/ diesel oil	
Vehicle type	Motorcycles	
Emission control technology	Unspecified	
consumption	1000 TJ	

**the activity data used in this activity are not real. Just examples only for this activity.*

Step 04: Save entered data

- Step 05: Open the worksheet Fuel combustion emissions and enter following data accordingly in the dialog box uncertainties for liquid fuels

Entry parameter		Entry
Activity data uncertainties	Upper	+5.00%
	Lower	-5.00%
Emission factors uncertainties		
Select the gas as Carbon Dioxide and enter following *(*when you are entering data for real GHG inventory calculation, please make sure to add uncertainties for other gases also)*		
	Upper	+3.00%
	Lower	-2.00%

**these values are not real. Just examples only for this activity.*

Step 06: Enter following data accordingly in the previously opened worksheet

Input parameter	Entry	Note
CO_2 emission factor	Default value, 74100	You can use specific values also. But please use the default value for this activity.
Amount captured	0 (Zero)	
CH_4 emission factor	Default value, 3.9	You can use specific values also. But please use the default value for this activity.
N_2O emission factor	Default value, 3.9	You can use specific values also. But please use the default value for this activity.

**the activity data used in this activity are not real. Just examples only for this activity.*

Step 07: Save entered data

Let’s do an example with the inventory tool!

Activity06

Step 01: Open the worksheet 1.A.3.b.vi – Urea-based catalysts and enter following data accordingly

Input parameter	Entry	Note
Subdivision	District A	
Amount of Urea-based additive consumed for use in catalytic converters	0.0001 Gg	
Purity (mass fraction of urea in the urea-based additive)	0.325	This is just an assumption

**the activity data used in this activity is not real. Just an assumption only for this activity.*

Step 02: Save entered data

Step 03: Enter uncertainties

Entry parameter		Entry
Activity data uncertainties	Upper	+1.00%
	Lower	-1.00%
Emission factors uncertainties		
Select the gas as Methane and enter following data *(*when you are entering data for real GHG inventory calculation, please make sure to add uncertainties for other gases also)*		
	Upper	+1.00%
	Lower	-1.00%

*these values are not real. Just an assumption only for this activity.

Results

Urea-based catalysts

Urea-based Catalysts

Worksheet

Sector: Energy

Category: Urea-based Catalysts

Subcategory: 1.A.3.b.vi - Urea-based catalysts

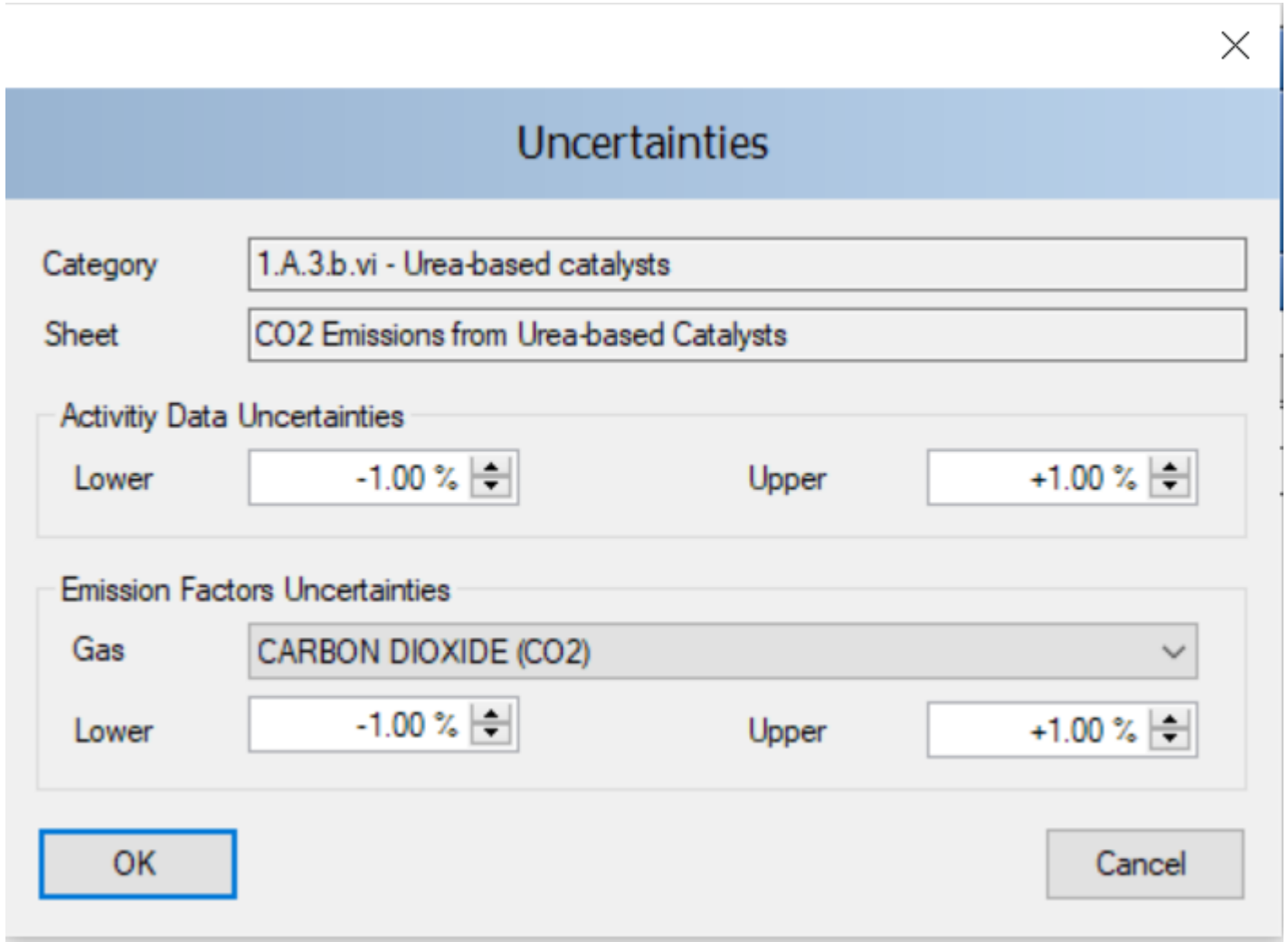
Sheet: CO2 Emissions from Urea-based Catalysts

2020

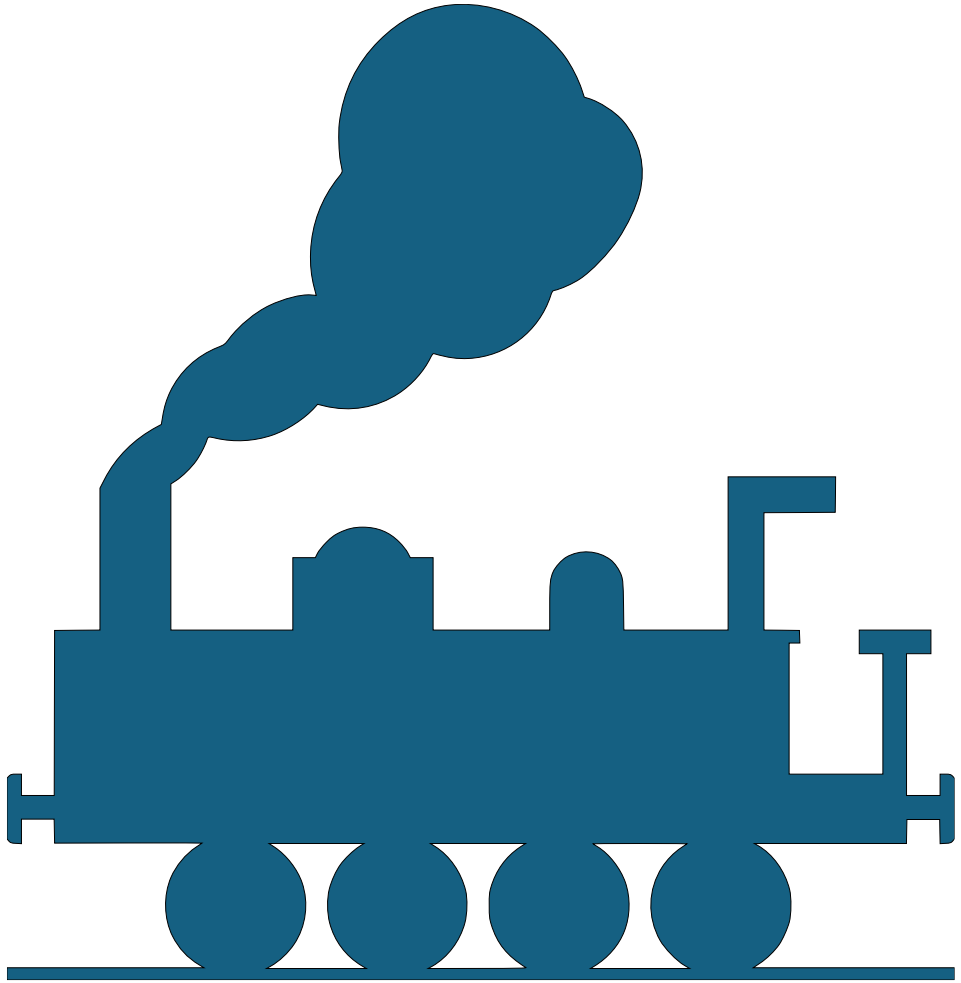
Data

Equation 3.2.2				
Subdivision	Amount of Urea-based Additive Consumed for Use in Catalytic Converters (Gg)	Purity (Mass Fraction of Urea in the Urea-based Additive) (Fraction)	CO2 Emissions (Gg CO2)	
S	A	B	C=A*12/60*B*44/12	
Unspecified	0.0002	0.325	0.00005	
Total				
	0.0002		0.00005	

Uncertainties



RAILWAYS



General method for emissions from locomotives		
$Emission = \sum_j [fuel_j * EF_j]$		
Parameter	Description	Unit
Emission	Emissions of CO_2	kg
$fuel_j$	Fuel type j consumed (as represented by fuel sold)	TJ
EF_j	Emission factor for fuel type j	kg/TJ
j	Fuel type	N/A

- Tier 1 approach use fuel-specific default emission factors assuming that for each fuel type the total fuel is consumed by a single locomotive type

Default EF values for Tier 1 calculations are available in IPCC guideline >> Volume 2 >> Chapter 3

Calculation example to find CO_2 emissions from railways in Philippines 2010, using general method (Tier 1)

Fuel type	consumption (ktoe)	2006 IPCC default CO_2 emission factor (kg/TJ)	Conversion factor (TJ/ ktoe)	Emissions = Fuel consumption * EF
Diesel	1.28	74100	41.87	Fuel consumption = 1.28 ktoe*41.87 TJ/ktoe = 53.5936 TJ E_{CO2} = 53.5936 TJ *74100 kg/TJ = 3,971,285.76 kg or 3.98 Gg

TABLE 3.4.1
DEFAULT EMISSION FACTORS FOR THE MOST COMMON FUELS USED FOR RAIL TRANSPORT

Gas	Diesel (kg/TJ)			Sub-bituminous Coal (kg/TJ)		
	Default	Lower	Upper	Default	Lower	Upper
CO_2	74 100	72 600	74 800	96 100	72 800	100 000
CH_4 [1]	4.15	1.67	10.4	2	0.6	6
N_2O [1]	28.6	14.3	85.8	1.5	0.5	5

2006, IPCC default EF

** conversion factor is used in here because activity data was present in ktoe (kilo tonne of oil equivalents)*

If CO_2 has captured, it must subtract from the total CO_2 emissions

Activity data Source: https://climate.emb.gov.ph/wp-content/uploads/2016/06/GHG-Manual.pdf

Calculation example to find CH_4 and N_2O emissions from railways in Philippines 2010, using Tier 1

Fuel type	consumption (ktoe)	2006 IPCC default emission factor (kg/TJ)		Conversion factor (TJ/ ktoe)	Emissions = Fuel consumption * EF
		CH_4	N_2O		
Diesel	1.28	4.15	28.6	41.87	Fuel consumption = 1.28 ktoe*41.87 TJ/ktoe = 53.5936 TJ E_{CH4} = 53.5936 TJ *4.15 kg/TJ = 222.41344 kg or 0.23 * 10^{-3} Gg E_{N2O} = 53.5936 TJ * 28.6 kg/TJ = 1532.77696 kg or 1.54 * 10^{-3} Gg

conversion factor is used in here because activity data was present in ktoe (kilo tonne of oil equivalents)

TABLE 3.4.1
DEFAULT EMISSION FACTORS FOR THE MOST COMMON FUELS USED FOR RAIL TRANSPORT

Gas	Diesel (kg/TJ)			Sub-bituminous Coal (kg/TJ)		
	Default	Lower	Upper	Default	Lower	Upper
CO_2	74 100	72 600	74 800	96 100	72 800	100 000
CH_4 [1]	4.15	1.67	10.4	2	0.6	6
N_2O [1]	28.6	14.3	85.8	1.5	0.5	5

2006, IPCC default EF

These default emission factors may, for non-CO2 gases, be modified depending on the engine design parameters. For that instances EF should be calculated using pollutant weighing factor as in below equation.

Pollutant weighing factors
IPCC>>Vol 2 >> Ch 3

TABLE 3.4.2
POLLUTANT WEGHTING FACTORS AS FUNCTIONS OF ENGINE DESIGN PARAMETERS FOR UNCONTROLLED ENGINES(DIMENSIONLESS)

Engine type	CH_4	N_2O
Naturally Aspirated Direct Injection	0.8	1.0
Turbo-Charged Direct Injection / Inter-cooled Turbo-Charged Direct Injection	0.8	1.0
Naturally Aspirated Pre-chamber Injection	1.0	1.0
Turbo-Charged Pre-chamber Injection	0.95	1.0
Inter-cooled Turbo-Charged Pre-chamber Injection	0.9	1.0

Source: EEA 2005 (Table 8-9);

EQUATION 3.4.4
WEIGHTING OF CH_4 AND N_2O EMISSION FACTORS FOR SPECIFIC TECHNOLOGIES

$$EF_{i,diesel} = PWF_i \bullet EF_{default,diesel}$$

Where:

$EF_{i,diesel}$ = engine specific emission factor for locomotive of type i (kg/TJ)

PWF_i = pollutant weighing factor for locomotive of type i [dimensionless]

$EF_{default,diesel}$ = default emission factor for diesel (applies to CH_4, N_2O) (kg/TJ)

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