

# GHG Inventory – Mobile combustion-Civil Aviation



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## Training on 2006 IPCC Guidelines for preparing National GHG Inventory:

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*Organized by the Capacity Building Initiative for  
Transparency  
Global Support Programme (CBIT-GSP)*

**ipcc**  
INTERGOVERNMENTAL PANEL ON climate change



# Content

Introduction

Civil aviation coverage in 2006 IPCC guideline

Civil aviation in Philippine GHGI, 2010

Calculation examples and exercises –  
Manually & using IPCC inventory tool

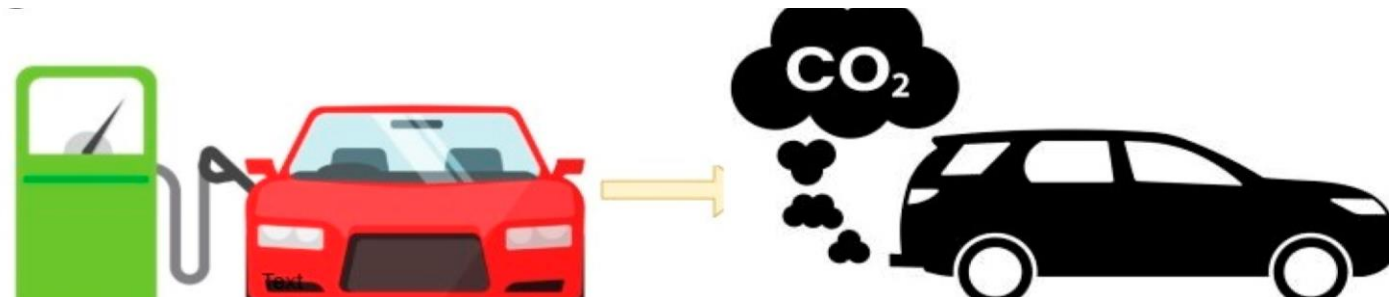
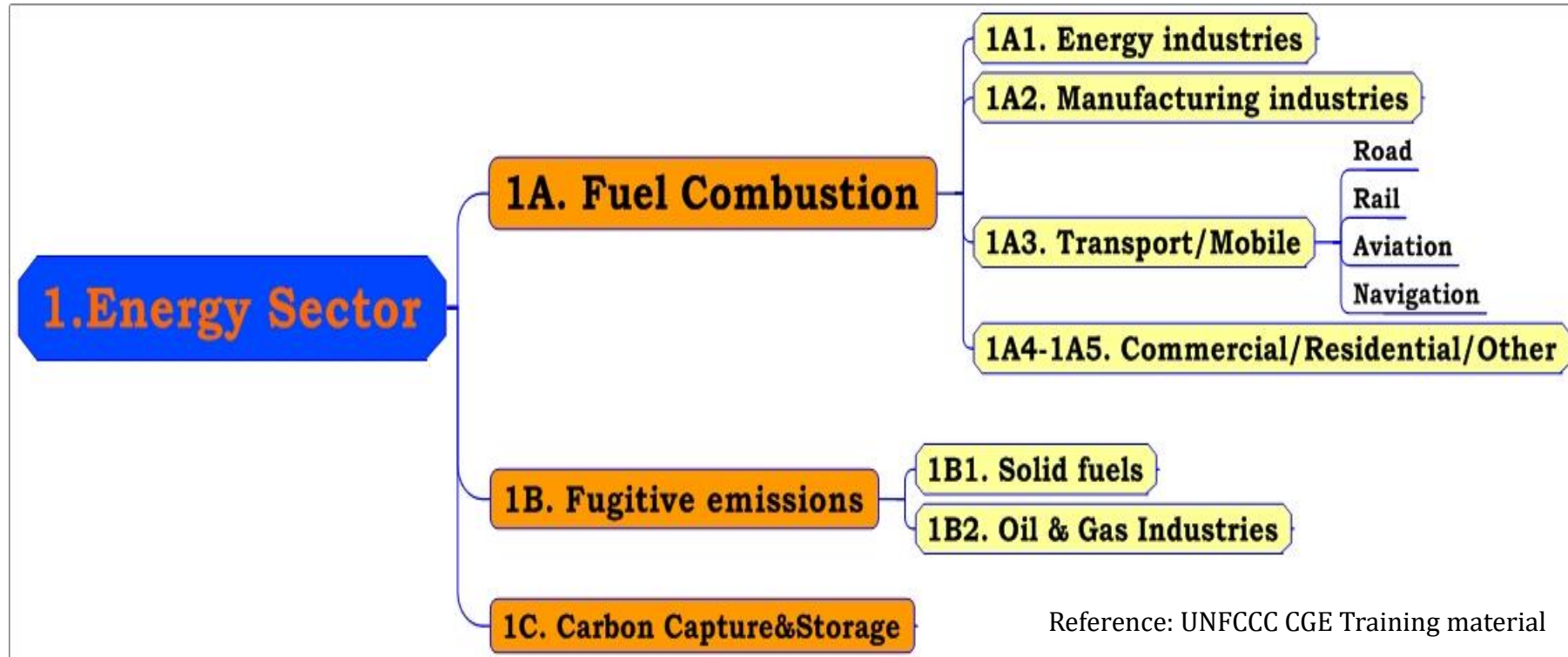


# Introduction

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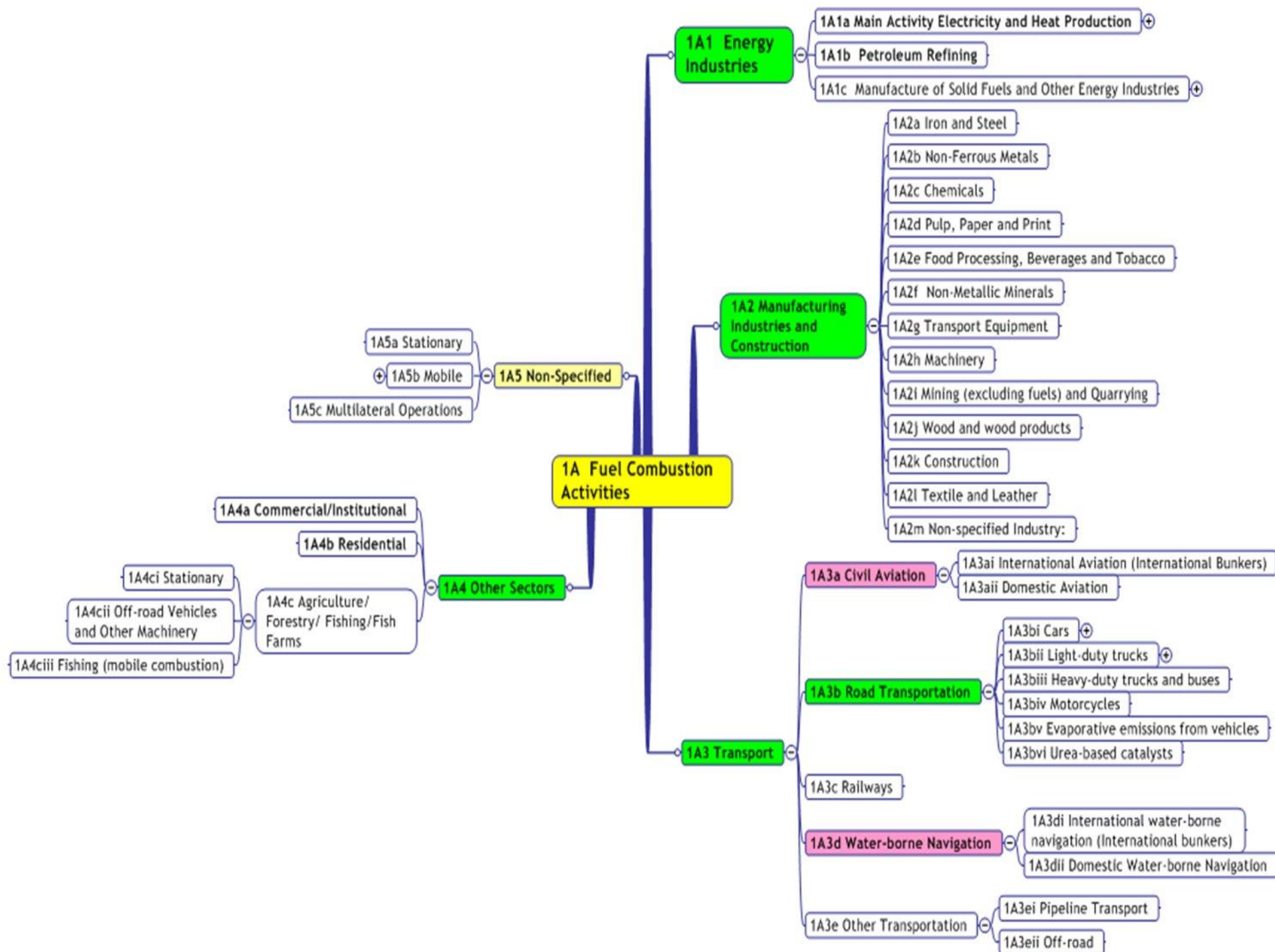


# Energy Sector



# Total GHG emissions-2010 in the Philippines (Million tons of CO<sub>2</sub>e)

	<i>CO<sub>2</sub></i>	<i>CH<sub>4</sub></i>	<i>N<sub>2</sub>O</i>	<i>HFCs</i>	<i>Total</i>
<i>Energy</i>	50.698	1.888	0.519	-	53.105
<i>Agriculture</i>	0.696	33.853	8.604	-	43.152
<i>Transport</i>	23.718	0.125	0.331	-	24.174
<i>Waste</i>	0.015	14.527	1.017	-	15.559
<i>IPPU</i>	7.564	0.009	0.019	0.771	8.363
<i>FOLU</i>	(37.016)	0.007	0.002	-	(37.007)
	<b><i>TOTAL</i></b>				<b><i>107.345</i></b>

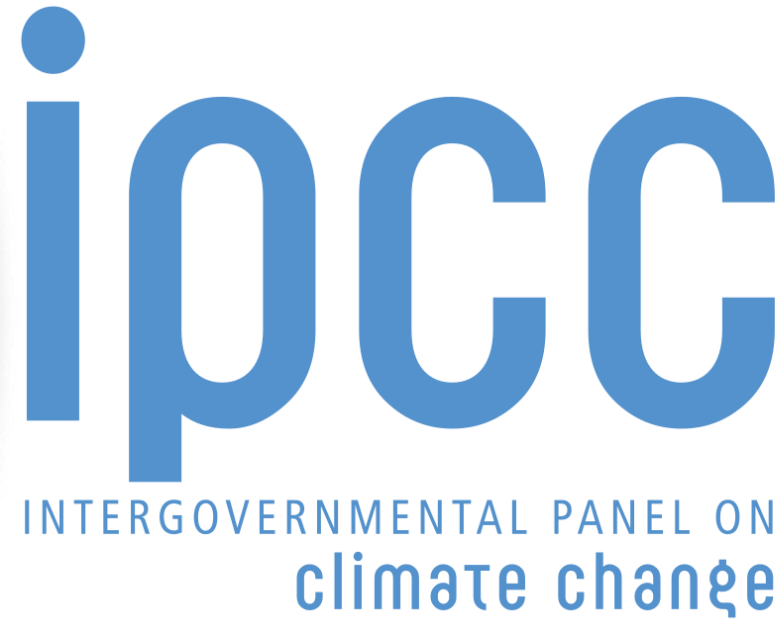




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# Civil aviation coverage in 2006 IPCC guideline



- ❑ 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 civil aviation

Emissions from **international and domestic** civil aviation **including take-offs and landings**

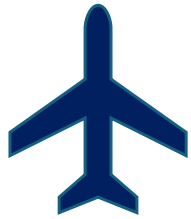
- According to the 2006 IPCC Guidelines it may include emissions from,

- **International Aviation (International Bunkers)**

- Emissions from flights that **depart in one country** and **arrive in a different country**
- Include take-offs and landings for these flight stages
- Emissions from international **military aviation can be included as a separate sub-category** if the same definitional distinction is applied and data are available to support the definition

- **Domestic Aviation**

- Emissions from civil domestic passenger and freight traffic that **departs and arrives in the same country** (commercial, private, agriculture , etc)
- Include take-offs and landings for these flight stages
- **Exclude military**





# Civil aviation in GHGI, 2010



## **2010 Philippine Greenhouse Gas Inventory Report** Executive Summary

## Approaches used for data collection

□ For GHGI, 2010 in Philippines



### Screening of available data



Overall energy balance sheet - Department of Energy (DoE)



### Literature sources



IPCC

## Activity data

- Fuel types used for Inventory calculation in GHGI, 2010
  - Jet kerosene
  - Aviation gasoline

### Activity data used for road transportation in GHGI, 2010

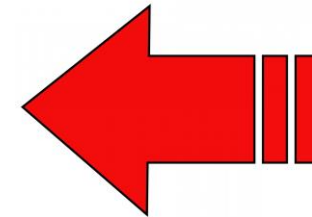
	Coal	Natgas	Crude	PremGas	RegGas	Kero	Diesel	Fuel Oil	LPG	Jet	Avgas	Naphtha
<b>Domestic Air Transport</b>	-	-	-	-	-	-	-	-	-	337.74	3.45	-
International Civic Aviation	-	-	-	-	-	-	-	-	-	511.92	-	-

# Emission factors

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

Example for CH<sub>4</sub> emission factors used for domestic aviation (highlighted 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					

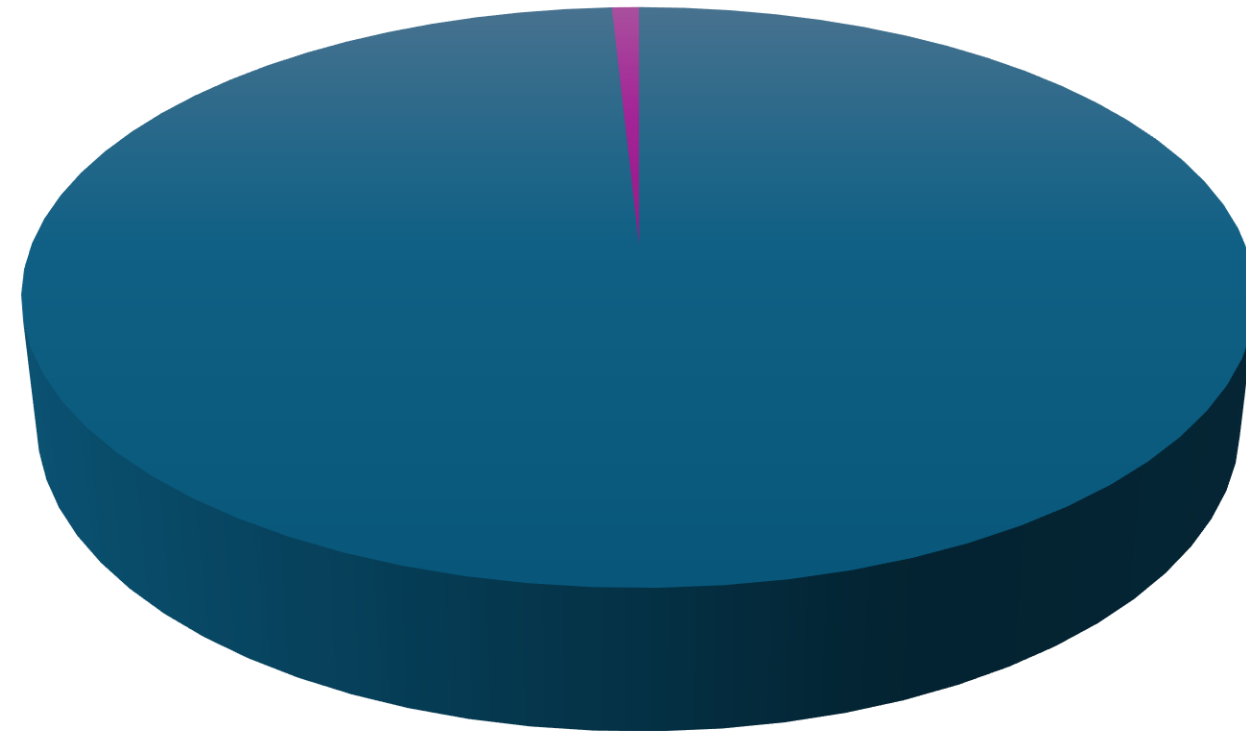


Source: IPCC (1997)

# Emissions

Gas	Emissions (Mt CO <sub>2</sub> e)
CO <sub>2</sub>	0.706
CH <sub>4</sub>	0.000
N <sub>2</sub> O	0.006
<b>Total</b>	<b>0.712</b>

GHG emissions in Civil aviation

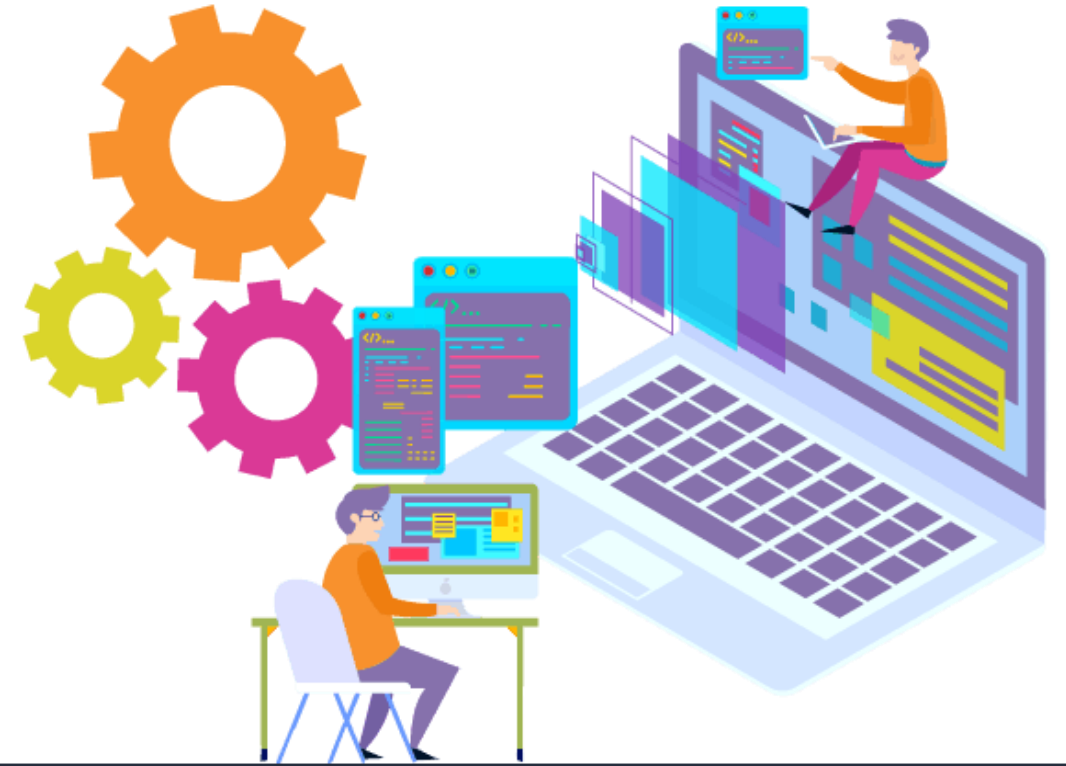


■ CO2 ■ CH4 ■ N2O

Source: [Executive Summary 2010 National GHGI Report.pdf \(climate.gov.ph\)](http://climate.gov.ph)

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# Calculation examples and exercises – Manually & using IPCC inventory tool



## Upcoming slides...

- Each sub-category contain an example and corresponding exercise to be done by you
- Sub-categories with same worksheet formats have only one example and exercise





## □ Tier 1 method

- Based on aggregate quantity of fuel consumption data for aviation (LTO and cruise)

### Aviation equation

$$\text{Emissions} = \text{Fuel Consumption} * \text{Emission Factor}$$

- Used to estimate emissions from **aircrafts that use aviation gasoline** and for **jet-fuelled aviation activities when aircraft operational use data are not available**
- Domestic and international emissions are to be estimated separately
- Use default emissions factors
- You can get those default emission factors from IPCC guidelines >> Volume 2 >> Chapter 3

## Calculation example to find emissions from civil aviation 2010 Philippine, using tier 1

2006 IPCC  
default EF

Fuel type	Consumption (ktoe)	IPCC default emission factor (kg/TJ)			Conversion factor (TJ/ktoe)
<i>Domestic aviation</i>					
Jet	337.74	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	41.87
		71500	0.5	2	
Aviation gas	3.45	70000	0.5	2	41.87
<i>International aviation</i>					
Jet	511.92	71500	0.5	2	41.87

TABLE 3.6.4  
CO<sub>2</sub> EMISSION FACTORS

Fuel	Default (kg/TJ)	Lower	Upper
Aviation Gasoline	70 000	67 500	73 000
Jet Kerosene	71 500	69 800	74 400

TABLE 3.6.5  
NON-CO<sub>2</sub> EMISSION FACTORS

Fuel	CH <sub>4</sub> Default (Uncontrolled) Factors (in kg/TJ)	N <sub>2</sub> O Default (Uncontrolled) Factors (in kg/TJ)
All fuels	0.5 <sup>a</sup> (-57%/+100%) <sup>b</sup>	2 (-70%/+150%) <sup>b</sup>

Domestic and international aviation report separately!

Fuel type	Emissions = Fuel Consumption * Emission Factor
	CO <sub>2</sub>
<i>Domestic aviation</i>	
Jet	Fuel consumption = 337.74 ktoe*41.87 TJ/ktoe = 14,141.1738 TJ E <sub>CO2</sub> = 14,141.1738 TJ * 71,500 kg/TJ = 1011093927 kg or 1011.09 Gg
<i>International aviation</i>	
Jet	Fuel consumption = 511.92 ktoe*41.87 TJ/ktoe = 21,434.0904 TJ E <sub>CO2</sub> = 21,434.0904 TJ * 71,500 kg/TJ = 1532537464 kg or 1532.54 Gg

Calculation for CH<sub>4</sub> & N<sub>2</sub>O is same as calculations done for CO<sub>2</sub>. only the EF change!

If CO<sub>2</sub> has captured, it must subtract from the total CO<sub>2</sub> emissions



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!

IPCC Inventory Software - dinukshi@climatesi - [Worksheets]

Application Database Inventory Year Administrate Worksheets Tools Export/Import Reports Window Help

2006 IPCC Categories

- 1 - Energy
- 2 - Industrial Processes and Product Use
- 3 - Agriculture, Forestry, and Other Land Use
- 4 - Waste
- 5 - Other

Time Series

Time Series

Category 1 - Energy

Gas CARBON DIOXIDE (CO2)

CARBON DIOXIDE (CO2) Emissions (Gg CO2 Equivalents)

\*1... 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018

\* Base year for assessment of uncertainty in trend: 1990

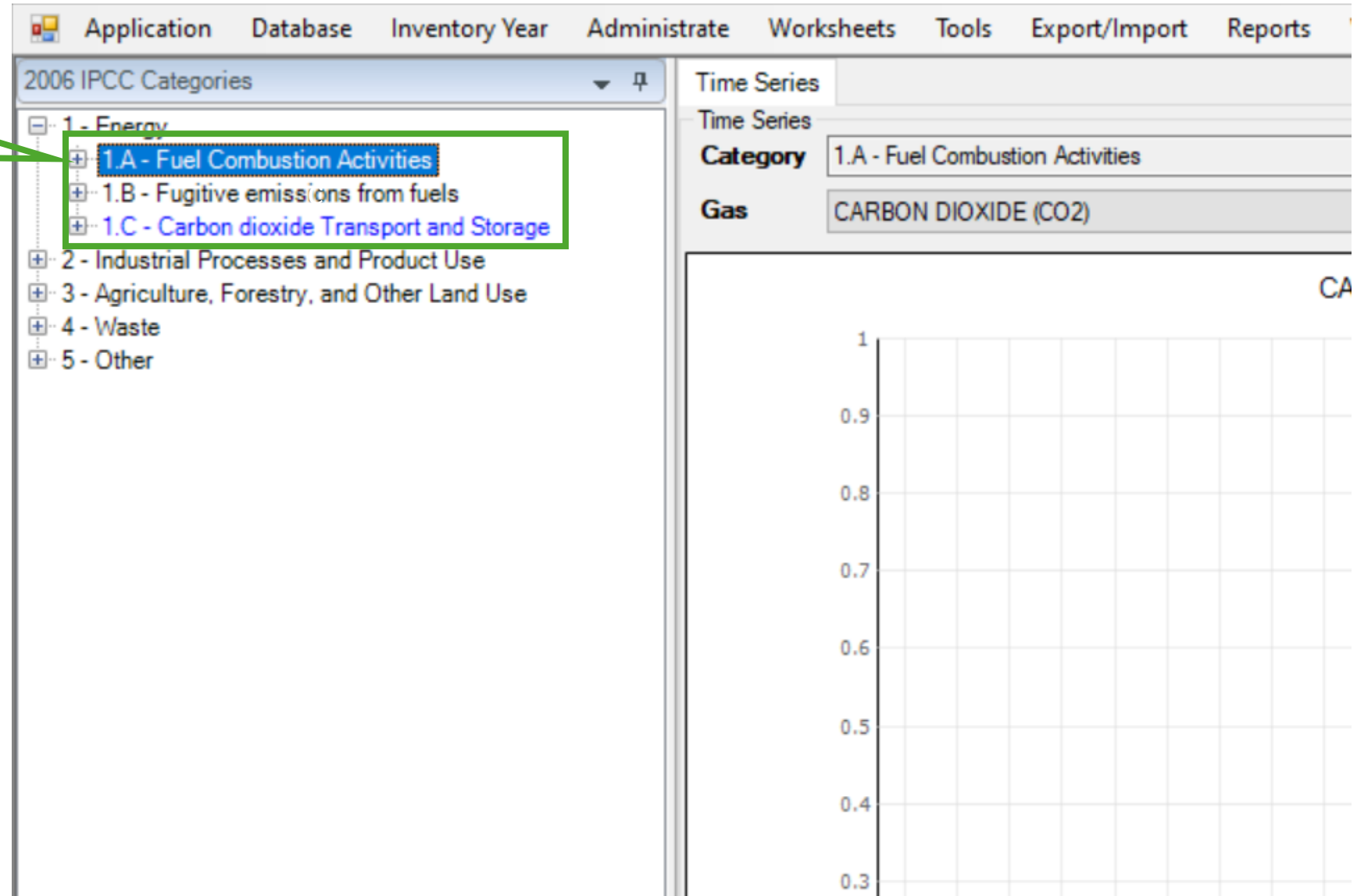
Select the sector that you want to enter data

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

IPCC Inventory Software - dinukshi@climatesi - [Worksheets]



The screenshot shows the IPCC Inventory Software interface. The left pane displays the '2006 IPCC Categories' tree with the following structure:

- 1 - Energy
  - 1.A - Fuel Combustion Activities
  - 1.B - Fugitive emissions from fuels
  - 1.C - Carbon dioxide Transport and Storage
- 2 - Industrial Processes and Product Use
- 3 - Agriculture, Forestry, and Other Land Use
- 4 - Waste
- 5 - Other

The right pane shows the 'Time Series' configuration for Category 1.A - Fuel Combustion Activities and Gas CARBON DIOXIDE (CO2). Below this, a chart is visible with a y-axis ranging from 0.3 to 1.0 and a grid. The chart title is 'CA'.

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

Application Database Inventory Year Administrate Worksheets Tools Export/Import Reports Window Help

2006 IPCC Categories

- 1.A.2.f - Non-Metallic Minerals
- 1.A.2.g - Transport Equipment
- 1.A.2.h - Machinery
- 1.A.2.i - Mining (excluding fuels) and Quar
- 1.A.2.j - Wood and wood products
- 1.A.2.k - Construction
- 1.A.2.l - Textile and Leather
- 1.A.2.m - Non-specified Industry
- 1.A.3 - Transport
  - 1.A.3.a - Civil Aviation
    - 1.A.3.a.i - International Aviation (Intern
    - 1.A.3.a.ii - Domestic Aviation
  - 1.A.3.b - Road Transportation
    - 1.A.3.b.i - Cars
      - 1.A.3.b.i.1 - Passenger cars with 3
      - 1.A.3.b.i.2 - Passenger cars without
    - 1.A.3.b.ii - Light-duty trucks
      - 1.A.3.b.ii.1 - Light-duty trucks with
      - 1.A.3.b.ii.2 - Light-duty trucks with
    - 1.A.3.b.iii - Heavy-duty trucks and bus
    - 1.A.3.b.iv - Motorcycles
    - 1.A.3.b.v - Evaporative emissions from
    - 1.A.3.b.vi - Urea-based catalysts
  - 1.A.3.c - Railways
  - 1.A.3.d - Water-borne Navigation
    - 1.A.3.d.i - International water-borne na
    - 1.A.3.d.ii - Domestic Water-borne Navi
  - 1.A.3.e - Other Transportation
    - 1.A.3.e.i - Pipeline Transport
    - 1.A.3.e.ii - Off-road
- 1.A.4 - Agriculture/Forestry/Fishing/Fi
  - 1.A.4.c - Agriculture/Forestry/Fishing/Fi
    - 1.A.4.c.ii - Off-road Vehicles and Ot
    - 1.A.4.c.iii - Fishing (mobile combusti
  - 1.A.5 - Non-Specified
    - 1.A.5.b - Mobile
      - 1.A.5.b.i - Mobile (aviation compone
      - 1.A.5.b.ii - Mobile (water-borne com
      - 1.A.5.b.iii - Mobile (Other)
    - 1.A.5.c - Multilateral Operations

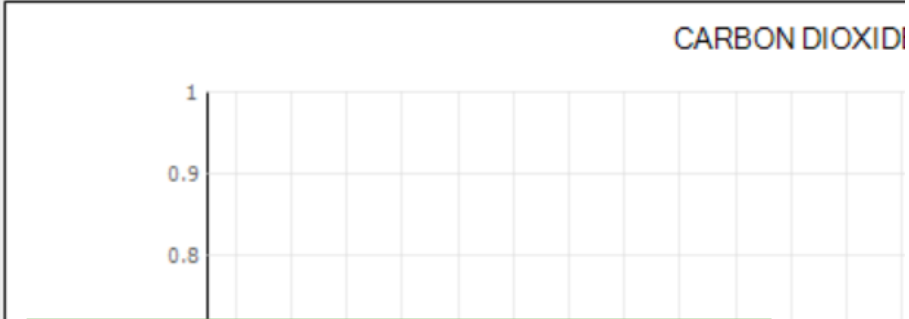
Mobile combustion related categories and sub-categories

1.A.4.c - Agriculture/Forestry/Fishing/Fi

- 1.A.4.c.ii - Off-road Vehicles and Ot
- 1.A.4.c.iii - Fishing (mobile combusti

1.A.5 - Non-Specified

- 1.A.5.b - Mobile
  - 1.A.5.b.i - Mobile (aviation compone
  - 1.A.5.b.ii - Mobile (water-borne com
  - 1.A.5.b.iii - Mobile (Other)
- 1.A.5.c - Multilateral Operations



## 1.A.3.a – Civil aviation

- In IPCC inventory tool, worksheets have same formats for both sub-categories *1.A.3.a.i – International aviation* and *1.A.3.a.ii – Domestic aviation*

Four worksheets in each sub-category  
} Tier 1  
1. Fuel consumption data  
2. Fuel combustion emissions

Application Database Inventory Year Administrate Worksheets Tools Export/Import Reports Window Help

2006 IPCC Categories

- 1.A.2.m - Non-specified Industry
- 1.A.3 - Transport
  - 1.A.3.a - Civil Aviation
    - 1.A.3.a.i - International Aviation (Intern)
    - 1.A.3.a.ii - Domestic Aviation
  - 1.A.3.b - Road Transportation
    - 1.A.3.b.i - Cars
      - 1.A.3.b.i.1 - Passenger cars with 3
      - 1.A.3.b.i.2 - Passenger cars without
    - 1.A.3.b.ii - Light-duty trucks
      - 1.A.3.b.ii.1 - Light-duty trucks with
      - 1.A.3.b.ii.2 - Light-duty trucks without
    - 1.A.3.b.iii - Heavy-duty trucks and bus
    - 1.A.3.b.iv - Motorcycles
    - 1.A.3.b.v - Evaporative emissions from
    - 1.A.3.b.vi - Urea-based catalysts
  - 1.A.3.c - Railways
  - 1.A.3.d - Water-borne Navigation
    - 1.A.3.d.i - International water-borne na
    - 1.A.3.d.ii - Domestic Water-borne Navi
  - 1.A.3.e - Other Transportation
    - 1.A.3.e.i - Pipeline Transport
    - 1.A.3.e.ii - Off-road

Fuel Consumption Data Fuel Combustion Emissions LTO Fuel consumption and LTO emissions - Tier 2 Cruise and total emissions - Tier 2

Worksheet

Sector: Energy  
Category: Fuel Combustion Activities  
Subcategory: 1.A.3.a.ii - Domestic Aviation  
Sheet: Fuel Consumption Data

Data

Fuel Type: Liquid Fuels

Equation 3.6.1

Subdivision	Fuel	Consumption (Mass, Volume or Energy Unit)	Consumption Unit	Conversion Factor (TJ/Unit) (NCV)	Total consumption (TJ)
S	F	C	U	CF	TC = C * CF
Total					0

# 1. Fuel consumption data



Select the 'fuel' using drop down menu here

Select the 'consumption unit' using drop down menu here. Please be aware when selecting either Auto or Manual

User-defined parameter. Enter the fuel consumption in defined units

Default or user-defined parameter

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

Select the 'fuel type'

Subdivision's Column allows to report at subnational level as well as to further disaggregate estimates according to e.g. drivers/stakeholders and/or relevant variables

Sector: Energy  
 Category: Fuel Combustion Activities  
 Subcategory: 1.A.3.a.ii - Domestic Aviation  
 Sheet: Fuel Consumption Data

Data

Fuel Type: Liquid Fuels

- (All fuels)
- Liquid Fuels
- Solid Fuels
- Gaseous Fuels
- Other Fossil Fuels
- Biomass - solid
- Biomass - liquid
- Biomass - gas
- Biomass - other

Fuel	Consumption (Mass, Volume or Energy Unit)	Consumption Unit
F	C	U
Aviation Gasoline		Gg (Auto CF)
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

Consumption Unit

U

- Gg (Auto CF)
- Gg (Auto CF)
- Gg (Manual CF)
- TJ

2006 IPCC Categories

- 1.A.3.a - Civil Aviation
  - 1.A.3.a.i - International Aviation
  - 1.A.3.a.ii - Domestic Aviation

Fuel Consumption Data

Sector: Energy  
 Category: Fuel Combustion Activities  
 Subcategory: 1.A.3.a.ii - Domestic Aviation  
 Sheet: Fuel Consumption Data

Data

Fuel Type: Liquid Fuels

Subdivision	Fuel	Consumption (Mass, Volume or Energy Unit)	Consumption Unit	Conversion Factor (TJ/Unit) (NCV)	Total consumption (TJ)
S	F	C	U	CF	TC = C * CF
All	Aviation Gasoline	144.4515	TJ	1	144.4515
All	Jet Kerosene	14141.1738	TJ	1	14141.1738
Total					14285.6253



## 2. Fuel combustion emissions

Select the 'fuel type' from here and, add uncertainties for each gas from each fuel type in here

Default or user-defined parameter

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

2006 IPCC Categories

- 1.A.3.a - Civil Aviation
  - 1.A.3.a.i - International Aviation
  - 1.A.3.a.ii - Domestic Aviation
- 1.A.3.b - Road Transportation
  - 1.A.3.b.i - Cars
    - 1.A.3.b.i.1 - Passenger
    - 1.A.3.b.i.2 - Passenger
  - 1.A.3.b.ii - Light-duty truck
    - 1.A.3.b.ii.1 - Light-duty
    - 1.A.3.b.ii.2 - Light-duty
  - 1.A.3.b.iii - Heavy-duty truck
  - 1.A.3.b.iv - Motorcycles
  - 1.A.3.b.v - Evaporative emissions
  - 1.A.3.b.vi - Urea-based catalyst
- 1.A.3.c - Railways
- 1.A.3.d - Water-borne Navigation
  - 1.A.3.d.i - International waterborne
  - 1.A.3.d.ii - Domestic waterborne

Fuel Consumption Data | Fuel Combustion Emissions | LTO Fuel consumption and LTO emissions - Tier 2 | Cruise and total emissions - Tier 2

Worksheet: Energy  
Sector: Fuel Combustion Activities  
Category: 1.A.3.a.ii - Domestic Aviation  
Subcategory: Fuel Combustion Emissions  
Sheet: Fuel Combustion Emissions

Data: Fuel Type: Liquid Fuels | Uncertainties for Liquid Fuels

Equation 3.6.1

Fuel consumption				CO <sub>2</sub>			CH <sub>4</sub>		N <sub>2</sub> O		
Subdivision	Fuel	Total fuel consumption (TJ)	CO <sub>2</sub> Emission Factor (kg CO <sub>2</sub> /TJ)	Amount Captured (Gg CO <sub>2</sub> )	CO <sub>2</sub> Emissions (Gg CO <sub>2</sub> )	CH <sub>4</sub> Emission Factor (kg CH <sub>4</sub> /TJ)	CH <sub>4</sub> Emissions (Gg CH <sub>4</sub> )	N <sub>2</sub> O Emission Factor (kg N <sub>2</sub> O/TJ)	N <sub>2</sub> O Emissions (Gg N <sub>2</sub> O)		
S	Δ∇	F	Δ∇	C	EF(CO <sub>2</sub> )	Z	CO <sub>2</sub> =C*EF (CO <sub>2</sub> )/10 <sup>6</sup> -Z	EF(CH <sub>4</sub> )	CH <sub>4</sub> =C*EF (CH <sub>4</sub> )/10 <sup>6</sup>	EF(N <sub>2</sub> O)	N <sub>2</sub> O=C*EF (N <sub>2</sub> O)/10 <sup>6</sup>
All		Aviation Gasoline		144.4515	70000	0	10.11161	0.5	0.00007	2	0.00029
All		Jet Kerosene		14141.1738	71500	0	1011.09393	0.5	0.00707	2	0.02828
Total				14285.6253			1021.20553		0.00714		0.02857

Uncertainties by Fuel Type

Liquid Fuels

Category: 1.A.3.a.ii - Domestic Aviation  
Sheet: Fuel Combustion Emissions

Activity Data Uncertainties  
Lower: -5.00 % | Upper: +5.00 %

Emission Factors Uncertainties  
Gas: CARBON DIOXIDE (CO<sub>2</sub>)  
Lower: -3.17 % | Upper: +4.21 %

OK | Cancel

Add activity data uncertainties and emission factor uncertainties for CO<sub>2</sub>, N<sub>2</sub>O and CH<sub>4</sub>



Let's do an example with the  
inventory tool!

## Exercise 1: Civil aviation

### Activity 01

- Step 01: Open the worksheet fuel consumption data and select the fuel type as Liquid fuels
- Step 02: Enter fuel consumption data into one of civil aviation worksheet (either domestic aviation or international aviation)

Input parameter	Entry
<i>Fuel consumption data</i>	
Subdivision	Unspecified
Fuel	Jet kerosene
Consumption	2810 million liters
Consumption unit	Gg (Auto CF)
Conversion factor	User-defined parameter

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

- Step 03: Save entered data

- Step 04: Open the worksheet Fuel combustion emissions and select the fuel type as liquid fuels
- Step 05: Enter fuel combustion emission data into previously data entered same sub-category (either domestic aviation or international aviation)

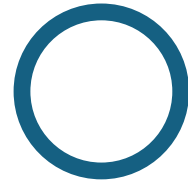
*Note: Here you have to enter emission factors. You can enter either default emission factors or specific emission factors. But for this activity, please enter default values only.*

Input parameter	Entry
<i>Fuel combustion emissions</i>	
CO <sub>2</sub> emission factor	Default value, 71500
Amount captured	0 (Zero)
CH <sub>4</sub> emission factor	Default value, 0.5
N <sub>2</sub> O emission factor	Default value, 2

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

- Step 05: Save entered data

# Results



## Fuel consumption data



Fuel Consumption Data | Fuel Combustion Emissions | LTO Fuel consumption and LTO emissions - Tier 2 | Cruise and total emissions - Tier 2

Worksheet

**Sector:** Energy 2020

**Category:** Fuel Combustion Activities

**Subcategory:** 1.A.3.a.i - International Aviation (International Bunkers)

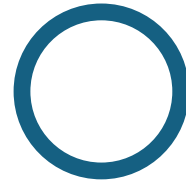
**Sheet:** Fuel Consumption Data

Data

**Fuel Type:** Liquid Fuels

Equation 3.6.1

Subdivision	Fuel	Consumption (Mass, Volume or Energy Unit)	Consumption Unit	Conversion Factor (TJ/Unit) (NCV)	Total consumption (TJ)
S	F	C	U	CF	TC = C * CF
► Unspecified	Jet Kerosene	2810	Gg (Auto CF)	44.1	123921
* Total					123921



## Fuel combustion emissions



Fuel Consumption Data **Fuel Combustion Emissions** LTO Fuel consumption and LTO emissions - Tier 2 Cruise and total emissions - Tier 2

Worksheet **2020**

**Sector:** Energy  
**Category:** Fuel Combustion Activities  
**Subcategory:** 1.A.3.a.i - International Aviation (International Bunkers)  
**Sheet:** Fuel Combustion Emissions

Data  
**Fuel Type** Liquid Fuels

Equation 3.6.1

Fuel consumption			CO2			CH4		N2O		
Subdivision	Fuel	Total fuel consumption (TJ)	CO2 Emission Factor (kg CO2/TJ)	Amount Captured (Gg CO2)	CO2 Emissions (Gg CO2)	CH4 Emission Factor (kg CH4/TJ)	CH4 Emissions (Gg CH4)	N2O Emission Factor (kg N2O/TJ)	N2O Emissions (Gg N2O)	
S	F	C	EF(CO2)	Z	$CO_2 = C * EF(CO_2) / 10^6 - Z$	EF(CH4)	$CH_4 = C * EF(CH_4) / 10^6$	EF(N2O)	$N_2O = C * EF(N_2O) / 10^6$	
► Unspecified	Jet Kerosene	123921	71500	0	8860.3515	0.5	0.06196	2	0.24784	
<b>Total</b>		123921			8860.3515		0.06196		0.24784	



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