IPCC Workshop on the Inventory Software

Hands-on demonstration: ENERGY

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IPCC TFI-TSU

INTERGOVERNMENTAL PANEL ON climate change

WMO

UN environment programme

Way of work for Energy session:

Morning Session:

We will be working together from **09:00 to 12:30**, 3-hour of **hands-on activities**.

Step-by-step Approach:

Guided exercises to build **familiarity** and **confidence** with the IPCC Inventory Software.

Increasing Complexity:

Start with **basic tasks** and gradually move to more **complex exercises**.

Hands-On Practice:

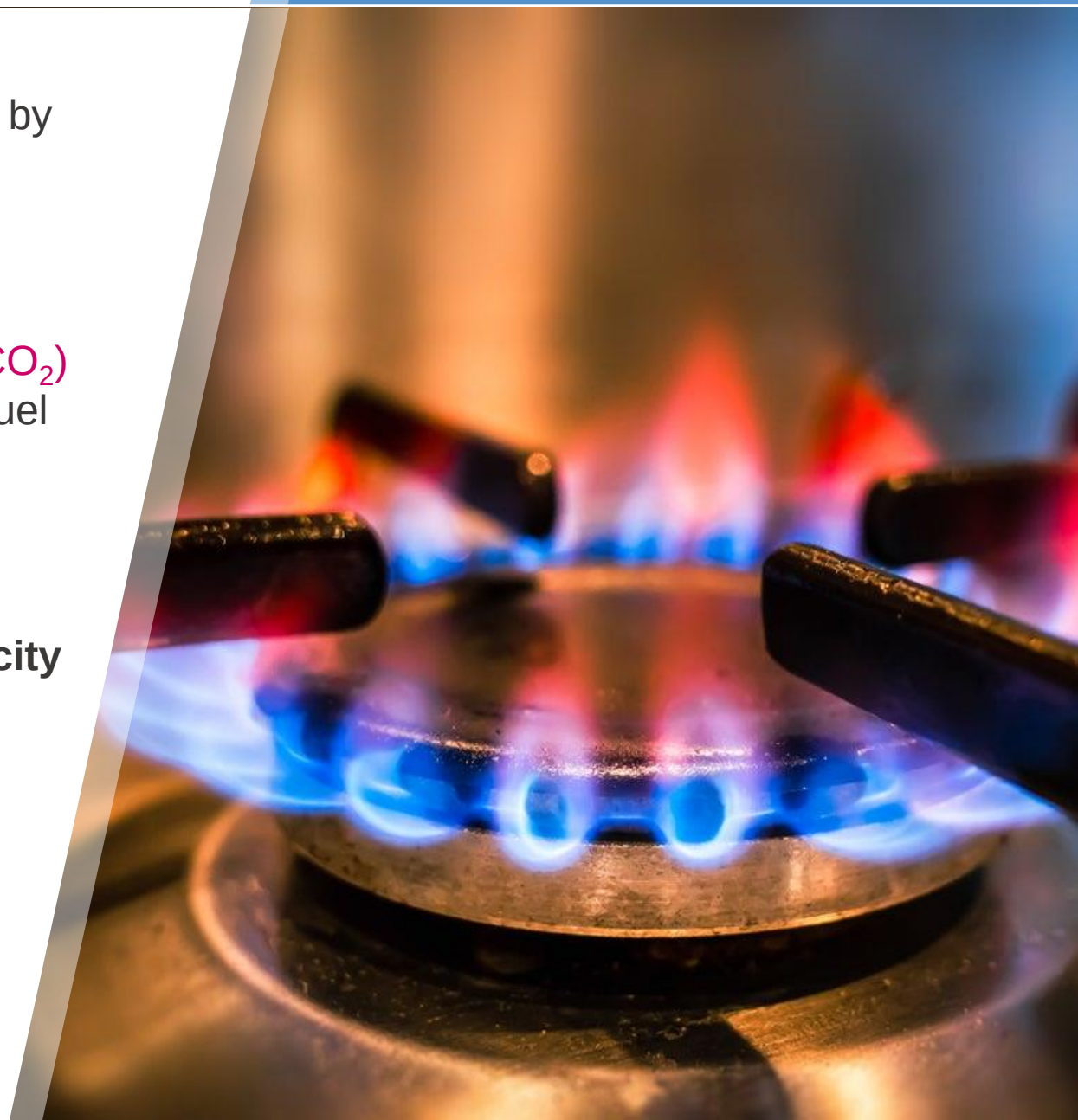
Download the Excel dataset with input data and the pdf presentation from the **EDG**

ENERGY SECTOR

- **Energy systems** are for most economies largely driven by the combustion of **fossil fuels.**

- During **combustion**, the **carbon and hydrogen** of the fossil fuels are converted mainly into **carbon dioxide** (CO_2) and **water** (H_2O), releasing the chemical energy in the fuel as **heat**.

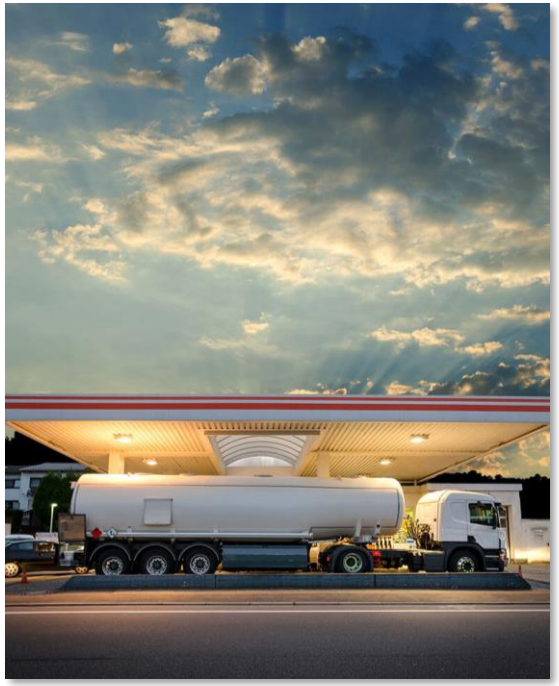
- This heat is generally either used directly or used to produce **mechanical energy**, often to **generate electricity** or for **transportation**.



Energy Sector: Source Categories

Exploration and exploitation of primary energy sources

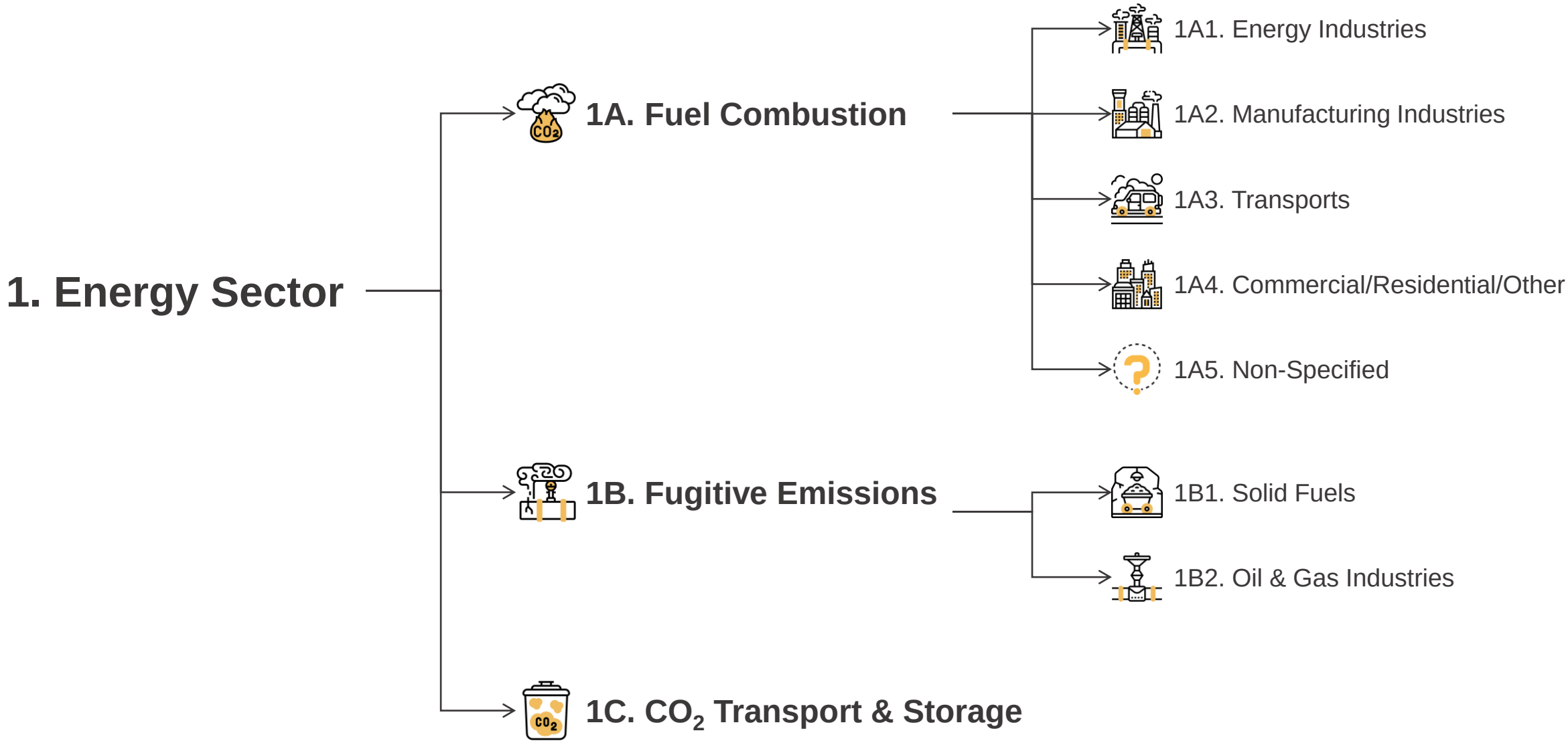
Conversion of primary energy sources into more useable energy forms in refineries and power plants



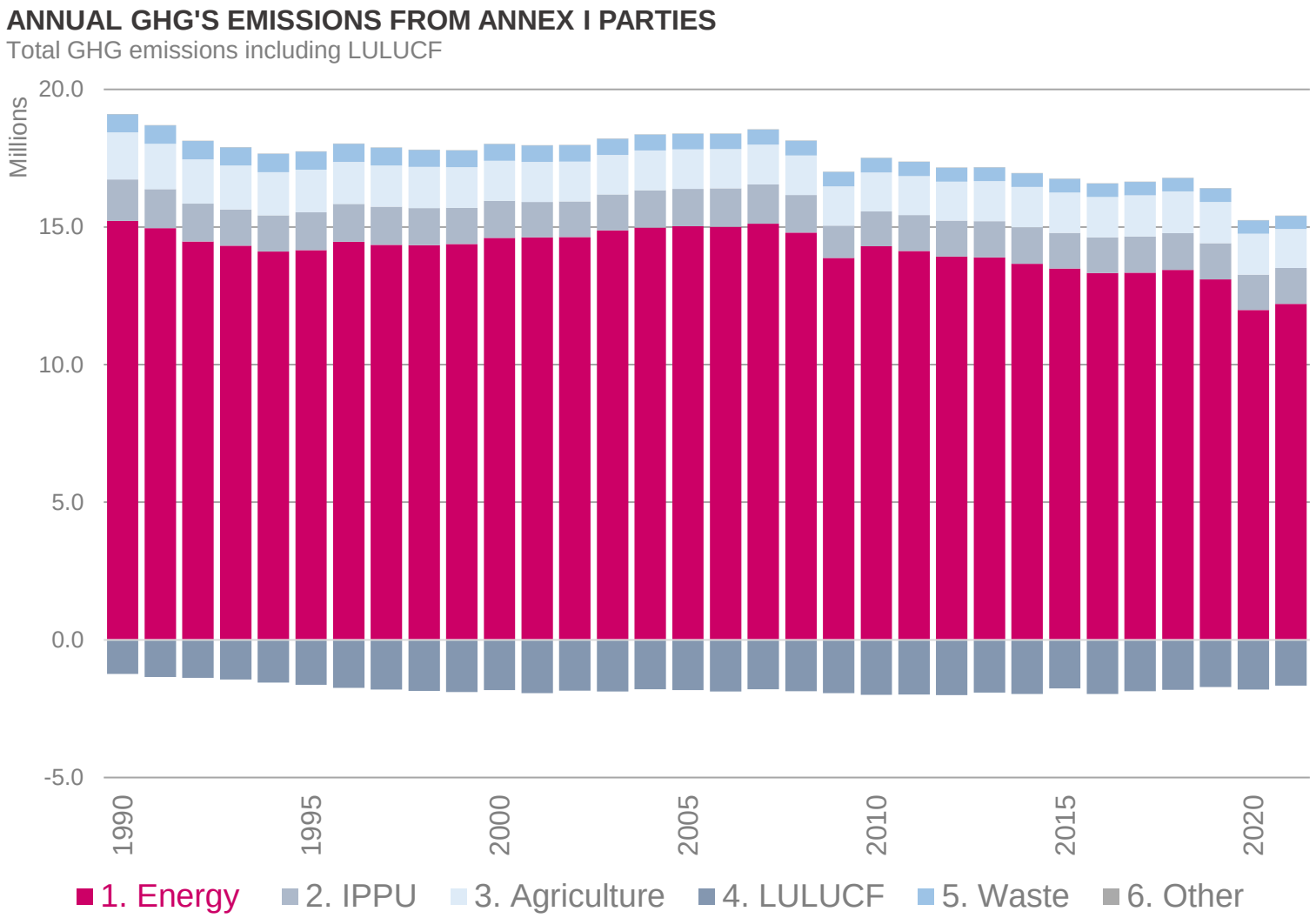
Transmission and distribution of fuels

Use of fuels in stationary and mobile applications

Introduce CRF1 structure



Importance of Energy Sector in Totals



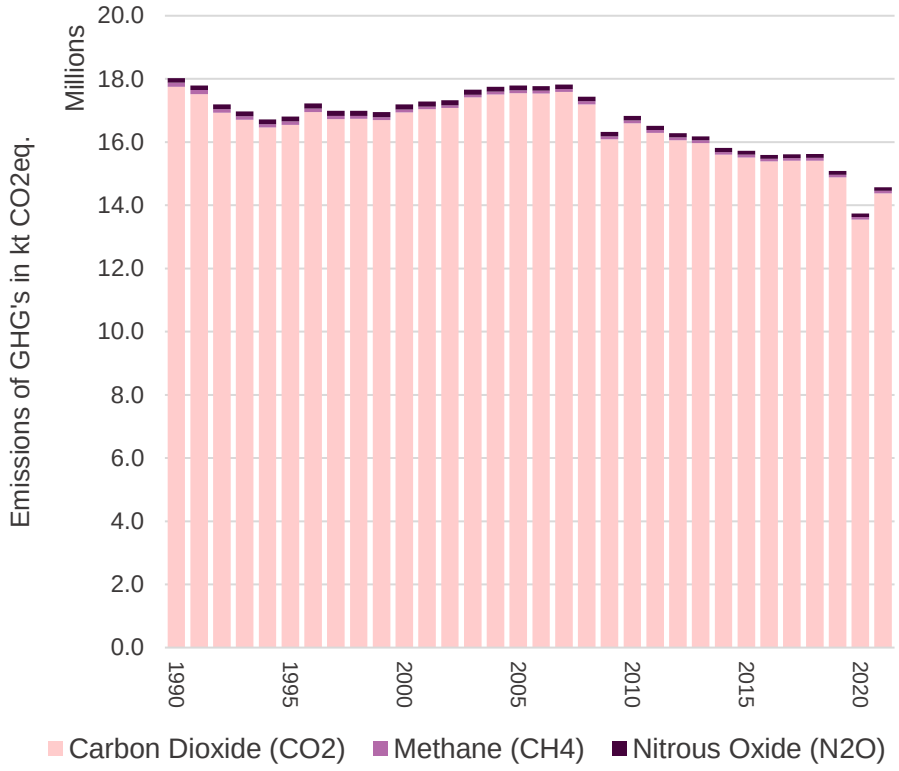
The **energy sector** is usually the **most important sector** in GHG inventories, and typically contributes **75% of the total GHG emissions** in **developed countries**.

- **Stationary combustion** is usually responsible for about **70% of the GHG** emissions from the energy sector.
- **Mobile combustion** (road and other traffic) causes about **25% of the emissions** in the energy sector.
- **Fugitive emissions** represent around **5% of the GHG** emissions from the energy sector

GHG emissions by gas

1A. ENERGY - FUEL COMBUSTION

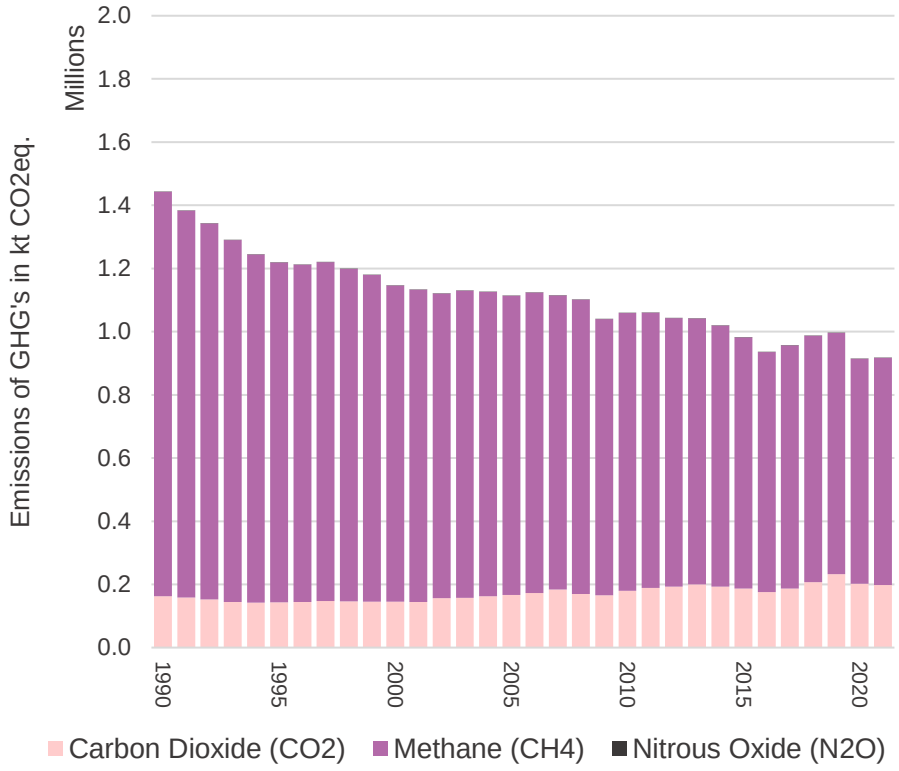
GHG's emissions by gas - Annex I Parties *(2023 submission)*



Around **99% do the emissions** from **category 1A** come from **Carbon Dioxide**

1B. ENERGY - FUGITIVE EMISSIONS

GHG's emissions by gas - Annex I Parties *(2023 submission)*



Around **80% to 85% do the emissions** from **category 1B** come from **Methane**

Goals for our session:

I. Get familiar with the IPCC Inventory Software Environment

- Navigate the software **interface** and **worksheets**
- Enter **activity data** and select **emissions factors**
- Use the **Fuel-Manager tool**
- Use the **Reference Approach tool**
- Create a **New Inventory Year**

II. Be able to estimate emissions using the IPCC Inventory Software

- Apply **default IPCC** factors (Tier 1)
- Apply **country/sector-specific** factors (Tier 2)
- Apply **plant-specific** factors (Tier 3)
- Produce the **Reference Approach**

EXERCISE 1 - Enter data into the IPCC Inventory Software

GHG Emissions from Fuel Combustion

GHG EMISSIONS – FUNDAMENTAL FORMULA

$$\text{Emission}_{GHG} = \text{Activity} \bullet \text{Emission Factor}_{GHG}$$

GHG EMISSIONS FROM FUEL COMBUSTION

$$\text{Emission}_{GHG,fuel} = \text{Energy Consumption}_{fuel} \bullet \text{Emission Factor}_{GHG,fuel}$$

CO_2 EMISSIONS FROM FUEL COMBUSTION – DETAILED PARAMETERS

$$\text{Emission}_{CO2,fuel} = \text{Fuel Consumption}_{fuel} * \text{Net Calorific Value}_{fuel} \bullet \text{Carbon Content}_{fuel} * \text{Oxidation Factor} * 44/12$$

- **Amount of fuel used** during a certain period, measured in *units of mass or energy*
- **Energy released** per unit of fuel when *completely burned*.
- a measure of **how much carbon is contained** within a given **quantity of that fuel**
- The **fraction of carbon** in the fuel that **actually oxidizes into CO_2** during combustion

GHG Emissions from Fuel Combustion

Non-CO_2 EMISSIONS FROM FUEL COMBUSTION

$$Emission_{CH4,fuel} = Fuel\ Consumption_{fuel} * Net\ Calorific\ Value_{fuel} \bullet Emission\ Factor_{CH4,fuel}$$

$$Emission_{N2O,fuel} = Fuel\ Consumption_{fuel} * Net\ Calorific\ Value_{fuel} \bullet Emission\ Factor_{N2O,fuel}$$

CH_4 and N_2O Emissions:

- Origin from **incomplete combustion** or **specific combustion processes**.
- **Not directly linked to the carbon content of the fuel**, unlike CO_2 emissions.

Oxidation Factor:

- **Not applicable** for calculating CH_4 and N_2O emissions, as these **do not result from the direct oxidation** of carbon, but rather **other combustion dynamics**

Exercise 1a – Tier 1 Method

CASE STUDY: APPLYING A TIER 1 METHOD

Using default data to estimate GHG emissions applying a Tier 1 method.

Scenario: In 2015, the electricity sector of your country consumed:

- 13 450 Gg of Bituminous Coal
- 6 320 Gg of Fuel Oil

Goal: Quickly and accurately **estimate the GHG emissions** from these fuels.

Your Task:

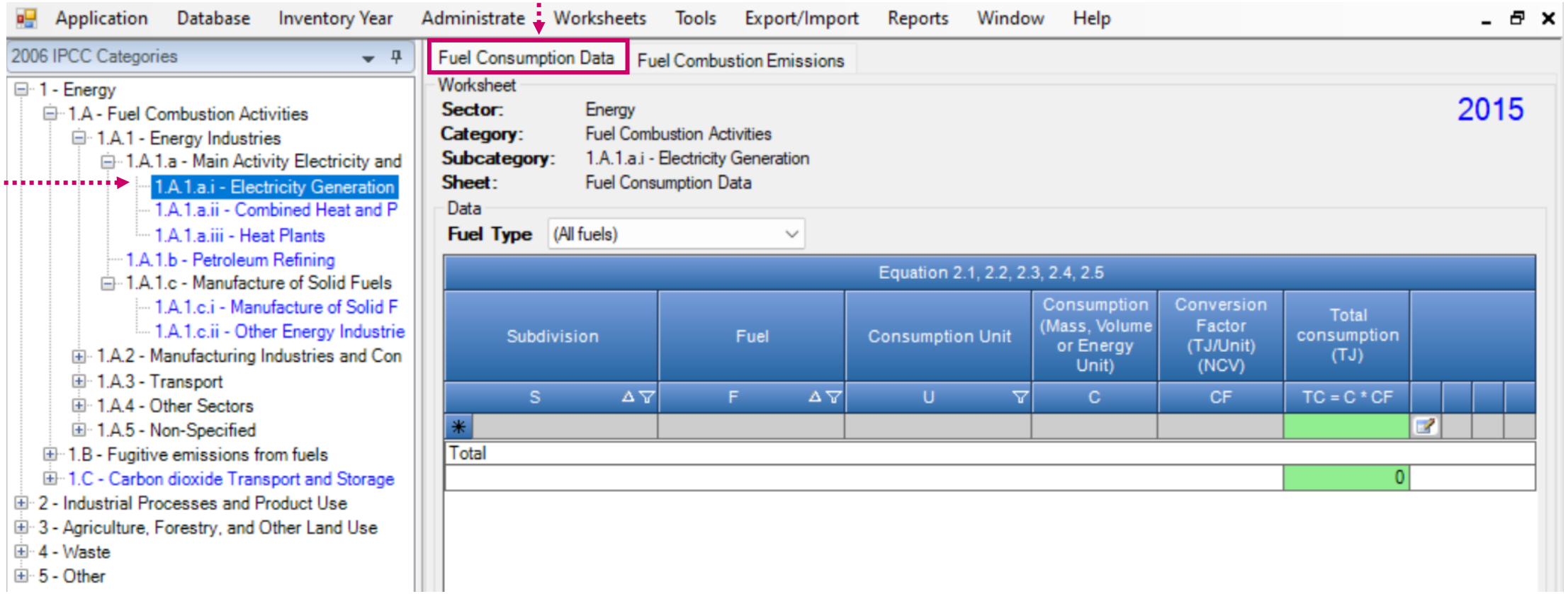
1. Input data to the IPCC Inventory Software
2. Select the default emission factors and net calorific values
3. Calculate Emissions

Exercise 1a – Tier 1 Method

1 – INPUT FUEL CONSUMPTION DATA

I. Confirm you're in the right place

- Select Category - 1.A.1.a.i Electricity Generation
- Select Worksheet - Fuel Consumption Data



Exercise 1a – Tier 1 Method

1 – INPUT FUEL CONSUMPTION DATA

II. Input data into the Software

Data

Fuel Type (All fuels)

Equation 2.1, 2.2, 2.3, 2.4, 2.5					
Subdivision	Fuel	Consumption Unit	Consumption (Mass, Volume or Energy Unit)	Conversion Factor (TJ/Unit) (NCV)	Total consumption (TJ)
S	F	U	C	CF	TC = C * CF
Unspecified	Other Bituminous Coal	Gg (Auto CF)	13450	25.8	347010
Unspecified	Residual Fuel Oil	Gg (Auto CF)	6320	40.4	255328
Total					602338

Fuel consumption 2015

Other Bituminous Coal
* 13450 Gg

Residual Fuel Oil
* 6320 Gg

|S| Subdivision: select *Unspecified*

|F| Fuel: select *Other Bituminous Coal* and *Residual Fuel Oil*

|U| Consumption Unit: select Gg (Auto CF) or Gg (Manual CF) or TJ

|C| Consumption: enter *amount of fuel consumed*

|CF| Conversion Factor: conversion factor to convert the consumption unit to an energy unit

Exercise 1 – Tier 1 Method

2 – SELECT EMISSION FACTORS

I. Move to the calculation Worksheet

* Fuel Combustion Emissions

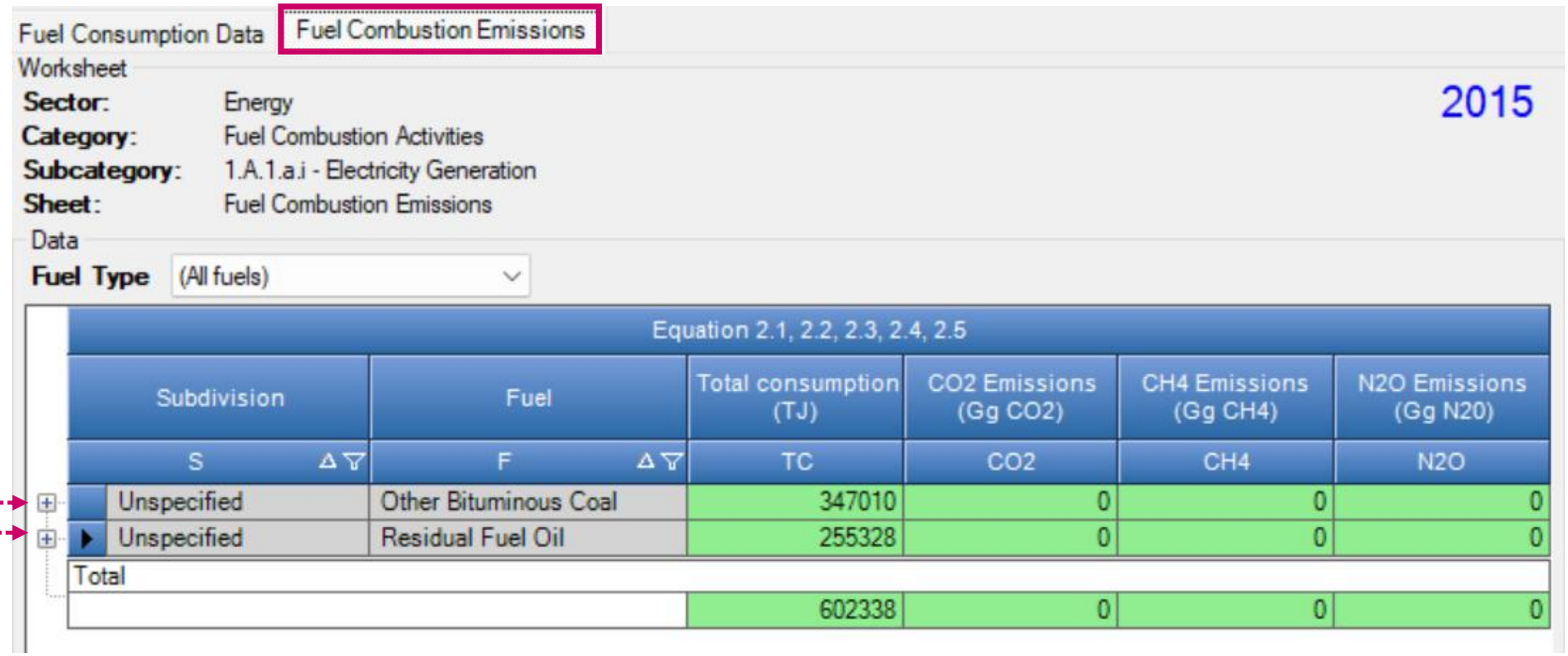
II. Verify Activity Data and Emissions

Verify that the **total consumption data** has been correctly **transferred** from the 'Fuel Consumption Data' sheet to this one.

*At this point, the **emissions** columns should display the value **zero**.*

III. Expand fuel rows to add Emission Factors

* Click the **plus sign (+) to expand the view**



Exercise 1a – Tier 1 Method

2 – SELECT EMISSION FACTORS

IV. Enter Technology Information

|T| Type of Technology: select *Unspecified*

|P| Technology penetration: select *100*

Technology		
Type of Technology	Technology penetration (%)	Consumption (TJ)
T	P	C=TC*(P/100)
*		

IV. Selection of CO_2 Emission Factor

|EF CO_2| Emission Factor:

- **Specified**: select the **IPCC default CO_2 EF** from the drop-down menu
- **Calculated**: calculate CO_2 EF from the **Carbon Content** and **Oxi. Factor**

|Z| Amount of CO_2 Captured: input the value *0*

CO2		
CO2 Emission Factor (kg CO2/TJ)	Amount Captured (Gg CO2)	CO2 Emissions (Gg CO2)
EF(CO2)	Z	CO2=C*EF (CO2)/10^6-Z

V. Selection of CH_4 and N_2O Emission Factor

|EF CH_4| : select the **IPCC default CH_4 EF** value from the drop-down menu

|EF N_2O| : select the **IPCC default N_2O EF** value from the drop-down menu

CH4		N2O	
CH4 Emission Factor (kg CH4/TJ)	CH4 Emissions (Gg CH4)	N2O Emission Factor (kg N2O/TJ)	N2O Emissions (Gg N20)
EF(CH4)	CH4=C*EF (CH4)/10^6	EF(N2O)	N2O=C*EF (N2O)/10^6

Exercise 1a – Tier 1 Method

2 – SELECT EMISSION FACTORS

Technology			CO2				CH4		N2O	
Type of Technology	Technology penetration (%)	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 N20)
T	P	C=TC*(P/100)	EF(CO2)		Z	CO2=C*EF(CO2)/10^6-Z	EF(CH4)	CH4=C*EF(CH4)/10^6	EF(N2O)	N2O=C*EF(N2O)/10^6
Unspecified	100	347010	Specified	94600	0	32827.15	1	0.35	1.5	0.52
Unspecified	100	255328	Specified	77400	0	19762.39	3	0.77	0.6	0.15

To select the IPCC default value from the drop-down menu

** Click on the right corner of the cell*

** A small panel will open showing default, lower and upper limit*

** Select the default value*

Other Bituminous Coal

Type of Technolog – Unspecified
Technology penetration – 100
CO_2 EF – Specified
CO_2 EF – Default (94600)
Amount Captured - 0
CH_4 EF – Default (1)
N_2O EF – Default (1.5)

Residual Fuel Oil

Type of Technolog – Unspecified
Technology penetration – 100
CO_2 EF – Specified
CO_2 EF – Default (77400)
Amount Captured - 0
CH_4 EF – Default (3)
N_2O EF – Default (0.6)

Exercise 1a – Tier 1 Method

3 – RESULTS

Equation 2.1, 2.2, 2.3, 2.4, 2.5					
Subdivision	Fuel	Total consumption (TJ)	CO2 Emissions (Gg CO2)	CH4 Emissions (Gg CH4)	N2O Emissions (Gg N20)
S	F	TC	CO2	CH4	N2O
Unspecified	Other Bituminous Coal	347010	32827.15	0.35	0.52
Unspecified	Residual Fuel Oil	255328	19762.39	0.77	0.15
Total					
		602338	52589.53	1.11	0.67

Gas	Emissions (Gg)	GWP AR.5	Emissions (Gg CO_2e)
CO_2 Emission	52,589.53	1	52,589.53
CH_4 Emission	1.11	28	31.08
N_2O emission	0.67	265	177.55
Total GHG emissions			**52 798.16**

Exercise 1b – Tier 2 Method

CASE STUDY: APPLYING A TIER 2 METHOD
Enter Country/Sector Specific factor to update to a Tier 2

Scenario: In one of its publications, the **association of electricity producers** released **specific metrics for the fuels** consumed in the **sector**:

Bituminous Coal:

- Net Calorific Value: 25.1 TJ/Gg
- CO_2 Emission Factor: 92 300 kg CO_2/TJ

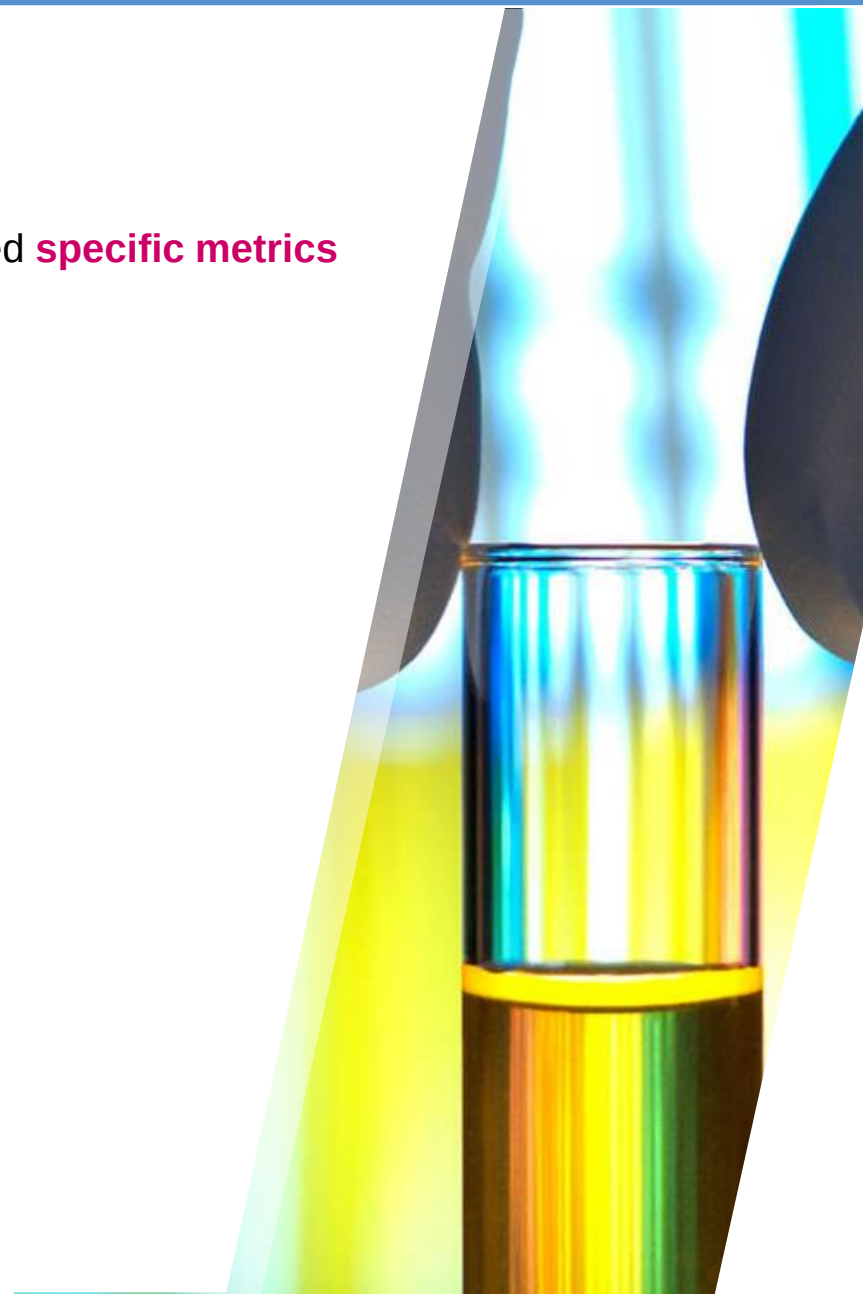
Fuel Oil:

- Net Calorific Value: 40.2 TJ/Gg
- CO_2 Emission Factor: 77 250 kg CO_2/TJ

Goal: Update data in the software to **Sector-Specific factors**

Your Task:

1. Update the CO2 emission factors and net calorific values
2. Calculate Emissions



Exercise 1.b – Tier 2 Method

1 – INPUT FUEL CONSUMPTION DATA

I. Confirm you're in the right place

II. Input data into the Software

- Set **'Consumption Unit**' to **'Gg (Manual)'** to allow for the addition of a specific conversion factor.
- Then manually enter the **sector-specific NCV value** in the **'Conversion Factor**' cell.

NET CALORIFIC VALUES

Other Bituminous Coal
* NCV: 25.1 TJ/Gg

Residual Fuel Oil
* NCV: 40.2 TJ/Gg

Equation 2.1, 2.2, 2.3, 2.4, 2.5					
Subdivision	Fuel	Consumption Unit	Consumption (Mass, Volume or Energy Unit)	Conversion Factor (TJ/Unit) (NCV)	Total consumption (TJ)
S	F	U	C	CF	TC = C * CF
Unspecified	Other Bituminous Coal	Gg (Manual CF)	13450	25.1	337595
Unspecified	Residual Fuel Oil	Gg (Manual CF)	6320	40.2	254064
Total					591659

Exercise 1.b – Tier 2 Method

2 – SELECT EMISSION FACTORS

I. Move to the calculation Worksheet

II. Verify Activity Data and Emissions

III. Expand fuel rows to add Emission Factors

IV. Enter Emission Factors

- Manually update the **CO_2 emission factor** values to the **Sector-Specific EF**.

CO_2 EMISSION FACTOR

Other Bituminous Coal
* EF: 92 300 kg CO_2/TJ

Residual Fuel Oil
* EF: 77 250 kg CO_2/TJ

Technology			CO2					CH4		N2O	
Type of Technology	Technology penetration (%)	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 N20)
T	P	C=TC*(P/100)	EF(CO2)			Z	CO2=C*EF (CO2)/10^6-Z	EF(CH4)	CH4=C*EF (CH4)/10^6	EF(N2O)	N2O=C*EF (N2O)/10^6
Unspecified	100	337595	Specified	92300		0	31160.02	1	0.34	1.5	0.51
Unspecified	100	254064	Specified	77250		0	19626.44	3	0.76	0.6	0.15

Exercise 1.b – Tier 2 Method

3 – RESULTS

Equation 2.1, 2.2, 2.3, 2.4, 2.5					
Subdivision	Fuel	Total consumption (TJ)	CO2 Emissions (Gg CO2)	CH4 Emissions (Gg CH4)	N2O Emissions (Gg N20)
S	F	TC	CO2	CH4	N2O
Unspecified	Other Bituminous Coal	337595	31160.02	0.34	0.51
Unspecified	Residual Fuel Oil	254064	19626.44	0.76	0.15
Total					
		591659	50786.46	1.1	0.66

Gas	Emissions (Gg)	GWP AR.5	Emissions (Gg CO_2e)
CO_2 Emission	50,786.46	1	50,786.46
CH_4 Emission	1.10	28	30.80
N_2O emission	0.66	265	174.90
Total GHG emissions			**50,992.16**

EXERCISE 2 - Using the Fuel Manager

Fuel Manager

What is the fuel manager?

- The fuel manager stores a list of fuels along with their NCVs and carbon content within the IPCC software.
- Initially it includes IPCC default fuels.
- The NCVs and carbon contents can be updated and additional fuels added.

Fuel Manager

What it does

- The fuel manager is linked to all the energy sector worksheets.
- When selecting a fuel within worksheets the default data (e.g. NCV) that is included comes from the Fuel Manager.
- Updates made within the fuel manager automatically update the worksheets.

Fuel Manager

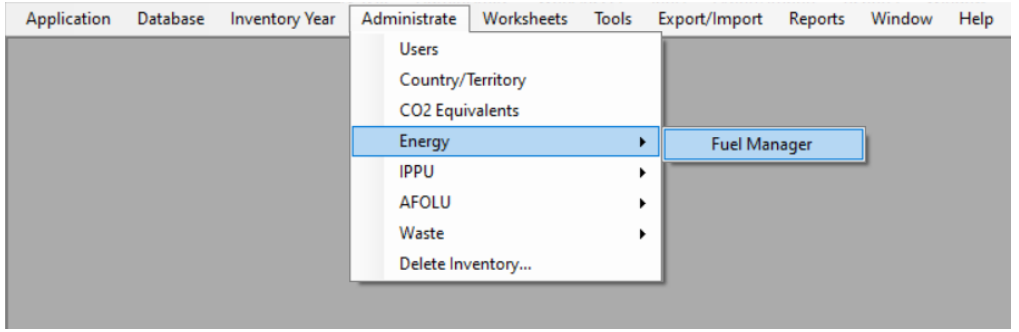
Why is it important?

- Underpins the workings of the worksheets.
- Only fuels within the fuel manager can be added to the worksheets.
- Ensures consistency in the data around fuels (where required).

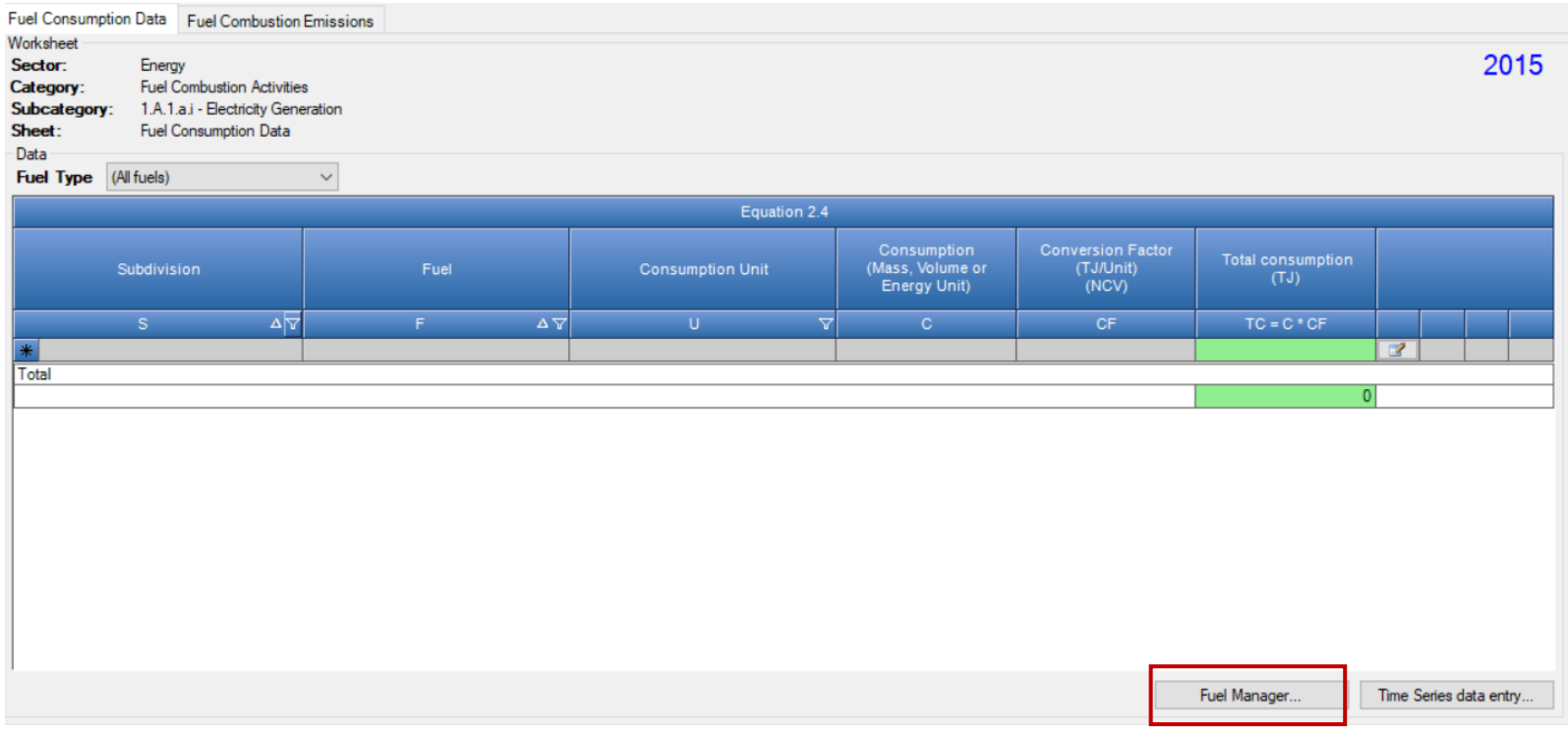
Accessing the Fuel Manager

1 – Under Administrate menu

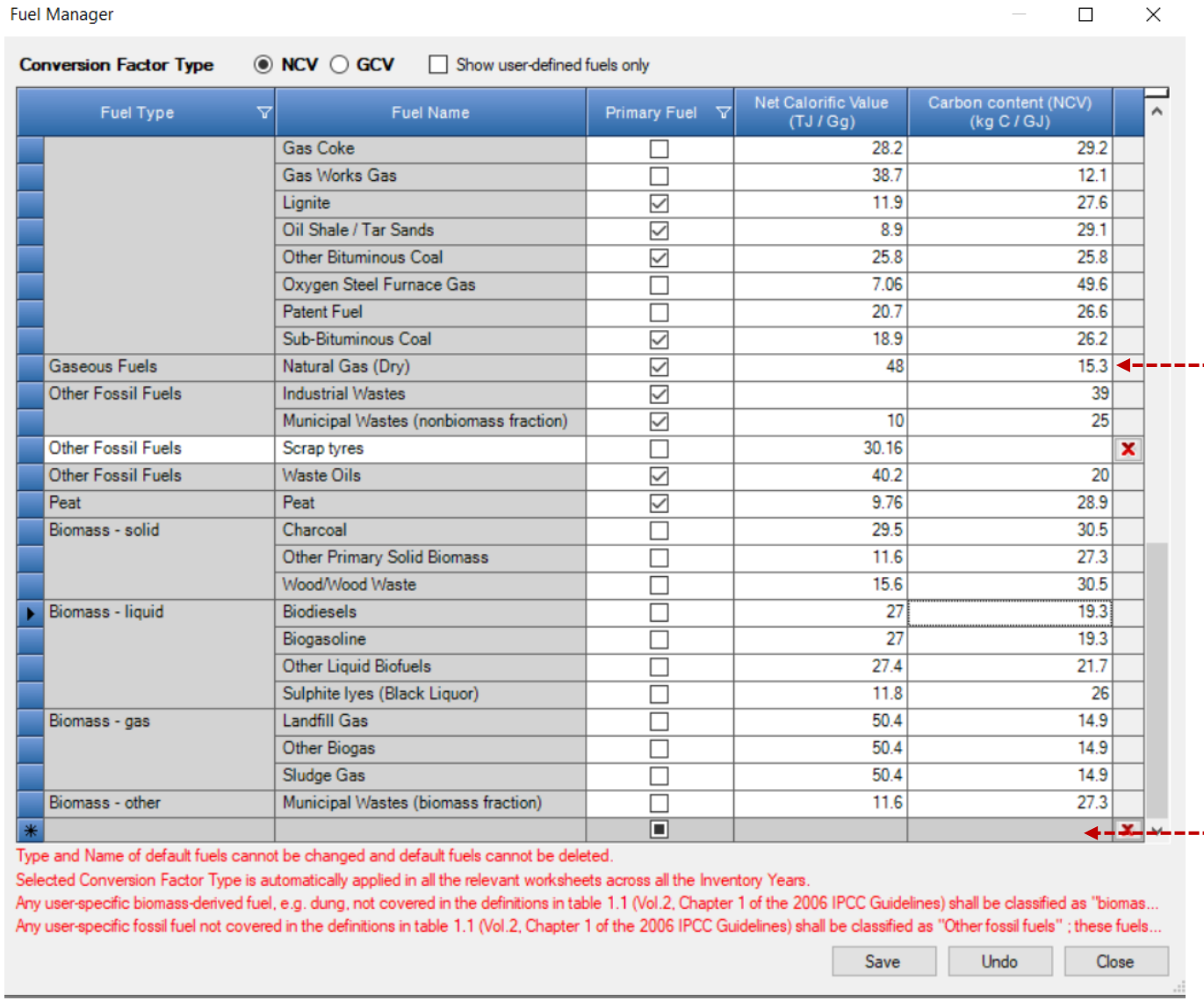
(Superuser access required)



2 – Via the energy sector worksheets



Updating the fuel manager



Fuel Type	Fuel Name	Primary Fuel	Net Calorific Value (TJ / Gg)	Carbon content (NCV) (kg C / GJ)
	Gas Coke	☐	28.2	29.2
	Gas Works Gas	☐	38.7	12.1
	Lignite	☑	11.9	27.6
	Oil Shale / Tar Sands	☑	8.9	29.1
	Other Bituminous Coal	☑	25.8	25.8
	Oxygen Steel Furnace Gas	☐	7.06	49.6
	Patent Fuel	☐	20.7	26.6
	Sub-Bituminous Coal	☑	18.9	26.2
Gaseous Fuels	Natural Gas (Dry)	☑	48	15.3
Other Fossil Fuels	Industrial Wastes	☑		39
	Municipal Wastes (nonbiomass fraction)	☑	10	25
Other Fossil Fuels	Scrap tyres	☐	30.16	
Other Fossil Fuels	Waste Oils	☑	40.2	20
Peat	Peat	☑	9.76	28.9
Biomass - solid	Charcoal	☐	29.5	30.5
	Other Primary Solid Biomass	☐	11.6	27.3
	Wood/Wood Waste	☐	15.6	30.5
Biomass - liquid	Biodiesels	☐	27	19.3
	Biogasoline	☐	27	19.3
	Other Liquid Biofuels	☐	27.4	21.7
	Sulphite lyes (Black Liquor)	☐	11.8	26
Biomass - gas	Landfill Gas	☐	50.4	14.9
	Other Biogas	☐	50.4	14.9
	Sludge Gas	☐	50.4	14.9
Biomass - other	Municipal Wastes (biomass fraction)	☐	11.6	27.3
		■		

Update data for default fuels
Type in updated values into the cells

Add additional fuels

Exercise 2 – Fuel Manager

CASE STUDY: ESTIMATE EMISSIONS FROM A CUSTOM FUEL
Enter a custom fuel in Fuel Manager

Scenario: In 2015, the cement production sector (2 plants) of your country consumed:

- Petroleum Coke
- Fuel Oil
- Old Tyres

Goal: Add a **custom fuel** to the **Fuel Manager**, use **Plant Specific factors**, and **estimate GHG emissions.**

Your Task:

1. Enter Old Tyres in Fuel Manager
2. Input data to the IPCC Inventory Software
3. Enter plant specific net calorific values and emission factors
4. Calculate Emissions

Note: The cement production sector is included in 1.A.2.f Non-Metallic Minerals of the IPCC Software

Exercise 2 – Fuel Manager

CASE STUDY: ESTIMATE EMISSIONS FROM A CUSTOM FUEL

Your Task:

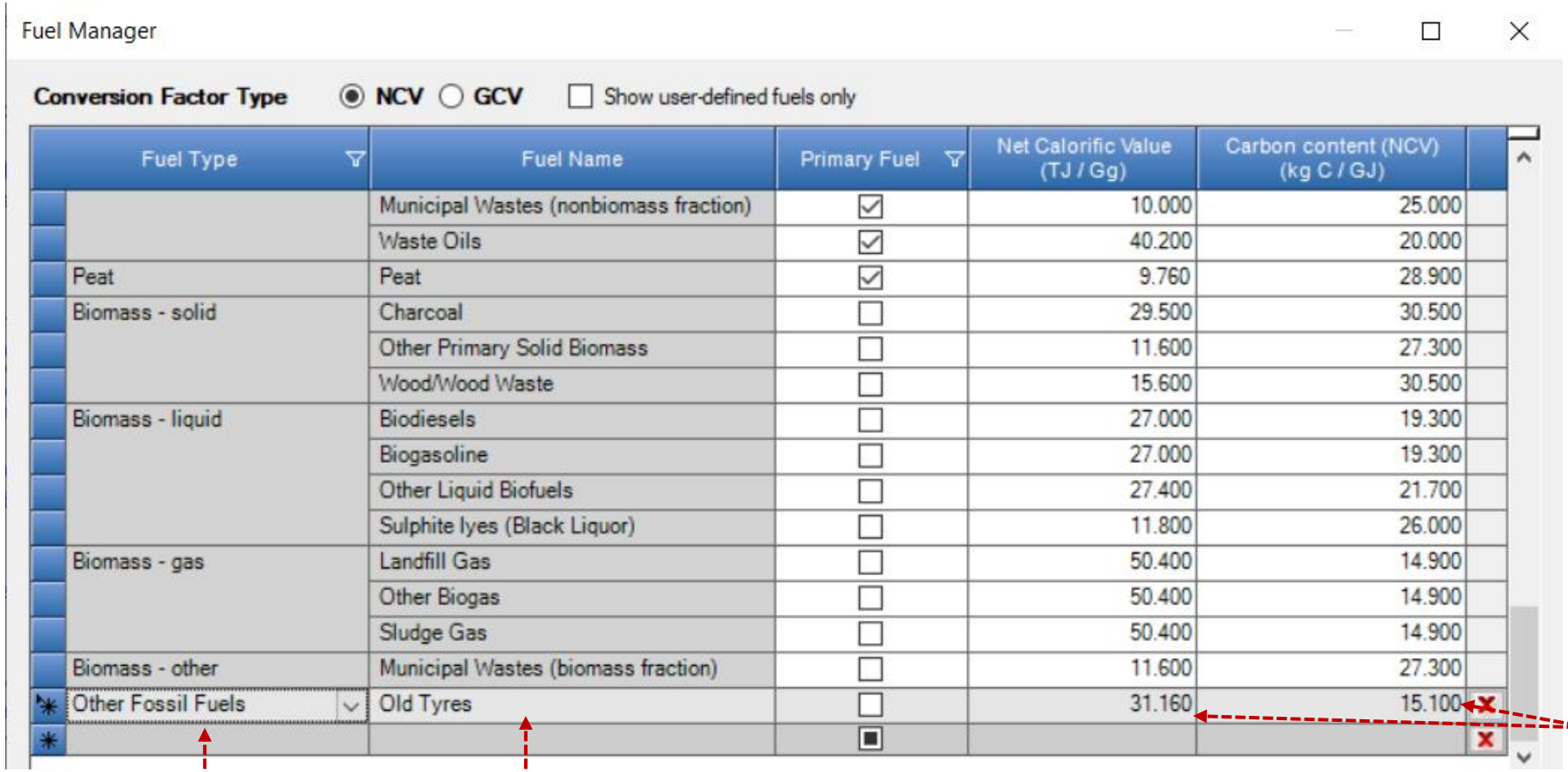
1. Enter Old Tyres in Fuel Manager
2. Input data to the IPCC Inventory Software
3. Enter plant specific net calorific values and emission factors
4. Calculate Emissions

Installation	Fuel	2015			
		Consumption (Gg)	NCV (TJ/Gg)	Carbon content (kg C/GJ)	Oxidation Factor
Plant 1	Petroleum Coke	71.480	31.60	30.3	0.98
	Fuel Oil	0.428	Default	Default	Default
	Old Tyres	18.389	31.16	15.1	Default
Plant 2	Petroleum Coke	108.930	30.50	30.2	0.97
	Fuel Oil	0.267	Default	Default	Default
	Old Tyres	19.714	31.16	15.1	Default

Note: The cement production sector is included in 1.A.2.f Non-Metallic Minerals of the IPCC Software

Exercise 2

RESULTS – Add Old Tyres to the Fuel Manager



Type in NCV and Carbon content

Select fuel type from dropdown

Type in fuel name

Exercise 2

RESULTS – FUEL CONSUMPTION DATA

Fuel Consumption Data | Fuel Combustion Emissions

Worksheet

Sector: Energy
Category: Fuel Combustion Activities
Subcategory: 1.A.2.f - Non-Metallic Minerals
Sheet: Fuel Consumption Data

2015

Data

Fuel Type (All fuels)

Equation 2.1, 2.2, 2.3, 2.4, 2.5

Subdivision	Fuel	Consumption Unit	Consumption (Mass, Volume or Energy Unit)	Conversion Factor (TJ/Unit) (NCV)	Total consumption (TJ)
S	F	U	C	CF	TC = C * CF
Plant 1	Old Tyres	Gg (Auto CF)	18.389	31.160	573.001
Plant 1	Petroleum Coke	Gg (Manual CF)	71.480	31.600	2258.768
Plant 1	Residual Fuel Oil	Gg (Auto CF)	0.428	40.400	17.291
Plant 2	Old Tyres	Gg (Auto CF)	19.714	31.160	614.288
Plant 2	Petroleum Coke	Gg (Manual CF)	108.930	30.500	3322.365
Plant 2	Residual Fuel Oil	Gg (Auto CF)	0.267	40.400	10.787
Total					6796.500

Manual input for petroleum coke NCV

Data input for each plant

Old tyres added into the fuel manager, with country specific NCV and carbon content

Exercise 2

RESULTS – EFs for Old tyres

Plant 1	Old Tyres	573.001	31.725	0.000	0.000

Technology			CO2				CH4		N2O		
Type of Technology	Technology penetration (%)	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 N20)	
T	P	C=TC*(P/100)	EF(CO2)		Z	CO2=C*EF (CO2)/10^6-Z	EF(CH4)	CH4=C*EF (CH4)/10^6	EF(N2O)	N2O=C*EF (N2O)/10^6	
Unspecified	100.000	573.001	Specified	55366.66666666...		31.725					
Total											
		573.001				31.725		0.000		0.000	

CO_2 EF based on the data in the Fuel Manager

No EF for CH4 or N2O available – leave blank

Exercise 2

RESULTS – EFs for Petroleum Coke

CO2 Emission Factor

Fuel	Carbon Content of Fuel (kg / GJ)	Oxidation Factor (Fraction)	CO2 Emission Factor (kg CO2/TJ)
F	CC	OX	EF = CC * OX * 44/12 * 1000
Petroleum Coke	30.300	0.980	108878.000

Cancel Save

Plant specific C content and Ox Factor

Plant 1 | Petroleum Coke

Technology			CO2				CH4		N2O		
Type of Technology	Technology penetration (%)	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 N20)	
T	P	C=TC*(P/100)	EF(CO2)		Z	CO2=C*EF (CO2)/10^6-Z	EF(CH4)	CH4=C*EF (CH4)/10^6	EF(N2O)	N2O=C*EF (N2O)/10^6	
Unspecified	100.000	2258.768	Calculated	108878.000		245.930	3	0.007	0.6		
Total											

Calculated CO_2 EF

Exercise 2

RESULTS – FUEL COMBUSTION EMISSIONS

Fuel Consumption Data | Fuel Combustion Emissions

Worksheet

Sector: Energy
Category: Fuel Combustion Activities
Subcategory: 1.A.2.f - Non-Metallic Minerals
Sheet: Fuel Combustion Emissions

Data

Fuel Type (All fuels)

Equation 2.1, 2.2, 2.3, 2.4, 2.5					
Subdivision	Fuel	Total consumption (TJ)	CO2 Emissions (Gg CO2)	CH4 Emissions (Gg CH4)	N2O Emissions (Gg N20)
S	F	TC	CO2	CH4	N2O
Plant 1	Old Tyres	573.001	31.725	0.000	0.000
Plant 1	Petroleum Coke	2258.768	245.930	0.007	0.001
Plant 1	Residual Fuel Oil	17.291	1.338	0.000	0.000
Plant 2	Old Tyres	614.288	34.011	0.000	0.000
Plant 2	Petroleum Coke	3322.365	356.860	0.010	0.002
Plant 2	Residual Fuel Oil	10.787	0.835	0.000	0.000
Total					
		6796.500	670.699	0.017	0.003

Emission Factor Input

Petroleum Coke
- Plant Specific for CO_2
- Default for CH_4 and N_2O

Residual Fuel Oil
- Default for CO_2, CH_4 and N_2O

Scrap Tyres
- Country Specific for CO_2
- None for CH_4 and N_2O

EXERCISE 3 - Reference Approach

Reference Approach - Definition

Overview:

- A **top-down method** using **energy supply data to estimate CO_2 emissions** from fossil fuel combustion. It's straightforward and relies on energy supply statistics.

Purpose:

- Compare energy consumption and CO_2 emissions between the **Reference** and **Sectoral** **Approaches** in the **1.A Fuel Combustion** sector.

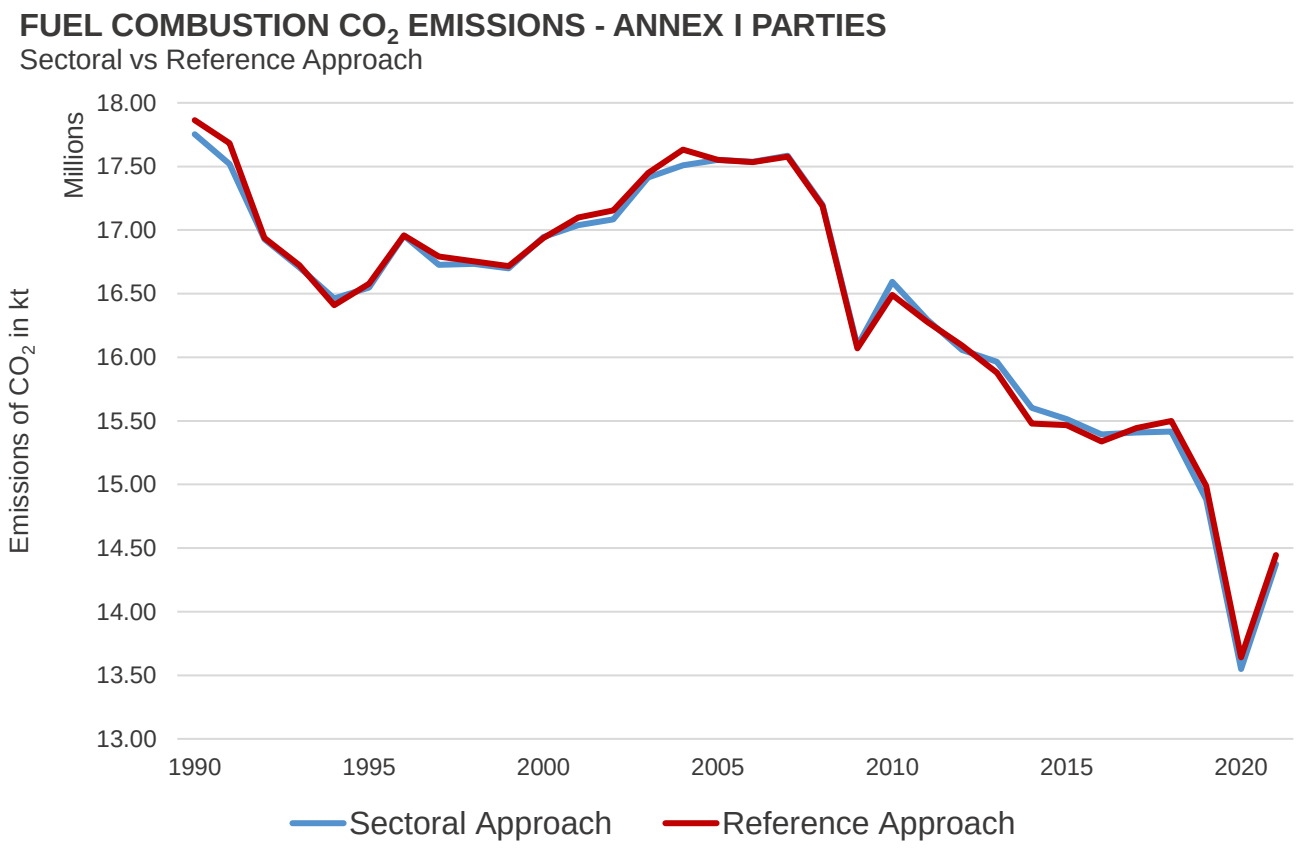
Key Comparisons:

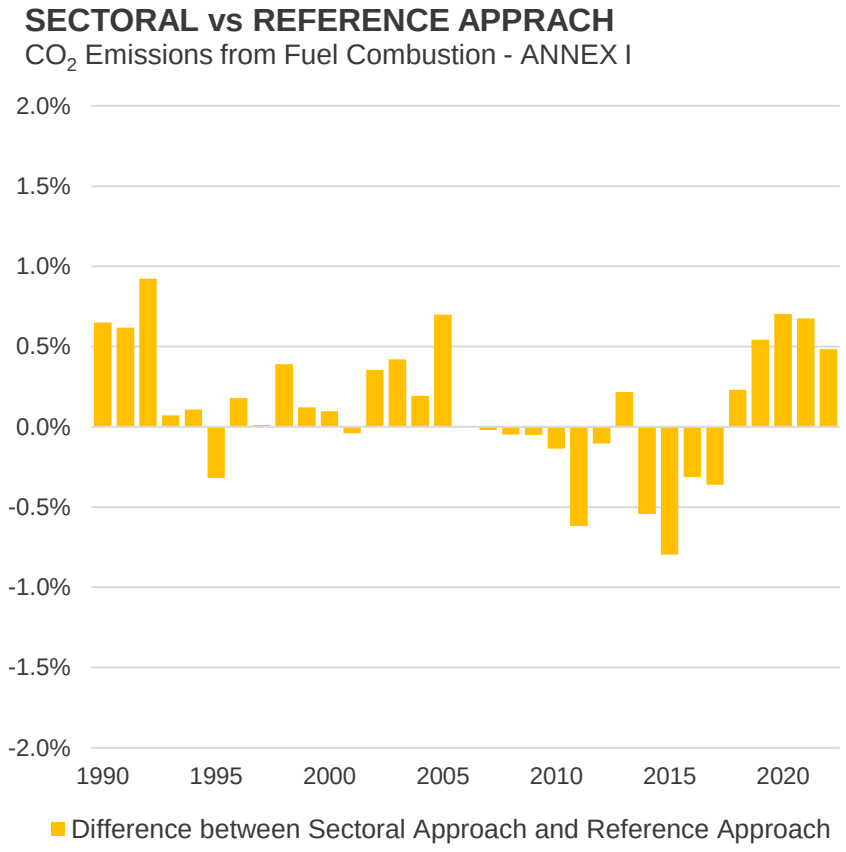
- **Apparent energy consumption**
- **CO_2 emissions**

Difference Analysis:

- Calculate relative differences to **assess consistency between methods**
- **Differences should be within +/- 2%.** Investigate any discrepancies beyond this threshold.

Comparison between the Reference Approach and Sectoral Approach





Reference Approach – Key Concepts

FULL COMBUSTION

- Assumes **all carbon** in **fossil fuels** is **fully oxidized to CO_2**.
- Simplifies calculations for consistent, reliable estimates, and efficiency.

CARBON CONSERVATION

- Assumes the **carbon content** of **primary fuels remains unchanged** when processed into **secondary products.**
- Ensures **all carbon is accounted** for, supporting consistency and completeness.

CARBON EXCLUDED

- The Reference Approach **excludes carbon** from **fuels that are not used for energy purposes**, such as in **feedstocks** or **non-energy applications**.
- Ensures that **CO_2 emissions** and **energy consumption** figures reflect **only the carbon used in combustion**.

Reference Approach - Key Equations

$$CO_2\ EMISSIONS_{fuel} = (Apparent\ Consumption_{fuel} \bullet Carbon\ Content_{fuel}) - Exclude\ Carbon_{fuel} \bullet 1 \bullet 44/12$$

Represents the **total estimated consumption of a fuel**, considering factors like **production**, **imports**, **exports**, and **changes in stocks**.

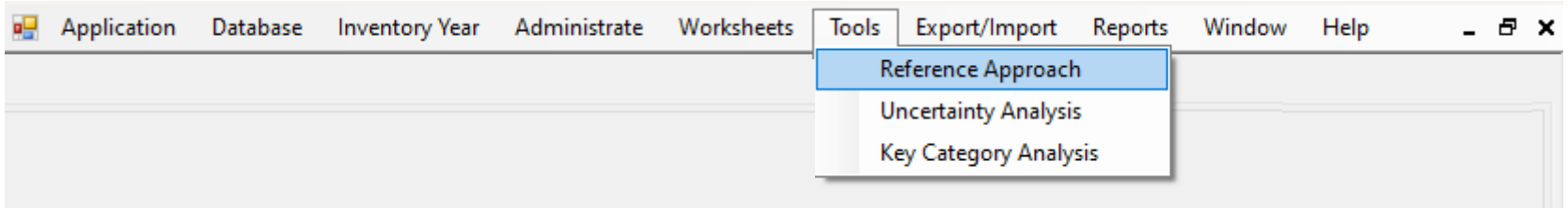
Represents carbon emissions that are **not directly** attributed to the act of **burning fuel for energy purposes**.

$$APPARENT\ CONSUMPTION_{fuel} = Production_{fuel} + Imports_{fuel} - Exports_{fuel} - International\ Bunkers_{fuel} - Stock\ Change_{fuel}$$

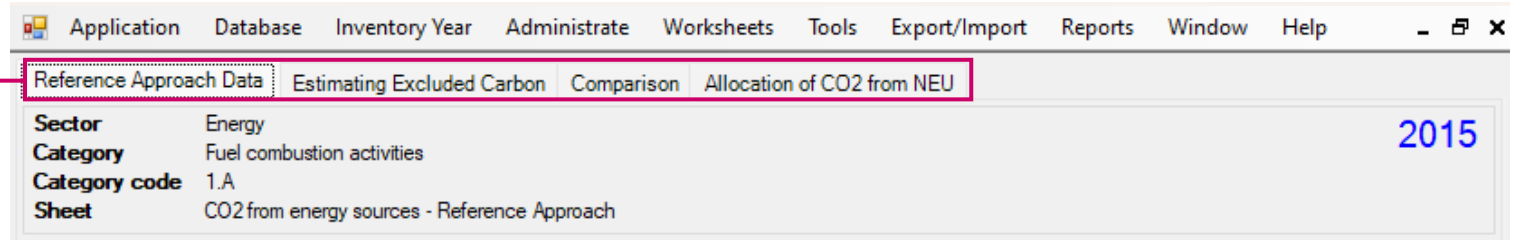
Production	Domestic production of fossil fuels.
Imports	Fossil fuels imported into the country.
Exports	Fossil fuels exported out of the country.
Stock Changes	Refers to the variation in the amount of fossil fuels stored in a country over a specific period
International Bunkers	Fuels used for international aviation and marine transport, which are *excluded from national totals*

Reference Approach – IPCC Software

The **IPCC Inventory Software** includes a **tool** for estimating the Reference Approach and comparing it with sectoral estimates generated in the software.



This tool features **four worksheets** designed to align with the structure of the **Inventory reporting tables**



Reference Approach Data	Inputs **fuel supply data, calorific value, carbon content**, and **calculates CO_2 emissions.**
Estimating Excluded Carbon	Calculates the **amount of carbon to exclude** from non-combustion fuels uses.
Comparison	**Compares CO_2 emissions estimates** from the **Reference** and **Sectoral** approaches.
Allocation of CO2 from NEU	Records **CO_2 excluded** that is later released in **another Inventory category**.

Exercise 3 – Reference Approach

CASE STUDY: ESTIMATING THE REFERENCE APPROACH

Using energy supply statistics

Scenario:

Consider emissions estimated in **Exercise 1 and 2** as your **Sectoral approach**.

Goal:

Use the **energy supply statistics** to estimate the **Reference approach**

Your Task:

1. Enter energy supply data and determine **Apparent Consumption**
2. Enter non-energy data and determine **Excluded Carbon**
3. Estimate **CO_2 Emissions**
4. **Compare** Reference and Sectoral Approach

Exercise 3 – Reference Approach

In the table bellow are the energy supply statistics relative to the year 2015

Fuel	Type of Fuel	Unit	Production	Imports	Exports	International Bunkers	Stock Change
Crude	Liquid	Gg	0.0	6500.0	0.0	0.0	+170.0
Petroleum Coke	Liquid	Gg	-	0.0	16.8	0.0	-5.5
Fuel Oil	Liquid	Gg	-	0.0	86.3	41.1	0.0
Bituminous Coal	Solid	Gg	0.0	10120.0	0.0	0.0	-3030.0
Natural Gas	Gaseous	Gg	96.5	0.0	85.3	0.0	-0.2
Old Tires	Other fossil fuels	Gg	30.0	8.0	0.0	0.0	0.0

Also relevant for the exercise, in 2015, an **ammonia-producing plant** consumed **11.3 Gg of natural gas** as **feedstock** in its process, resulting in **CO_2 emissions of 30.42 Gg**

Exercise 3 – Reference Approach

1. ENTER FUEL DATA

1.1 Enter **fuel supply** data — WORKSHEET: **Reference Approach Data**

1.2 Enter **non-energetic use of fuel** data — WORKSHEET: **Estimating Excluded Carbon**

2. VALIDADE AND CROSS-CHECK RESULTS

2.1 Review the updated CO_2 emissions — WORKSHEET: **Reference Approach Data**

2.2 **Compare CO_2 estimates** between the **RA and SA** — WORKSHEET: **Comparison**

3. FINALIZE FOR REPORTING

3.1 **Allocate CO_2 emissions from NEU** to source category — WORKSHEET: **Allocation of CO2 from NEU**

Exercise 3 – Reference Approach

1.1 Enter fuel supply data: Reference Approach Data worksheet, for each fuel:

- Select or enter manually the **measurement unit used**
- **Input fuel supply data** and let the software estimate CO_2 emissions.
- Enter the **fraction of oxidized carbon** *(use "1" if no specific data is available).*

			Step 1					
			Production (Unit)	Imports (Unit)	Exports (Unit)	International Bunkers (Unit)	Stock change (Unit)	Apparent Consumption (Unit)
Fuel Types		Unit	A	B	C	D	E	F=A+B-C-D-E
Liquid Fuels: 22 item(s)								
Primary Fuels	Crude Oil	Gg	0.000	6500.000	0.000	0.000	170.000	6330.000
Secondary Fuels	Petroleum Coke	Gg		0.000	16.800	0.000	-5.500	-11.300
	Residual Fuel Oil	Gg		0.000	86.300	41.100	0.000	-127.400
Solid Fuels: 15 item(s)								
Primary Fuels	Other Bituminous Coal	Gg	0.000	10120.000	0.000	0.000	-3030.000	13150.000
Gaseous Fuels: 1 item(s)								
Primary Fuels	Natural Gas (Dry)	Gg	96.500	0.000	85.300	0.000	-0.200	11.400
Other Fossil Fuels: 4 item(s)								
Primary Fuels	Old Tires	Gg	30.000	8.000	0.000	0.000	0.000	38.000

Exercise 3 – Reference Approach

1.2 Enter non-energetic use of fuel data: Estimating Excluded Carbon worksheet, for each relevant fuel:

- Enter the estimated **quantity of the fuel not used for combustion** purposes
- Select or enter manually the **measurement unit used**

Fuel Types	Estimated Quantities (Unit) A	Unit	Conversion Factor (TJ/Unit) B	Estimated Quantities (TJ) C = A * B	Carbon content (t C/TJ) D	Excluded Carbon (Gg C) E = C * D / 1000
⊞ Liquid Fuels: 22 item(s)				0.000		0.000
⊞ Solid Fuels: 15 item(s)				0.000		0.000
⊟ Gaseous Fuels: 1 item(s)				542.400		8.299
Natural Gas (Dry)	11.300	Gg	48.000	542.400	15.300	8.299
⊞ Other Fossil Fuels: 4 item(s)				0.000		0.000
⊞ Peat: 1 item(s)				0.000		0.000
⊞ Biomass - solid: 3 item(s)				0.000		0.000
⊞ Biomass - liquid: 4 item(s)				0.000		0.000
⊞ Biomass - gas: 3 item(s)				0.000		0.000
⊞ Biomass - other: 1 item(s)				0.000		0.000
Total						
			Fossil:	542.400		8.299
			Biogenic:	0.000		0.000

in 2015,
An **ammonia-producing plant** consumed

- **11.3 Gg of Natural Gas** as feedstock in its process,
- resulting in **CO_2 emissions of 30.42 Gg**

Exercise 3 – Reference Approach

2.2 Compare CO2 estimates between the RA and SA: Comparison worksheet, for each fuel type:

- Review the comparison results for **Energy Consumption**
- Review the comparison results for **CO_2 Emissions**

	Reference Approach				Sectoral Approach		Difference	
Fuel Types	Apparent Consumption (TJ)	Excluded consumption (TJ)	Apparent Consumption (excluding non-energy use and feedstocks) (TJ)	CO2 Emissions (Gg)	Energy Consumption (TJ)	CO2 Emissions (Gg)	Energy Consumption (%)	CO2 Emissions (%)
⊞ Liquid Fuels: 22 item(s)	262244.790	0.000	262244.790	19201.638	259673.211	20231.407	0.990	-5.090
⊞ Solid Fuels: 15 item(s)	339270.000	0.000	339270.000	32094.942	337595.000	31160.019	0.496	3.000
⊞ Gaseous Fuels: 1 item(s)	547.200	542.400	4.800	0.269	0.000	0.000	100.000	100.000
⊞ Other Fossil Fuels: 4 item(s)	1184.080	0.000	1184.080	65.559	1187.289	65.736	-0.270	-0.270
⊟ Peat: 1 item(s)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total								
	603246.070	542.400	602703.670	51362.408	598455.500	51457.162	0.710	-0.184

Exercise 3 – Reference Approach

3.1 Finalize for Reporting: Allocate CO_2 emissions from NEU worksheet, for each relevant fuel:

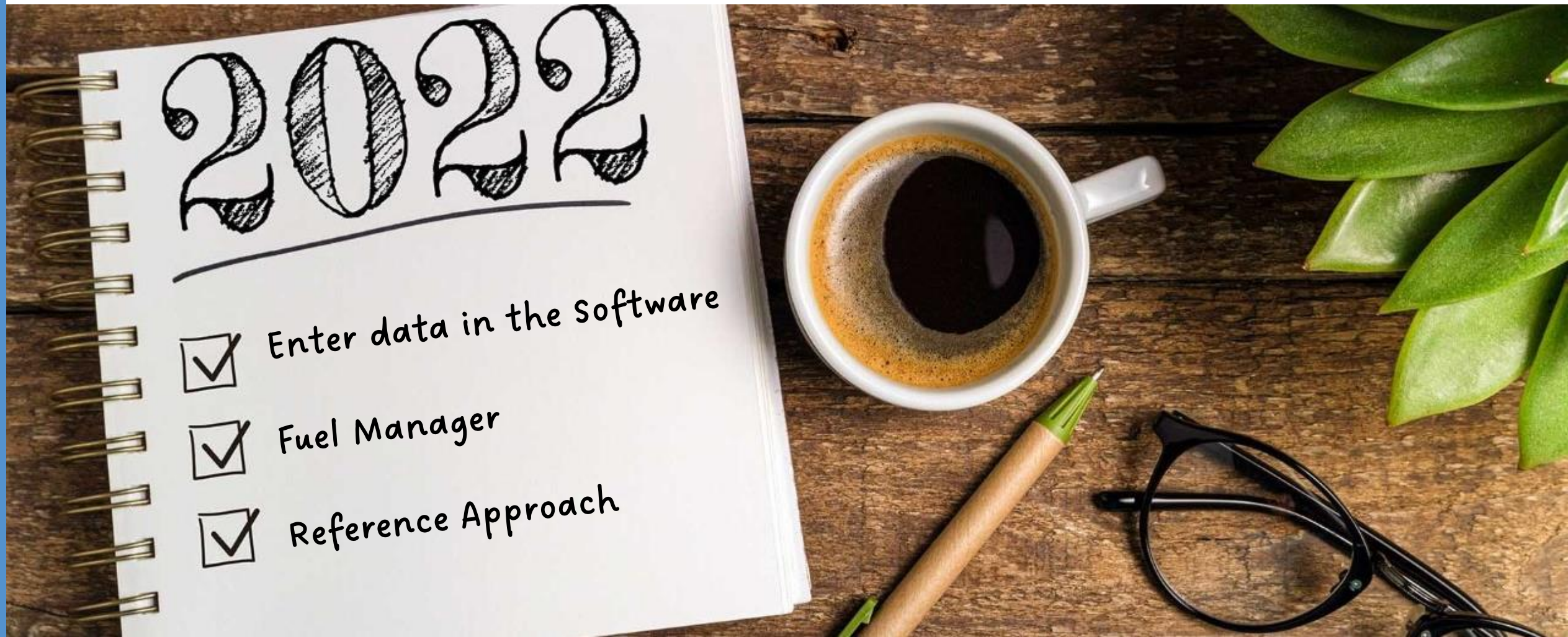
- Enter the **quantity** of **CO_2 emissions from NEU** that is **reported elsewhere** in the NGHGI
- Select one or more **categories of the inventory** where these **CO_2 emissions are reported**

	CO2 Excluded from Reference Approach (Gg CO2)	CO2 emissions from NEUs reported in the inventory (Gg CO2)	Categories under which CO2
Fuel Types	EXCLra	CO2neu	
⊞ Liquid Fuels: 22 item(s)	0.000	0.000	
⊞ Solid Fuels: 15 item(s)	0.000	0.000	
⊟ Gaseous Fuels: 1 item(s)	30.429	30.420	
Natural Gas (Dry)	30.429	30.420	Ammonia Production
⊞ Other Fossil Fuels: 4 item(s)	0.000	0.000	
⊞ Peat: 1 item(s)	0.000	0.000	
⊞ Biomass - solid: 3 item(s)	0.000	0.000	
⊞ Biomass - liquid: 4 item(s)	0.000	0.000	
⊞ Biomass - gas: 3 item(s)	0.000	0.000	
⊞ Biomass - other: 1 item(s)	0.000	0.000	
Total			
Fossil:	30.429	30.420	
Biogenic:	0.000	0.000	

in 2015,
An **ammonia-producing plant** consumed

- **11.3 Gg of Natural Gas** as feedstock in its process,
- resulting in **CO_2 emissions of 30.42 Gg**

Exercise 4 - Create a new Inventory Year



Exercise 4 – New Inventory Year

CASE STUDY: UPDATING EMISSION ESTIMATES WITH NEW DATA

Replicating and updating previous estimates using 2022 activity data.

Scenario:

You have already estimated GHG emissions for the **year 2015** in **Exercises 1, 2, and 3**. Now, you are tasked with repeating the same exercises using data from the **year 2022**

Goal:

Accurately replicate the GHG emission estimates for the year 2022, following the same methodologies used for 2015.

Your Task:

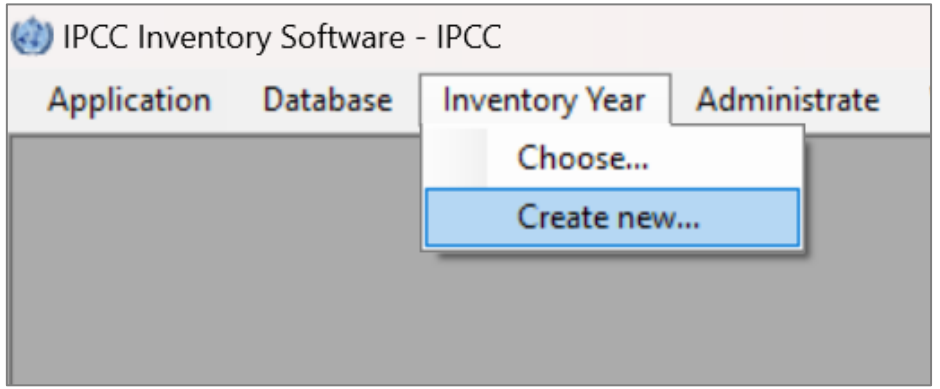
1. Create a **new inventory year** in the IPCC Inventory Software
2. **Update** activity data and other relevant parameters
3. Calculate Emissions
4. Compare Results

Exercise 4 – New Inventory Year

1 – CREATE A NEW INVENTORY YEAR

I. Select the year

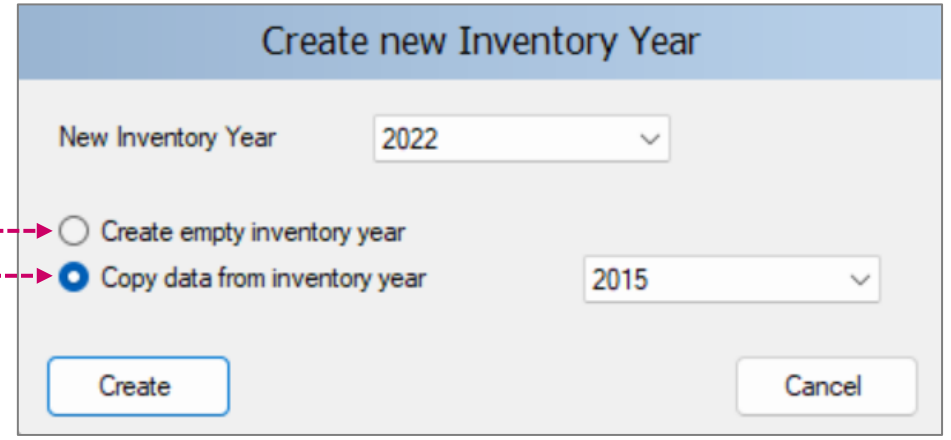
Choose a year from the "New Inventory Year" list.



II. Choose a Creation Mode

Create empty Inventory Year: This option creates a completely new inventory year with **no pre-existing data**.

Copy data from Inventory Year: This option creates a new inventory year by **copying all data** from a selected existing year.



Exercise 4a – Tier 2 Method

CASE STUDY: UPDATE THE TIER 2 METHOD

2022 Data:

Bituminous Coal:

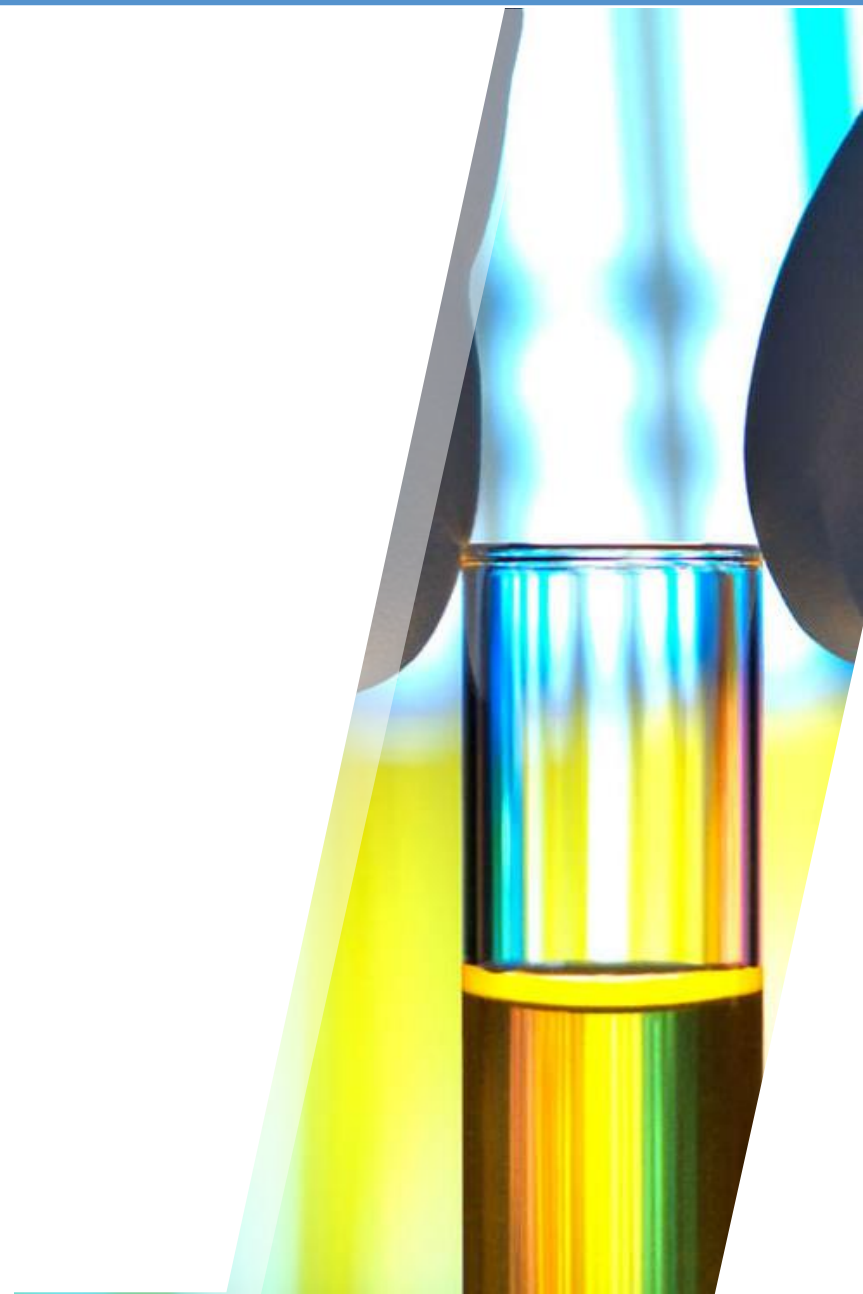
• Fuel consumption:	12 510	Gg
• Net Calorific Value:	25.1	TJ/Gg
• CO_2 Emission Factor:	92 300	kg CO_2/TJ

Fuel Oil:

• Fuel Consumption:	6 130	Gg
• Net Calorific Value:	40.2	TJ/Gg
• CO_2 Emission Factor:	77 250	kg CO_2/TJ

Your Task:

1. Update activity data, CO2 emission factors and net calorific values
2. Calculate Emissions



Exercise 4a – Tier 2 Method

RESULTS – 2022

Worksheet

Sector: Energy

Category: Fuel Combustion Activities

Subcategory: 1.A.1.a.i - Electricity Generation

Sheet: Fuel Combustion Emissions

2022

Data

Fuel Type (All fuels)

Equation 2.1, 2.2, 2.3, 2.4, 2.5					
Subdivision	Fuel	Total consumption (TJ)	CO2 Emissions (Gg CO2)	CH4 Emissions (Gg CH4)	N2O Emissions (Gg N20)
S	F	TC	CO2	CH4	N2O
Unspecified	Other Bituminous Coal	314001.000	28982.292	0.314	0.471
Unspecified	Residual Fuel Oil	246426.000	19036.409	0.739	0.148
Total					
		560427.000	48018.701	1.053	0.619

Exercise 4b – Fuel Manager

CASE STUDY: UPDATE THE TIER 2 METHOD

- Update the user-defined fuel in the Fuel Manager
- Update activity data, CO2 emission factors and net calorific values

2022 Data:

Installation	Fuel	2022			
		Consumption (Gg)	NCV (TJ/Gg)	Carbon content (kg C/GJ)	Oxidation Factor
Plant 1	Petroleum Coke	78.628	32.40	31.96	0.98
	Fuel Oil	0.470	Default	Default	Default
	Old Tyres	20.228	31.16	15.1	Default
Plant 2	Petroleum Coke	107.006	32.51	32.12	0.97
	Fuel Oil	0.262	Default	Default	Default
	Old Tyres	24.643	31.16	15.1	Default

Exercise 4b – Fuel Manager

RESULTS – 2022

Fuel Consumption Data | Fuel Combustion Emissions

Worksheet

Sector: Energy

Category: Fuel Combustion Activities

Subcategory: 1.A.2.f - Non-Metallic Minerals

Sheet: Fuel Combustion Emissions

2022

Data

Fuel Type (All fuels)

Equation 2.1, 2.2, 2.3, 2.4, 2.5					
Subdivision	Fuel	Total consumption (TJ)	CO2 Emissions (Gg CO2)	CH4 Emissions (Gg CH4)	N2O Emissions (Gg N20)
S	F	TC	CO2	CH4	N2O
Plant 1	Old Tires	630.304	34.898	0.000	0.000
Plant 1	Petroleum Coke	2547.547	292.568	0.008	0.002
Plant 1	Residual Fuel Oil	18.988	1.470	0.000	0.000
Plant 2	Old Tires	767.876	42.515	0.000	0.000
Plant 2	Petroleum Coke	3478.765	397.415	0.010	0.002
Plant 2	Residual Fuel Oil	10.585	0.819	0.000	0.000
Total					
		7454.065	769.684	0.018	0.004

Exercise 4c – Reference Approach

CASE STUDY: ESTIMATING THE REFERENCE APPROACH 2022

In the table bellow are the energy supply statistics relative to the **year 2022**

Fuel	Type of Fuel	Unit	Production	Imports	Exports	International Bunkers	Stock Change
Crude	Liquid	Gg	0.0	6170.0	0.0	0.0	50.0
Petroleum Coke	Liquid	Gg	-	0.0	8.9	0	-0.5
Fuel Oil	Liquid	Gg	-	0.0	38.7	85.5	0.0
Bituminous Coal	Solid	Gg	0.0	11750.0	0.0	0.0	-440.0
Natural Gas	Gaseous	Gg	106.5	0.0	91.0	0.0	0.0
Old Tires	Other fossil fuels	Gg	36.6	6.3	0.0	0.0	0.0

Also relevant for the exercise, in 2022, an **ammonia-producing plant** consumed **15.5 Gg of natural gas** as **feedstock** in its process, resulting in **CO_2 emissions of 41.70 Gg**

Exercise 4c – Reference Approach

RESULTS – 2022

	Reference Approach				Sectoral Approach		Difference	
Fuel Types	Apparent Consumption (TJ)	Excluded consumption (TJ)	Apparent Consumption (excluding non-energy use and feedstocks) (TJ)	CO2 Emissions (Gg)	Energy Consumption (TJ)	CO2 Emissions (Gg)	Energy Consumption (%)	CO2 Emissions (%)
⊞ Liquid Fuels: 22 item(s)	253585.320	0.000	253585.320	18569.412	252481.885	19728.680	0.437	-5.876
⊞ Solid Fuels: 15 item(s)	314502.000	0.000	314502.000	29751.889	314001.000	28982.292	0.160	2.655
⊞ Gaseous Fuels: 1 item(s)	744.000	744.000	0.000	0.000	0.000	0.000	0.000	0.000
⊞ Other Fossil Fuels: 4 item(s)	1399.084	0.000	1399.084	77.463	1398.180	77.413	0.065	0.065
⊟ Peat: 1 item(s)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	570230.404	744.000	569486.404	48398.764	567881.065	48788.385	0.283	-0.799

THANK YOU
FOR YOUR ATTENTION

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