Virtual technical training on updating the national greenhouse gas inventories for the energy sector

Western Balkan and Eastern Europe

Presenters: **Verica Taseska-Gjorgievska, Aleksandar Dedinec**

Scientific collaborator at *Macedonian Academy of Sciences and Arts*

9th December 2020

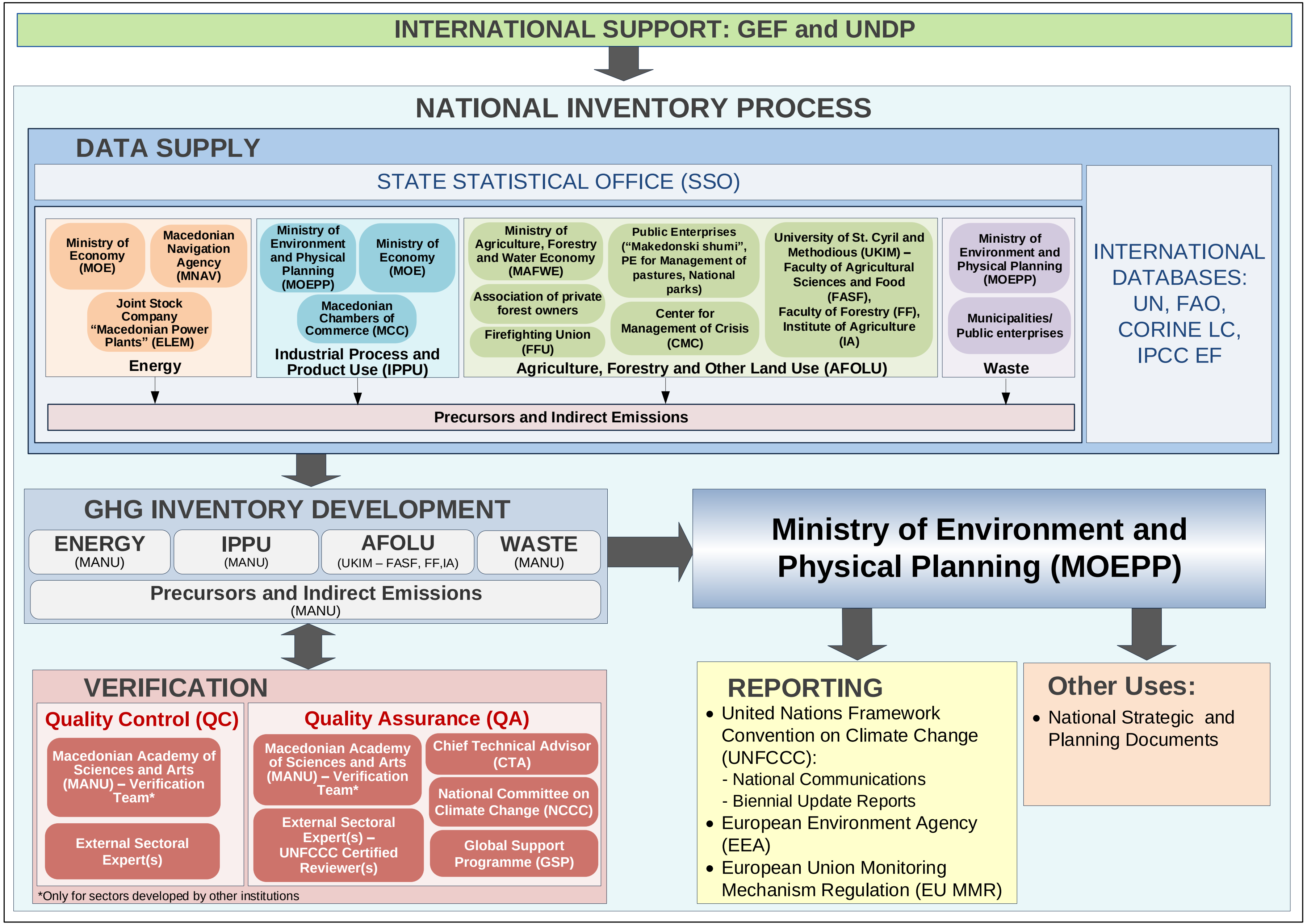
Agenda

- GHG Inventory of North Macedonia
- Updating GHG inventory in energy sector – Training
    - Questionnaires – Results
    - Part 1: Source categories, methodological approach for emissions estimation, approach to data collection, time series consistency
    - Part 2: Reference vs sectoral approach, key category analyses, uncertainty analysis, QA/QC
- Interaction with participants (using Mentimeter)
- Presentations by country
- Q/A with participants
- Closing remarks

GHG Inventory of North Macedonia

Current status and next steps

Inventory process



Methodology

- 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Refinements of IPPC Guidelines from 2019)

  (http://www.ipcc-nggip.iges.or.jp/public/2006gl/)

- IPPC Inventory Software Ver. 2.54

  (http://www.ipcc-nggip.iges.or.jp/software/index.html)

- GWP factors - IPCC Forth Assessment Report (AR4), 2007, 100-years time horizon

  (https://www.ipcc.ch/site/assets/uploads/2018/05/ar4_wg1_full_report-1.pdf)

*

Overview

- Reported gases:
  - GHG: CO_2, CH_4, N_2O, PFCs и HFCs
  - Indirect: CO, NO_x, NMVOC, SO_2 и NH_3

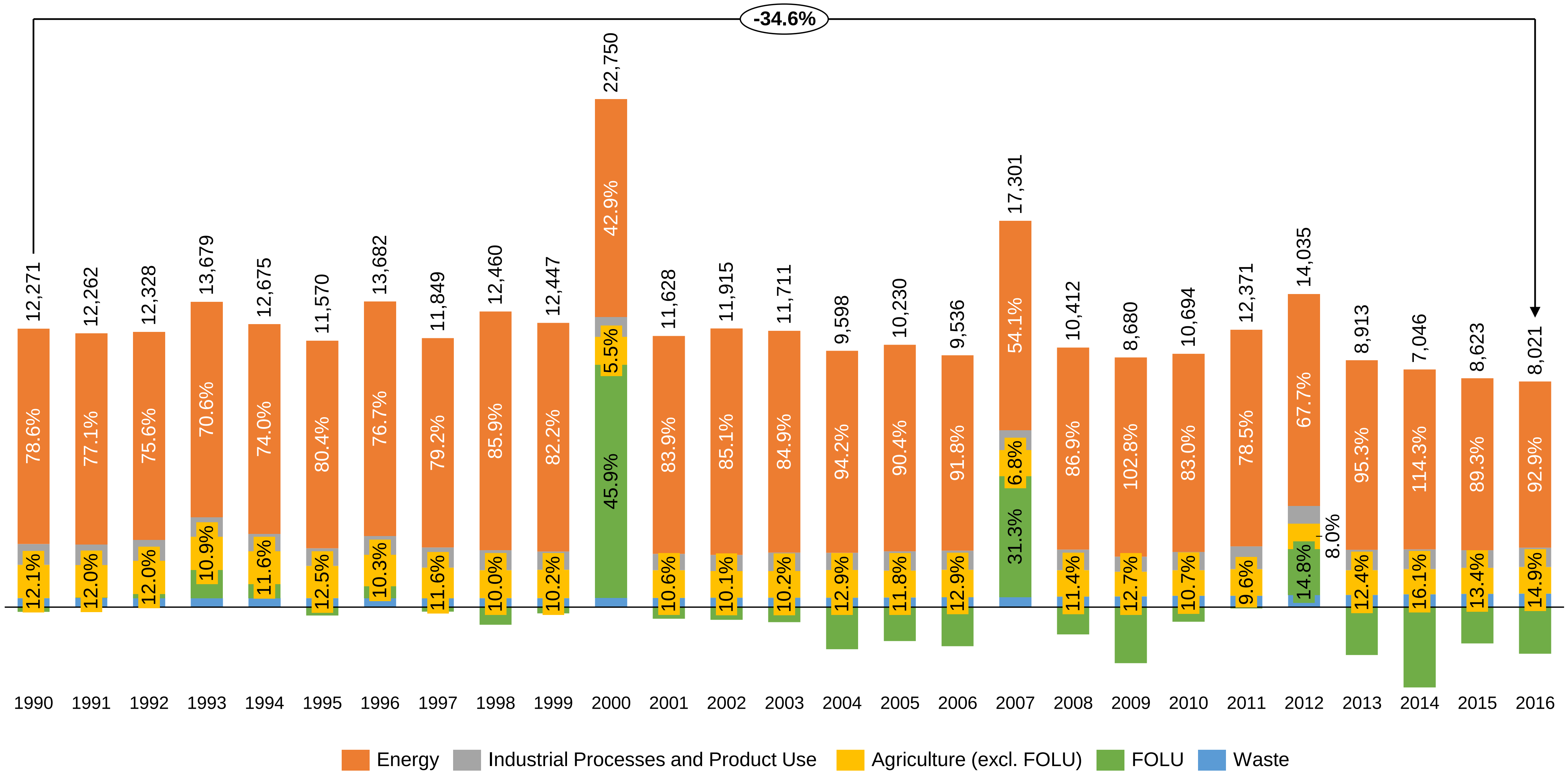
- Time series 1990 – 2016
- Latest update for years 2014, 2015 and 2016 in the NIR - 3rd BUR

- Tier 2 method applied in:
  - Energy (Fuel combustion activities – Country-specific EF for CO_2 emissions)
  - Industrial Processes and Product Use – IPPU (Mineral and metal industry)
  - Waste (IPCC FOD method)

*

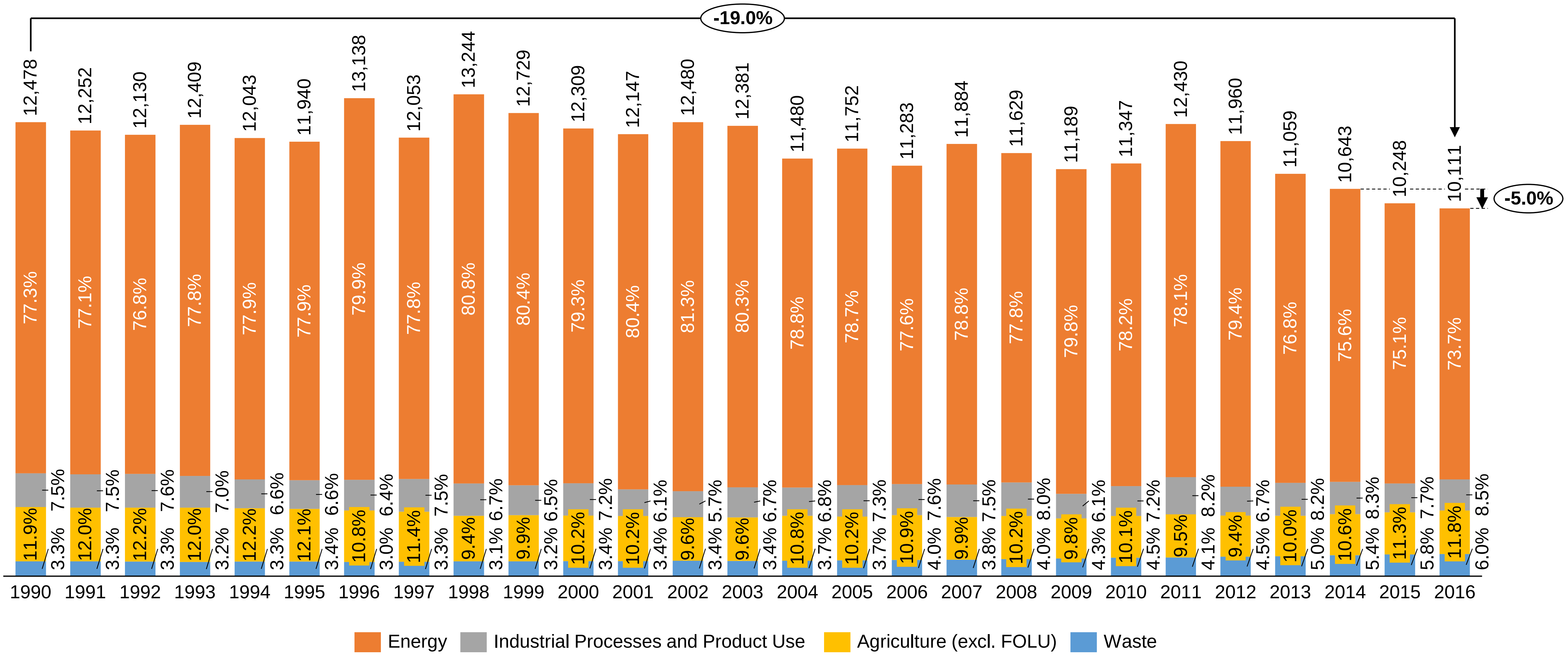
Emissions trend - summary (net emissions)

Net GHG emissions by category (in Gg CO_2-eq)



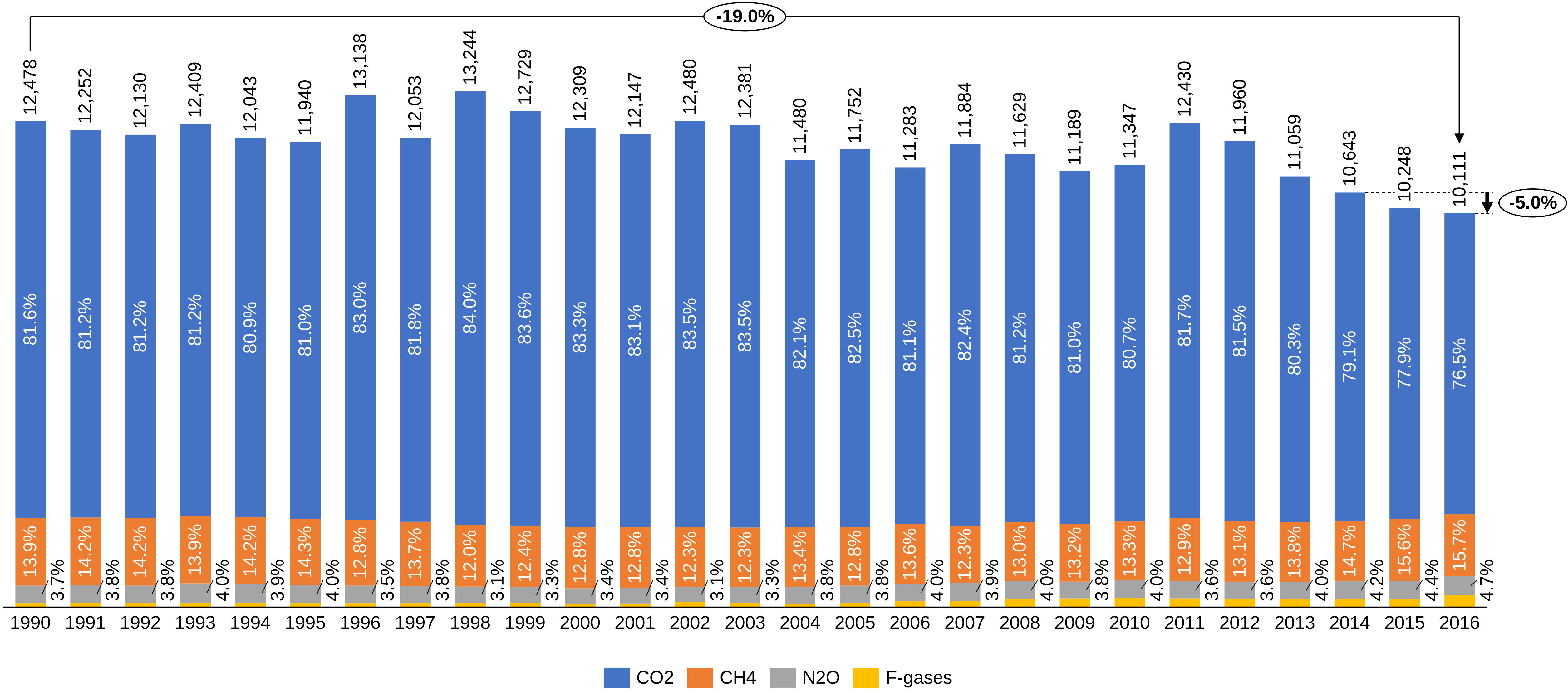
Emissions trend - summary

Total GHG emissions by category, excluding Forestry and Other land use (in Gg CO2- eq)



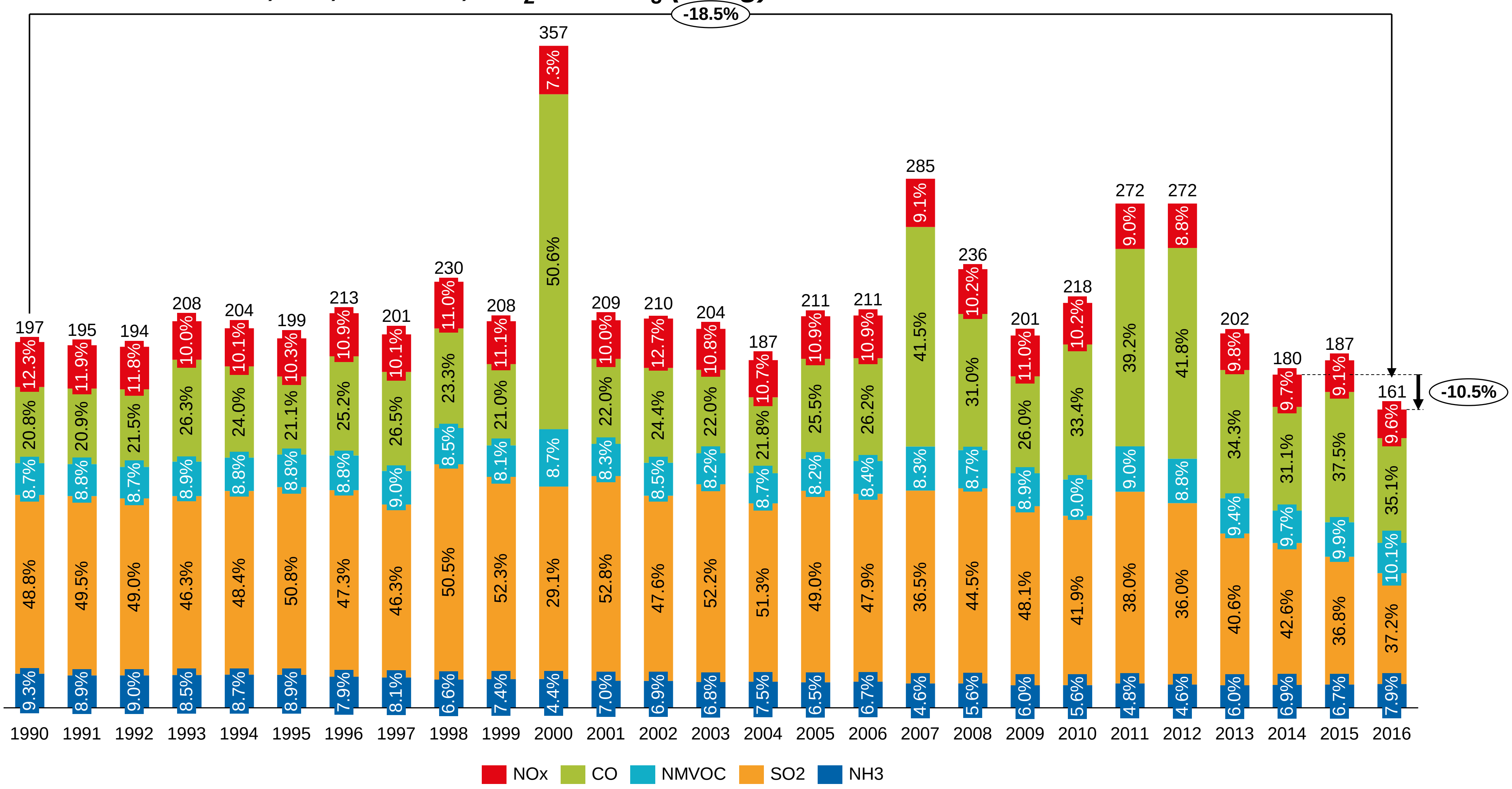
Emissions trend - summary

Total GHG emissions by gas, excluding Forestry and Other land use (in Gg CO2- eq)

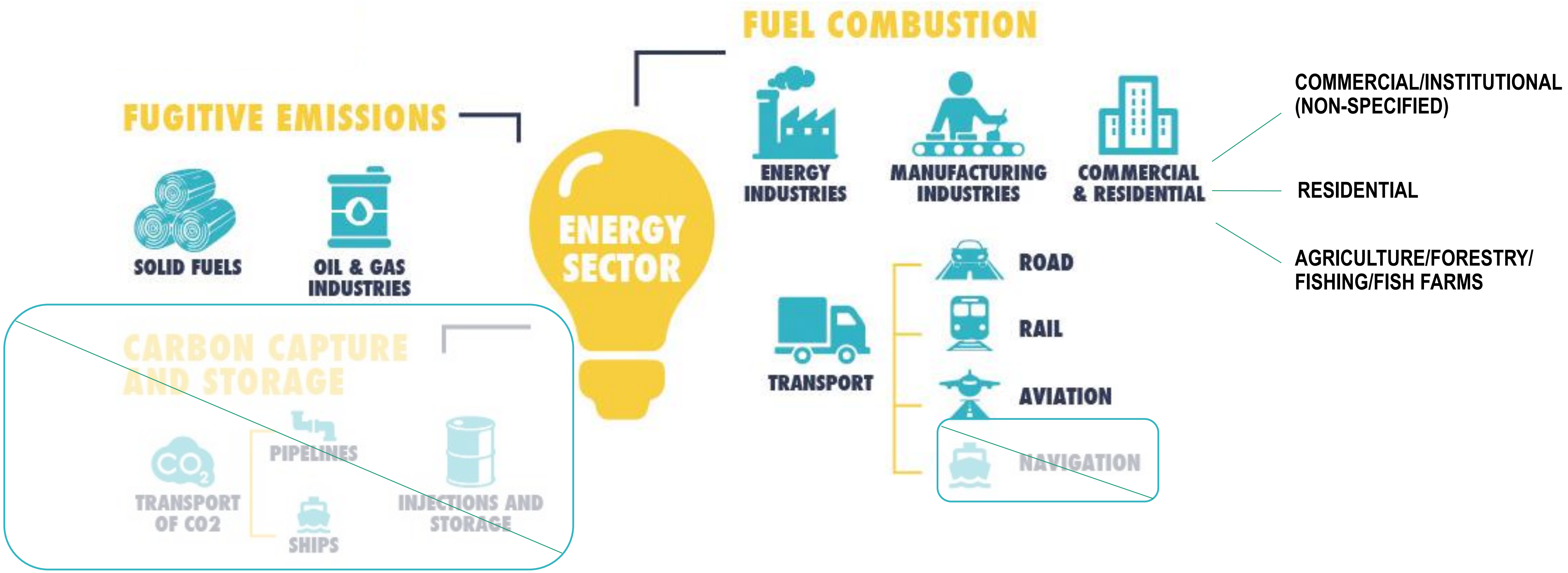


Precursors and indirect emissions - summary

Emissions of NOx, CO, NMVOC, SO_2 and NH_3 (in Gg)



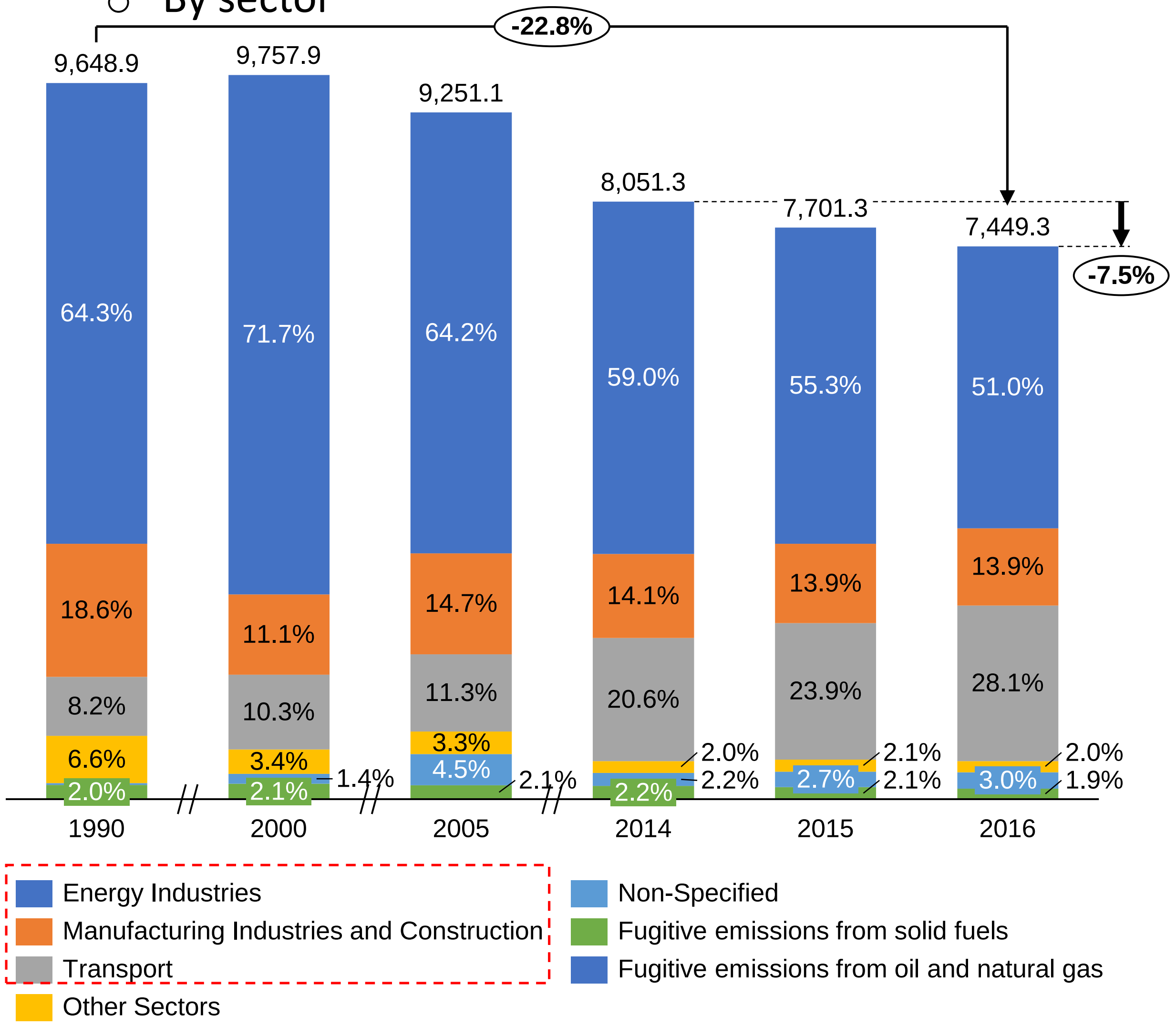
Energy sector



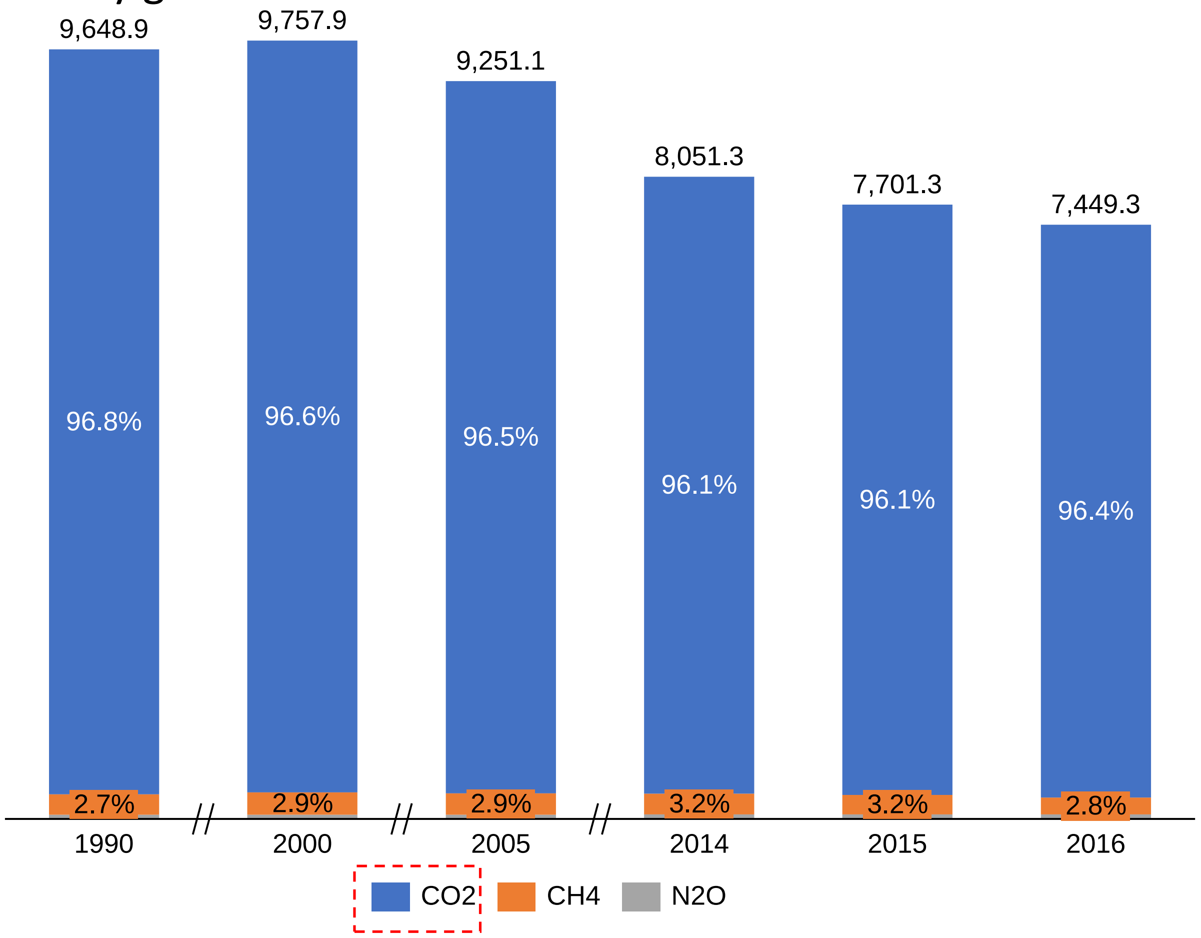
Source:

Energy sector

- GHG emissions (in Gg CO_2-eq)
  - By sector

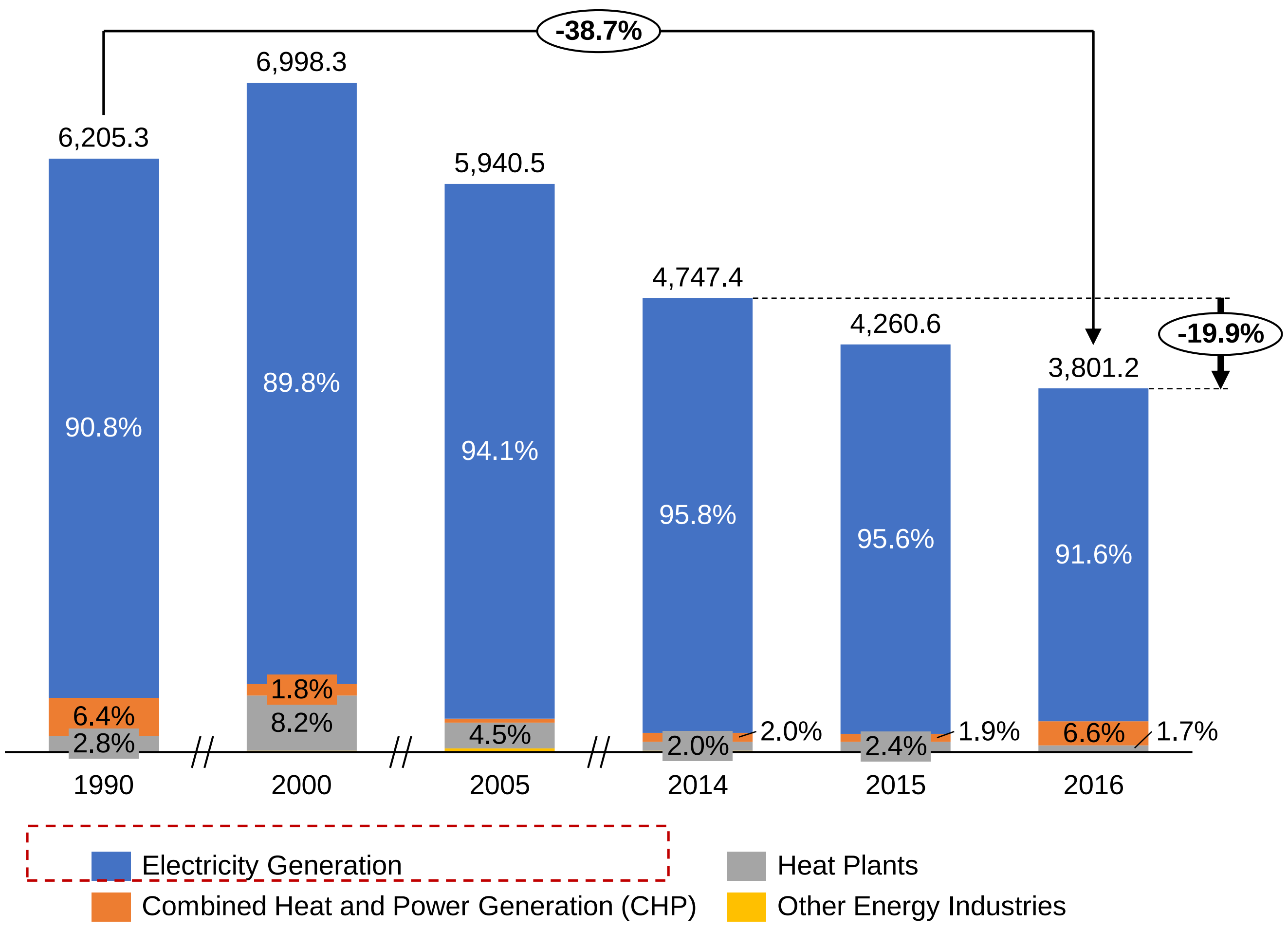


  - By gas



Energy – Energy industries

GHG emissions (in Gg CO_2-eq)

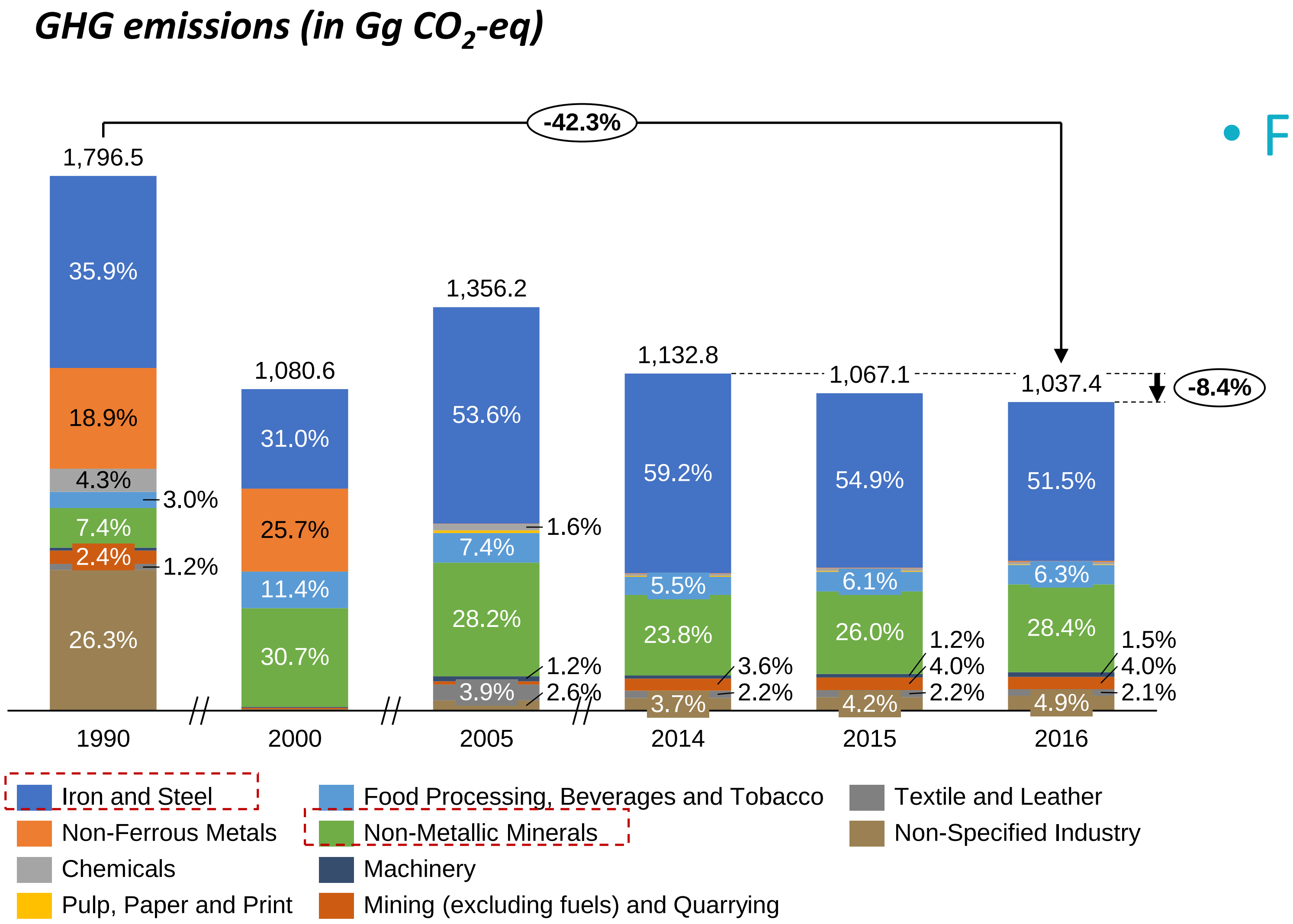


- Main fuels:
  - lignite (domestic resource)
  - natural gas
  - Residual fuel oil (gradually replaced by natural gas)

- GHG emission reduction due to:
  - Fuel switch (RFO with natural gas) – for electricity and heat production
  - Reduced electricity generation (from fossil fuels)

*

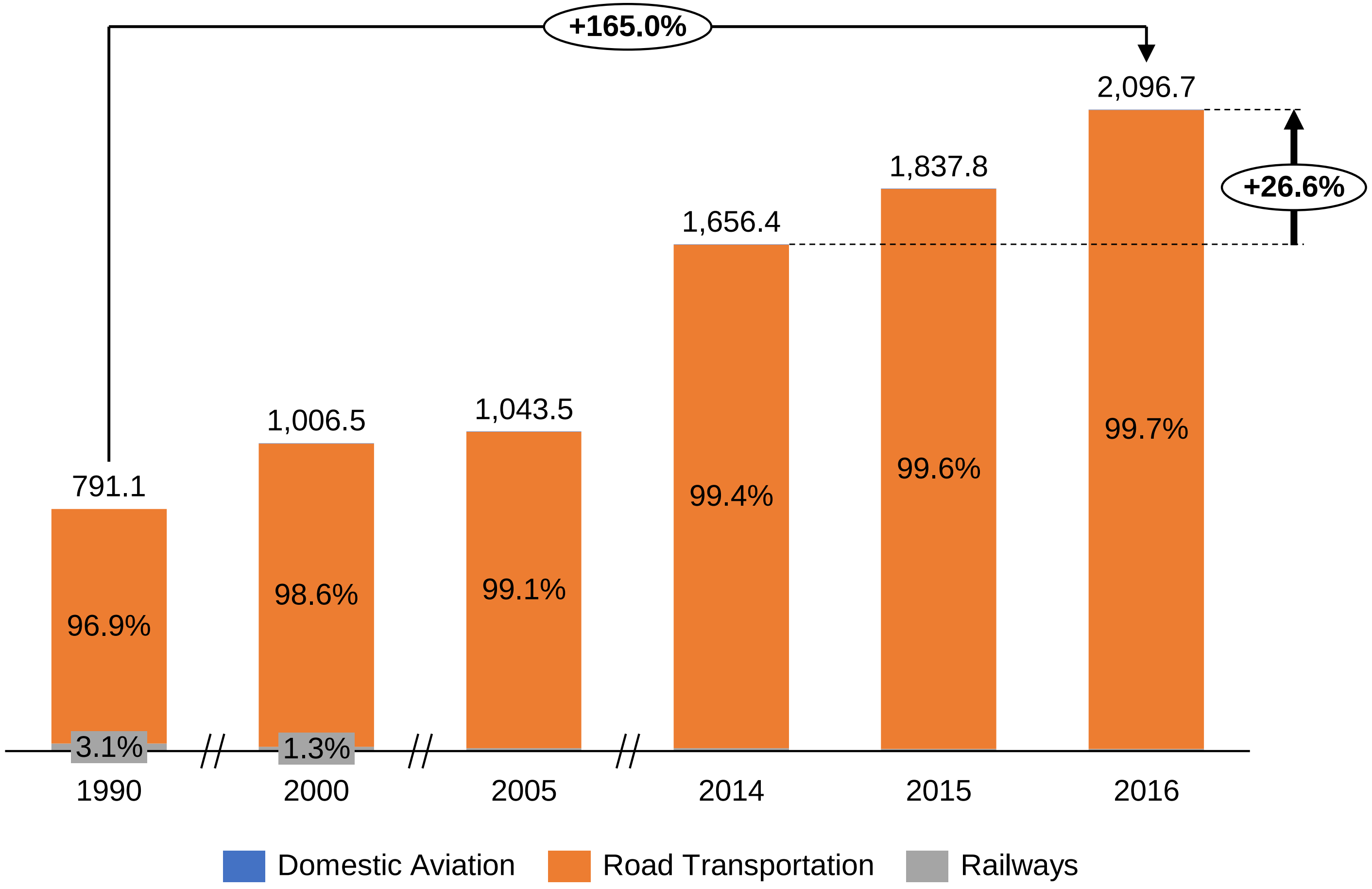
Energy – Manufacturing industries and construction



- Fuels:
  - Coking coal, other bituminous coal, lignite, liquefied petroleum gases, residual fuel oil, natural gas, wood/wood waste (biomass and wood wastes, wood briquettes and pellets), sub-bituminous coal, petroleum coke, and gas/diesel oil (road diesel, and heating and other gasoil

Energy – Transport

GHG emissions (in Gg CO_2-eq)

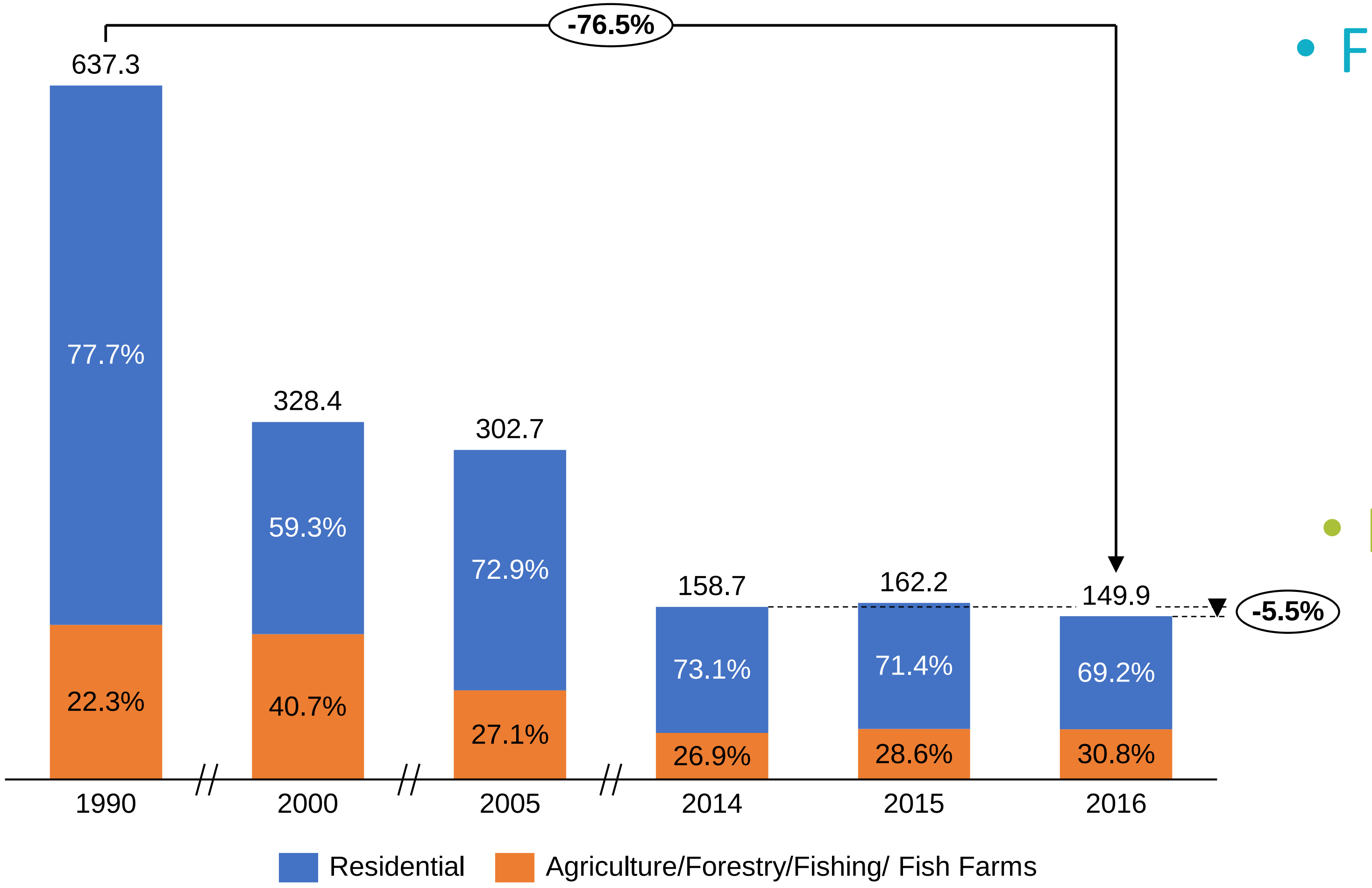


- Fuels:
  - Diesel oil (for transport), motor gasoline, LPG, motor gasoline (used in domestic aviation) and natural gas
- Increase in emissions due to increased number of vehicles (mostly using diesel)

*

Energy – Other sectors

GHG emissions (in Gg CO_2-eq)



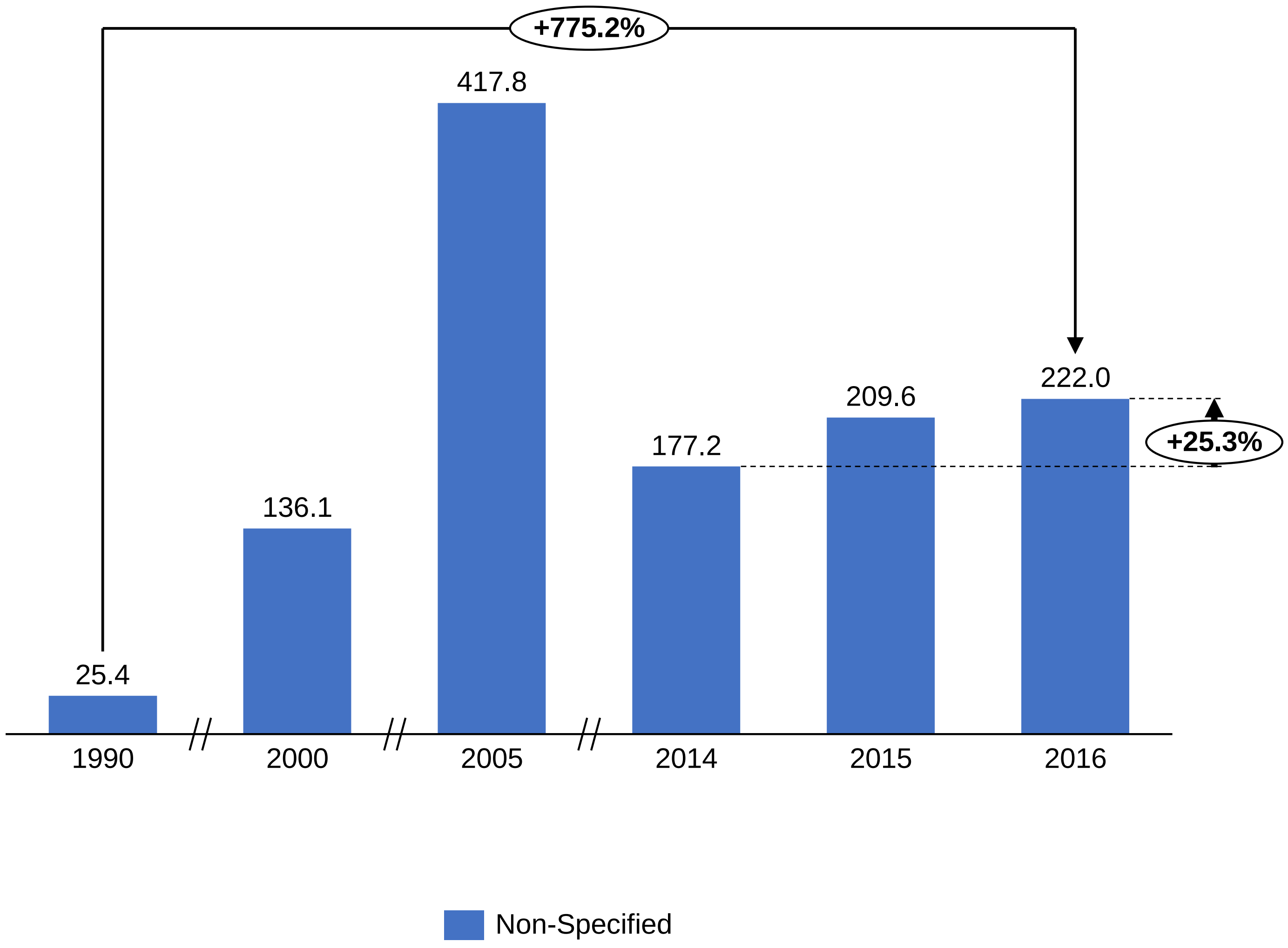
- Fuels:
  - lignite, LPG, motor gasoline, biomass (fuelwood), wood waste, briquettes and pellets, diesel for transport and heating oil, and natural gas
- Reduced emissions due to :
  - Household – reduced consumption of heating oil

*CO_2 emissions from biomass combustion are not included in sector's total emissions

*

Energy – Non-Specified

GHG emissions (in Gg CO_2-eq)

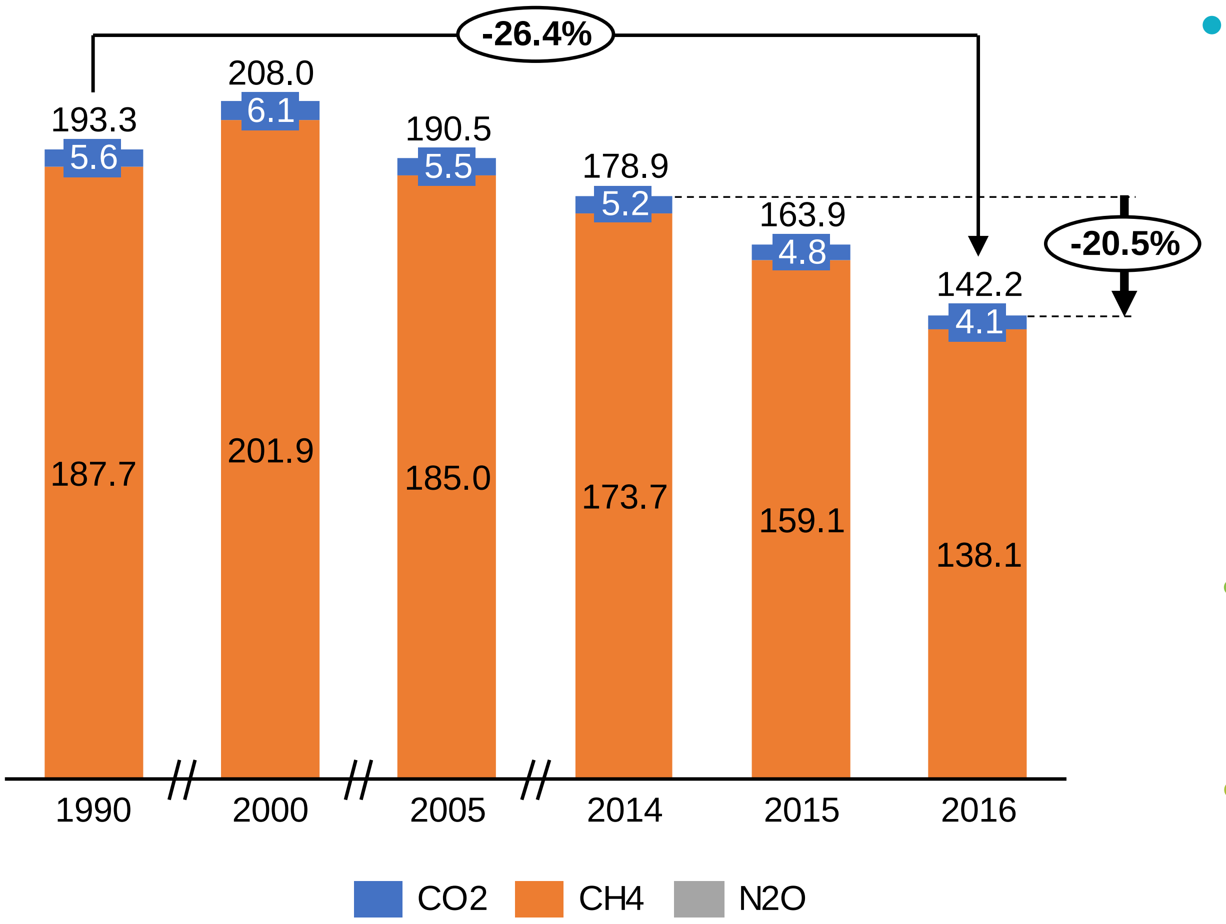


- Fuels:
  - lignite, LPG, residual fuel oil, natural gas, biomass (fuelwood), diesel for transport and heating oil

- Increased emissions due to :
  - Increased consumption of fuel (RFO) in last years
  - Peak year is 2005 – higher consumption of lignite, RFO and Gas/Diesel Oil in 2005, while in 2016 there is more Electricity consumption

Energy – Fugitive emissions

GHG emissions (in Gg CO_2-eq)



- Fuels:
  - Coal mining and handling – surface mines (Mining and Post-mining)
  - Oil refining and transmission of natural gas

- The 2019 Refinements of 2006 IPCC Guidelines introduce a CO_2 emission factor

- Decrease in emissions due to reduced production from coal mines

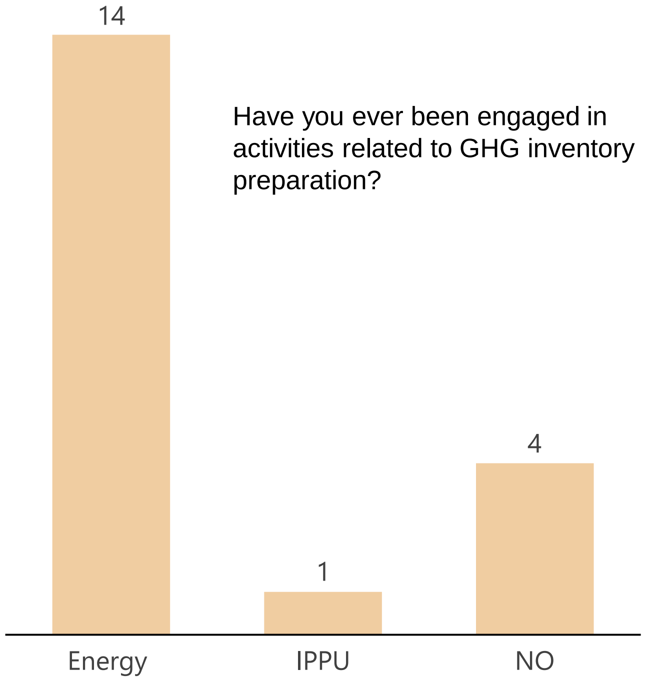
Recommendations for future inventories

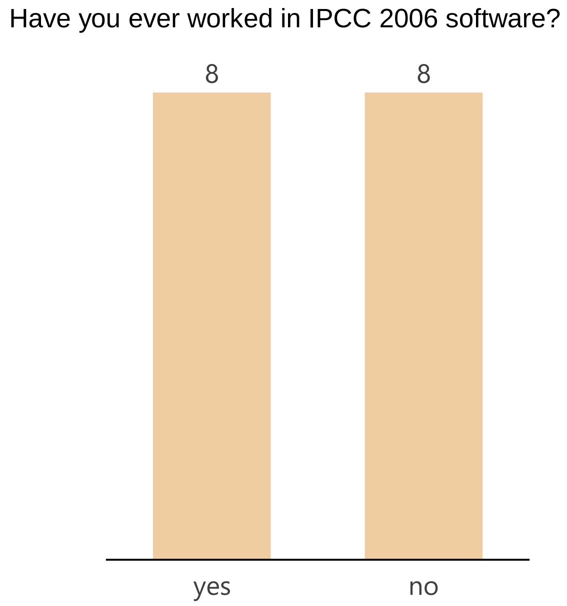
- Secure and constant channels for acquiring data on composition and carbon content of fuels should be established with relevant institutions in order to facilitate the estimation of country specific emission factors. This can be achieved by signing some kind of agreement, for instance, a Memorandum of Understanding.
- Having in mind that there are several existing biogas power plants, their electricity production should be also taken into account in the next inventories, especially if more of this type of power plants will become available in the future. Since there are no data available on the amount of biogas used for electricity production, it is recommended to develop a separate study for the existing biogas power plants. This study would be also relevant for the AFOLU and Waste sectors since the biogas is produced from manure.

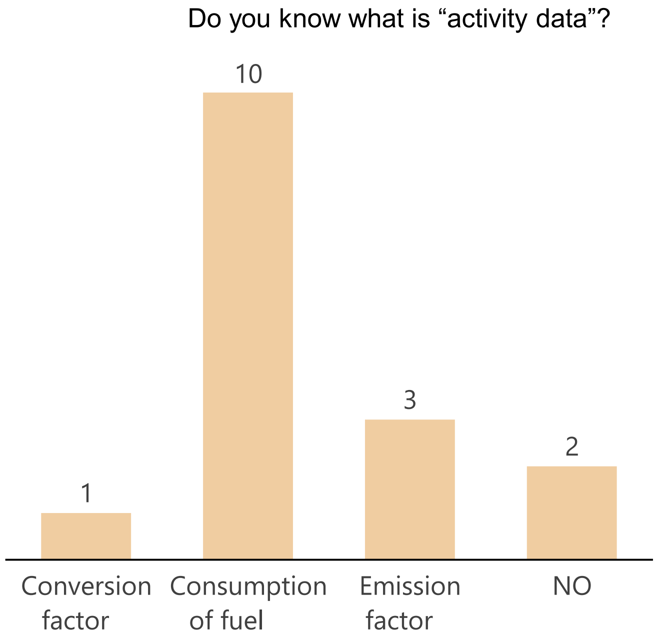
Updating GHG inventory in energy sector - Training

Questionnaires - Results

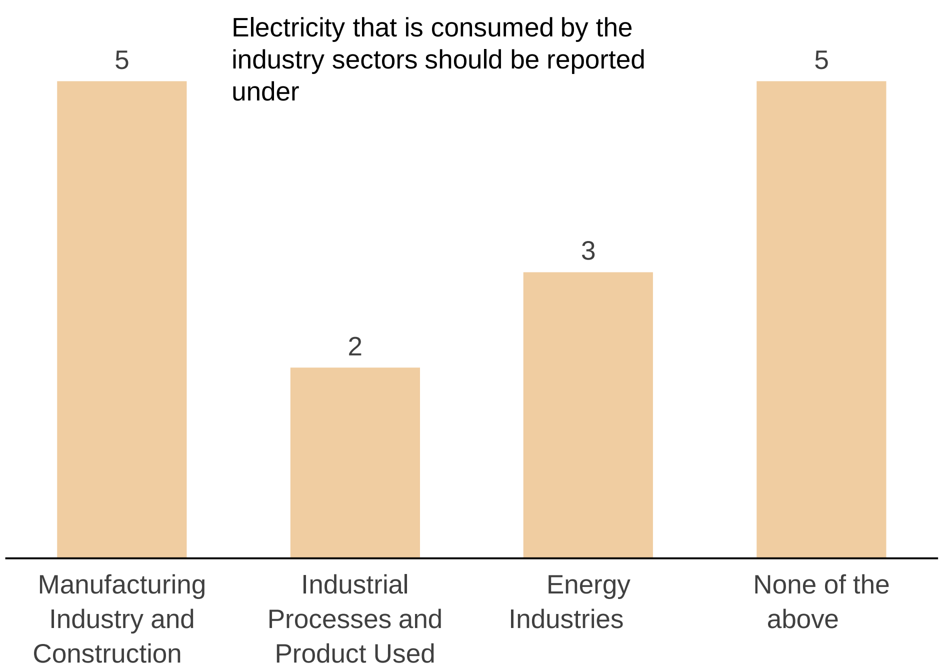
Questionnaire - results

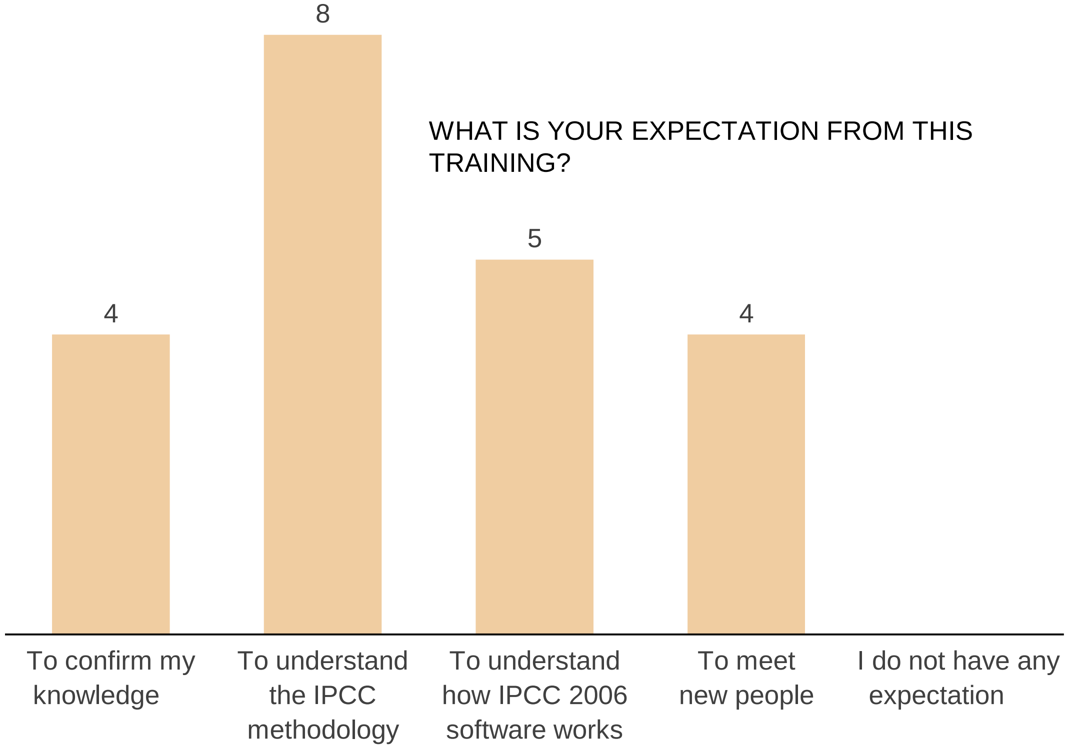






Questionnaire - results





2014,2016,2017 latest inventory,
Other software – IPCC 1996, COPERT, LEAP, own etc.

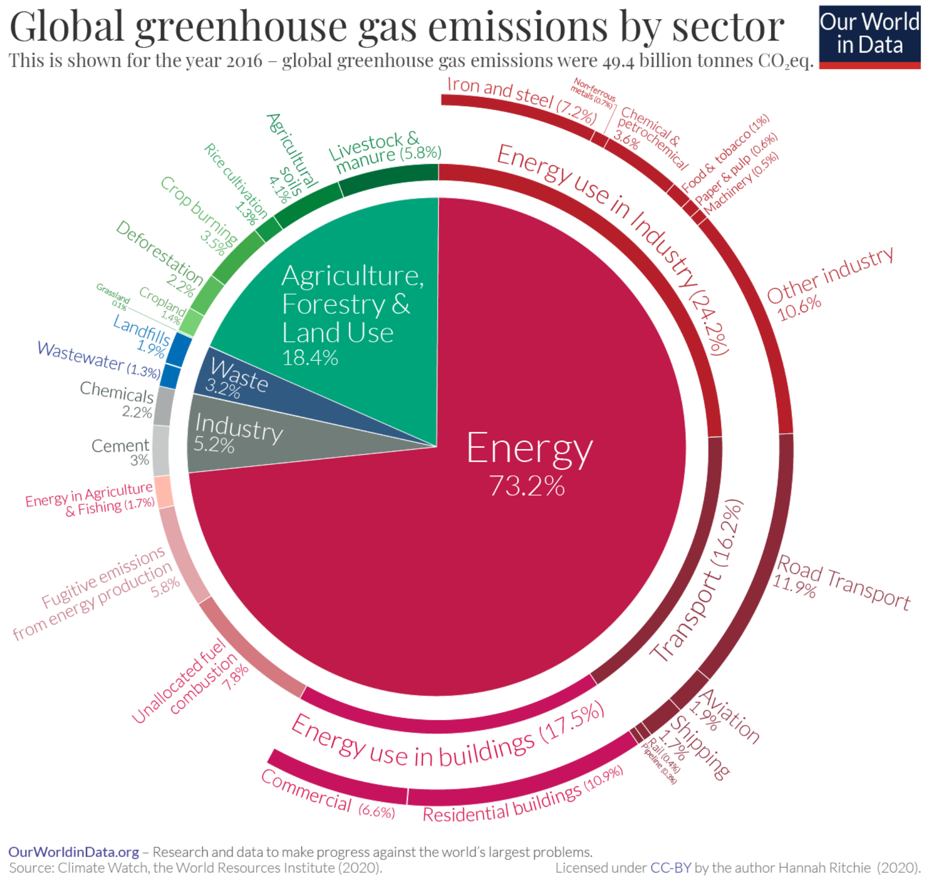
Updating GHG inventory in energy sector – 1st part

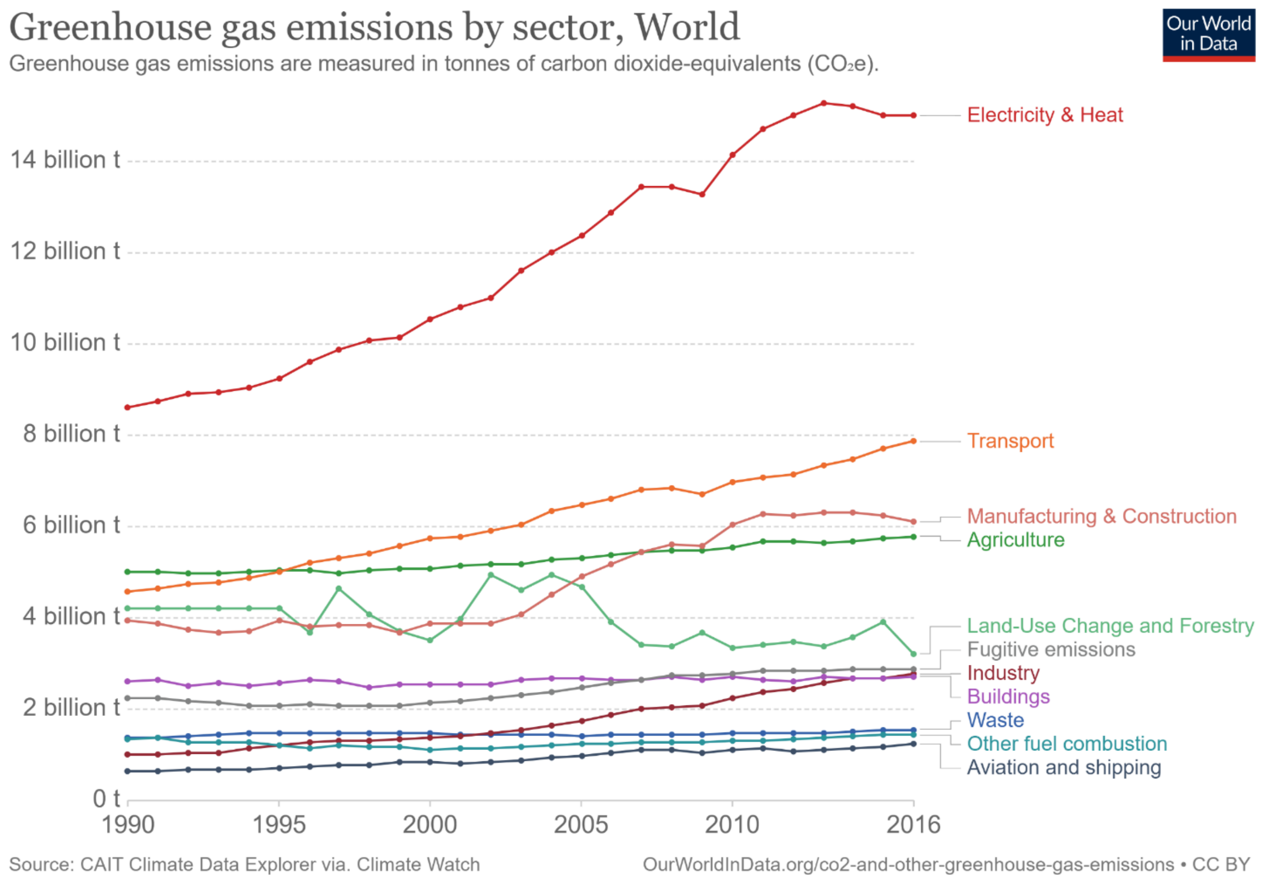
Source categories, methodological approach for emissions estimation, approach to data collection, time series consistency

Presenter: Verica Taseska-Gjorgievska

Why is energy sector important?

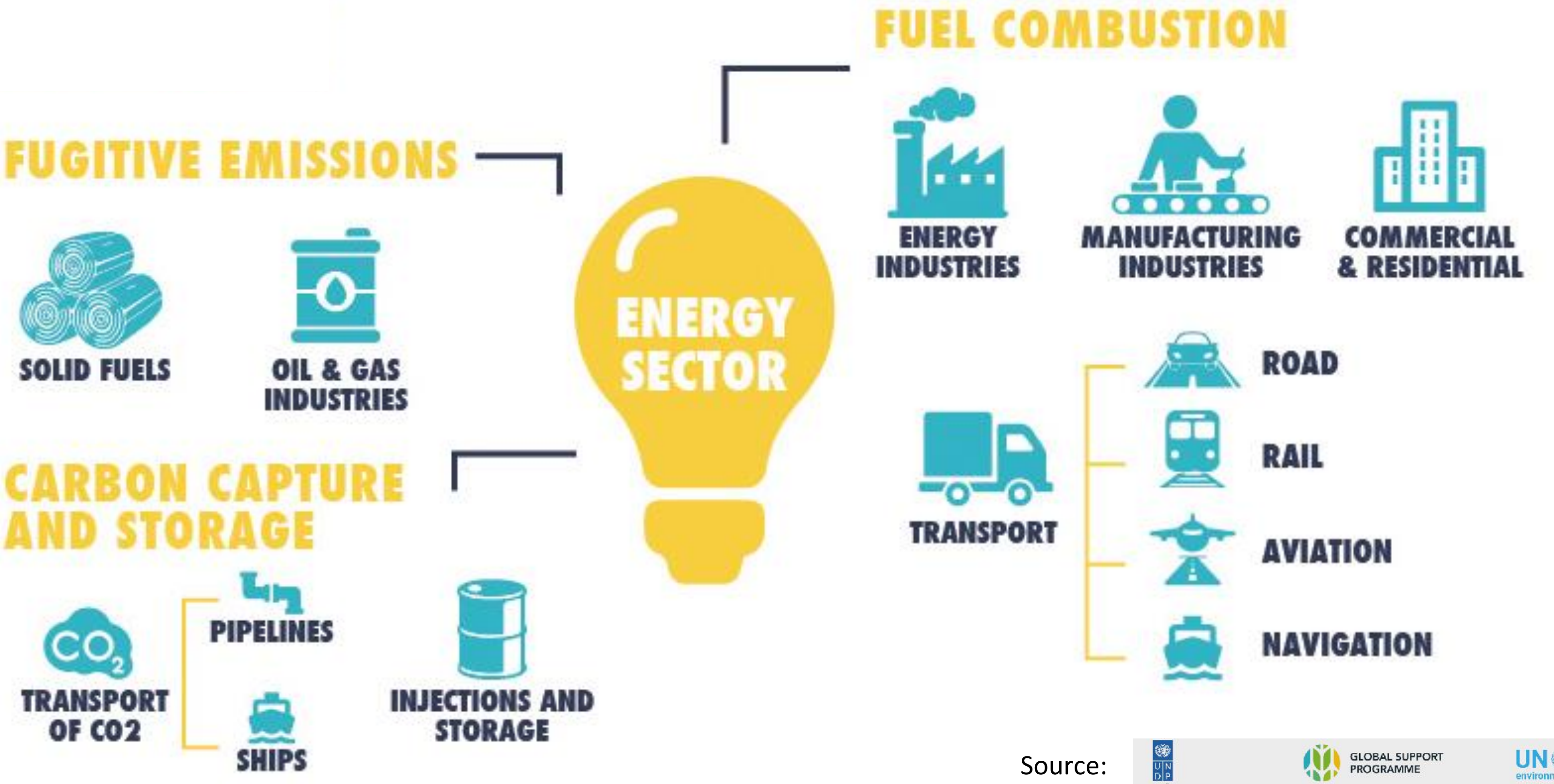
- Energy sector contributes to approx. 70% of the world emissions
  - It has the highest share in total GHG emissions for most of the countries





Sector Overview

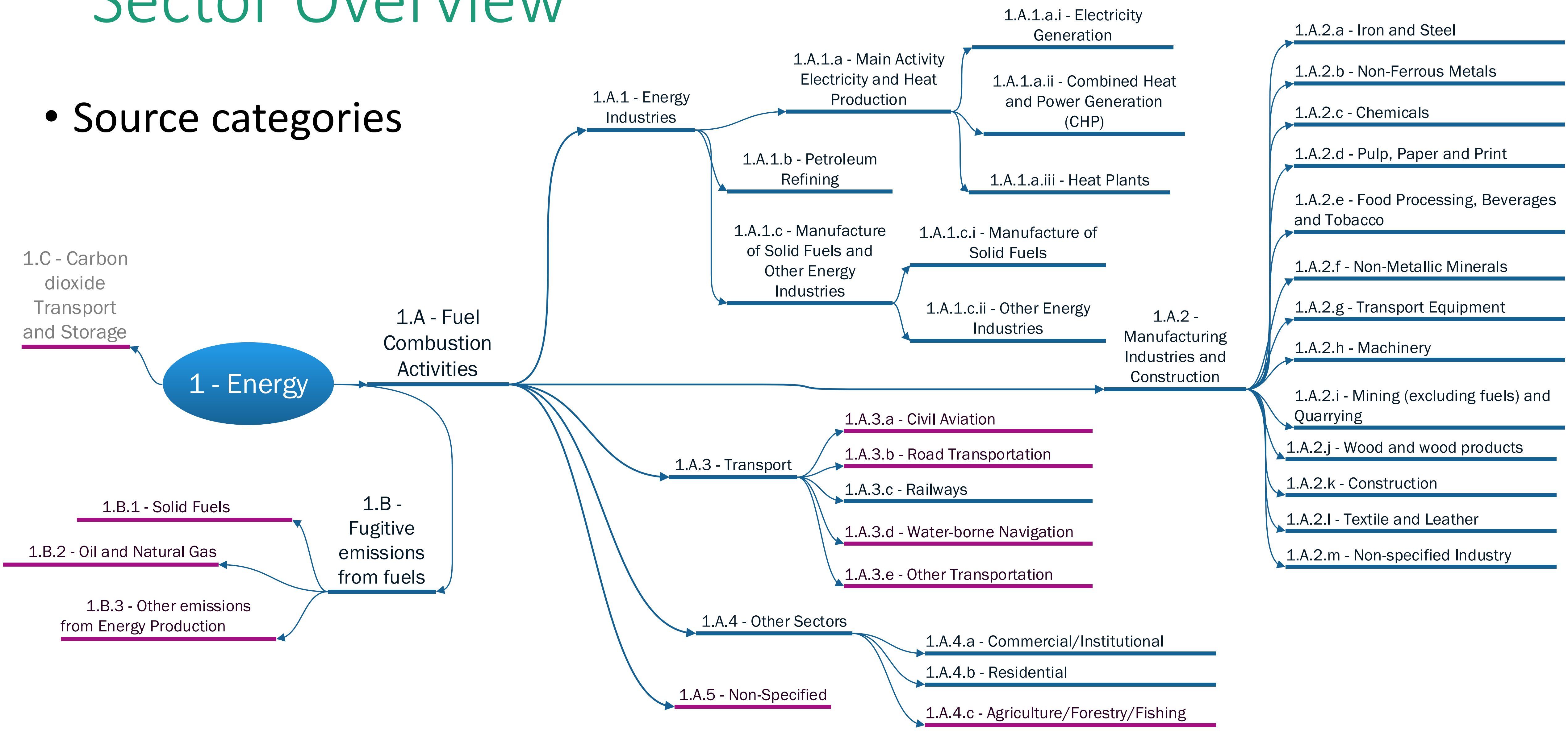
- *2006 IPCC Guidelines* for national GHG inventories identify around 70 source categories of GHG emissions in the Energy sector
- Scope:
  - Exploration and exploitation of primary energy sources
  - Conversion of primary energy sources into more useable energy forms in refineries and power plants
  - Transmission and distribution of fuels
  - Use of fuels in stationary and mobile applications
- Most emissions are associated with fuels combustion in energy industries, mainly in electricity and heat production activities, but also in transport and manufacturing industries



Source: GLOBAL SUPPORT PROGRAMME

Sector Overview

- Source categories



Emissions from fossil fuel combustion
Methodological approach

- CO_2 emissions depend almost entirely on the carbon content of the fuel, and are independent of the combustion technology
- During the combustion process, most carbon is immediately emitted as CO_2. Some carbon is released as CO, CH_4 or NMVOCs, which eventually oxidise to CO_2 in the atmosphere
- CH_4 and N_2O emissions are strongly dependent on the combustion technology (which differ widely between source categories)
- Three *Tiers* (levels of methodological complexity) presented in *2006 IPCC GL*

Emissions = AD × EF = Amount of Fuel × NCV × EF

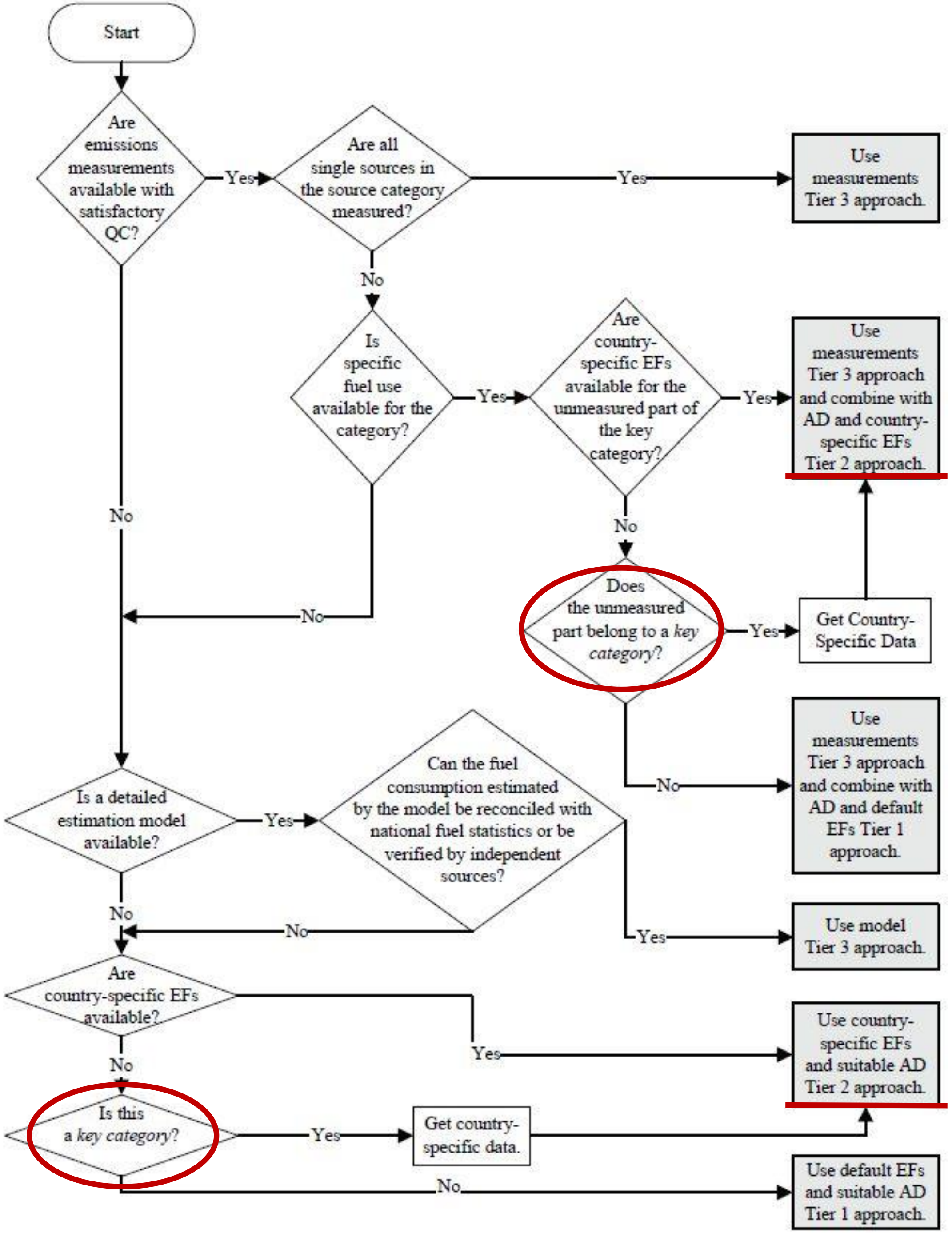
EF_{CO2} = Carbon Content × Oxidation fraction × 44/12

*(where **AD** = Activity Data; **EF** = Emission Factor)*

  - ***Tier 1*** - Amount of fuel combusted, default values for NCV, carbon content, CO_2 EF, N_2O EF, CH_4 EF
  - ***Tier 2*** - Amount of fuel, country-specific values for NCV, carbon content and CO_2 EF, 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)

Emissions from fossil fuel combustion
Methodological approach

- Generalised decision tree
  (Figure 2.1, Vol. 2, Chapter 1, 2006 IPCC GL)
  - applies in general for each of the fuel combustion activities and for each of the gases
- Relation to other inventory approaches
  - IPCC approach - UNFCCC reporting needs
  - EMEP/CORINAIR approach - technology based and includes spatial allocation of emissions (point and area sources)
  - Now both are generally well harmonized:
    - 2006 IPCC Guidelines - concentrate on emissions of direct greenhouse gases, CO_2, CH_4 and N_2O
    - EMEP/CORINAIR Emission Inventory Guidebook - emission estimation methods for indirect GHG and other air pollutants



Emissions from fossil fuel combustion

Activity data

- **Inventory definition:** Data on the magnitude of human activity resulting in emissions or removals taking place during a given period of time.

AD = Amount of Fuel (Consumption) × NCV

(The default NCV values are given in Table 1.2, Vol. 2, Chapter 1, 2006 IPCC GL)

- Fuels:
  - SOLID (Coal and Coal Products)
  - LIQUID (Crude Oil and Petroleum Products)
  - 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

    (Definition of fuel types in Table 1.1, Vol. 2, Chapter 1, 2006 IPCC GL)

Fuel consumption units:

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

The 2006 IPCC Guidelines - SI units :

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

Emissions from fossil fuel combustion

Activity data

- **Sources**
  - Most appropriate and accessible AD can be obtained from fuel statistics collected by an officially recognised national body
    - Energy balances from national statistical offices
  - International energy statistics:
    - the International Energy Agency (IEA)
    - the United Nations (UN)
  - European statistics (Eurostat)

The structure of categories under 1.A - Fuel Combustion Activities is very similar to the structure of the energy balances

Emissions from fossil fuel combustion

Activity data

IEA

	Coal	Crude oil	Oil products	Natural gas	Nuclear	Hydro	Wind, solar, etc.	Biofuels and waste	Electricity	Heat	Total
	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
Production	3 768 012	4 461 494		3 136 586	687 380	350 064	257 470	1 305 118		2 073	13 968 196
Imports	823 706	2 460 319	1 370 698	990 788				27 061	62 855	6	5 735 433
Exports	-852 516	-2 380 169	-1 477 986	-1 015 549				-21 660	-63 251	-5	-5 811 136
International marine bunkers											
International aviation bunkers											
Stock changes	47 999	16 896	5 574	-12 955				506			58 019
TES	3 787 200	4 558 540	-101 715	3 098 870	687 380	350 064	257 470	1 311 024	-395	2 074	13 950 512
Transfers	-1 226	-236 903	263 761								25 631
Statistical differences	-870	5 184	12 424	4 764			-101	-931	-1 695	4 195	22 970
Electricity plants	-1 709 178	-35 046	-151 304	-882 500	-683 898	-350 064	-207 944	-123 499	1 859 171	-894	-2 285 155
CHP plants	-643 762	-14	-15 830	-321 816	-3 482		-2 703	-64 548	343 065	241 662	-467 429
Heat plants	-22 065	-492	-9 112	-64 271			-1 417	-12 581	-708	100 927	-9 719
Gas works	-12 894		-2 702	5 575				-534			-10 555
Oil refineries		-4 326 398	4 232 632								-93 766
Coal transformation	-279 625		-2 328	-43				-160			-282 155
Liquefication plants	-14 471	15 349		-14 435							-13 557
Other transformation	-257	50 145	-38 359	-14 326				-81 858		-696	-85 350
Energy industry own use	-83 181	-9 945	-209 567	-278 734			-2	-13 114	-185 073	-37 101	-816 717
Losses	-2 245	-7 743	-460	-18 909			-10	-189	-169 131	-19 525	-218 210
Total final consumption	1 017 425	12 678	3 977 441	1 514 175			45 293	1 013 611	1 845 233	290 643	9 716 500
Industry	812 748	3 315	302 337	572 446			960	203 730	771 206	138 875	2 805 617
Transport	126	10	2 600 775	105 067				83 769	31 661		2 821 408
Residential	77 389		215 185	446 996			32 732	681 952	497 317	101 343	2 052 914
Commercial and public services	33 330		83 571	192 349			8 175	30 343	402 271	38 929	788 970
Agriculture / forestry	16 481	11	108 181	10 190			2 182	11 599	55 622	3 472	207 737
Fishing	2		6 118	46			59	25	648	57	6 955
Non-specified	26 181	1	21 442	3 368			1 185	2 193	86 508	7 967	148 846
Non-energy use	51 168	9 341	639 832	183 713							884 054

IPCC Inventory Software

Emissions from fossil fuel combustion

Activity data

Good practices in N. Macedonia

- Energy balances from the State Statistical Office (SSO) are used:
  - Values in natural units*
  - Values in ktoe
  - NCV values are derived (TJ/Unit)*
    - Conversion of data from ktoe ➔ TJ

$$NCV = \frac{fuel\ consumption\ in\ TJ}{fuel\ consumption\ in\ natural\ units}$$

*Input in IPCC software

Improvements over the years

- Alignment of the methodology for development of energy balances developed by different state institutions (Ministry of Economy and SSO)
- Collaboration with SSO – Department for environment, energy and transport
  - Data irregularities, possible uncertainties

Emissions from fossil fuel combustion

Emission factors

- Default emission factors
  - CO_2 emission factors for fuel combustion are relatively insensitive to the combustion process itself and hence are primarily dependent only on the carbon content of the fuel
    (Default values of carbon content, Table 1.3, Vol. 2, Chapter 1, 2006 IPCC GL;
    Default CO_2 emission factors for combustion , Table 1.4, Vol. 2, Chapter 1, 2006 IPCC GL)
  - CH_4 and N_2O emissions are strongly dependent on the combustion technology (which differ widely between source categories)
    (Default emission factors for stationary combustion, Tables 2.2 to 2.5, Vol. 2, Chapter 2, 2006 IPCC GL;
    Road transport default CO_2 emission factors, Table 3.2.1, Vol. 2, Chapter 3, 2006 IPCC GL)
- Country-specific emission factors

  $$EF_{CO2} = \text{Carbon Content} \times \text{Oxidation fraction} \times 44/12$$

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

Emissions from fossil fuel combustion
Emission factors

Good practices in N. Macedonia

- Country-specific emission factors (CS-EF) for CO_2 emissions

  EF_{CO2} = Carbon Content × Oxidation fraction × 44/12

  - In three National Communications – CS – EF developed in line with *1996 IPCC Guidelines* (oxidation fractions <1)
  - By default the *2006 IPCC Guidelines* assume a complete combustion process (100% carbon conversion or oxidation fraction is 1)
  - Under the 1st BUR CS-EF were revised in line with *2006 IPCC Guidelines:*
    - *Lignite* (data source for carbon content - Power company ESM, experimental values on samples from coal mines)
    - *Residual fuel oil* (data source for carbon content – Oil refinery OKTA)
    - *Natural gas* (data source for carbon content – GAMA – natural gas transmission system operator)

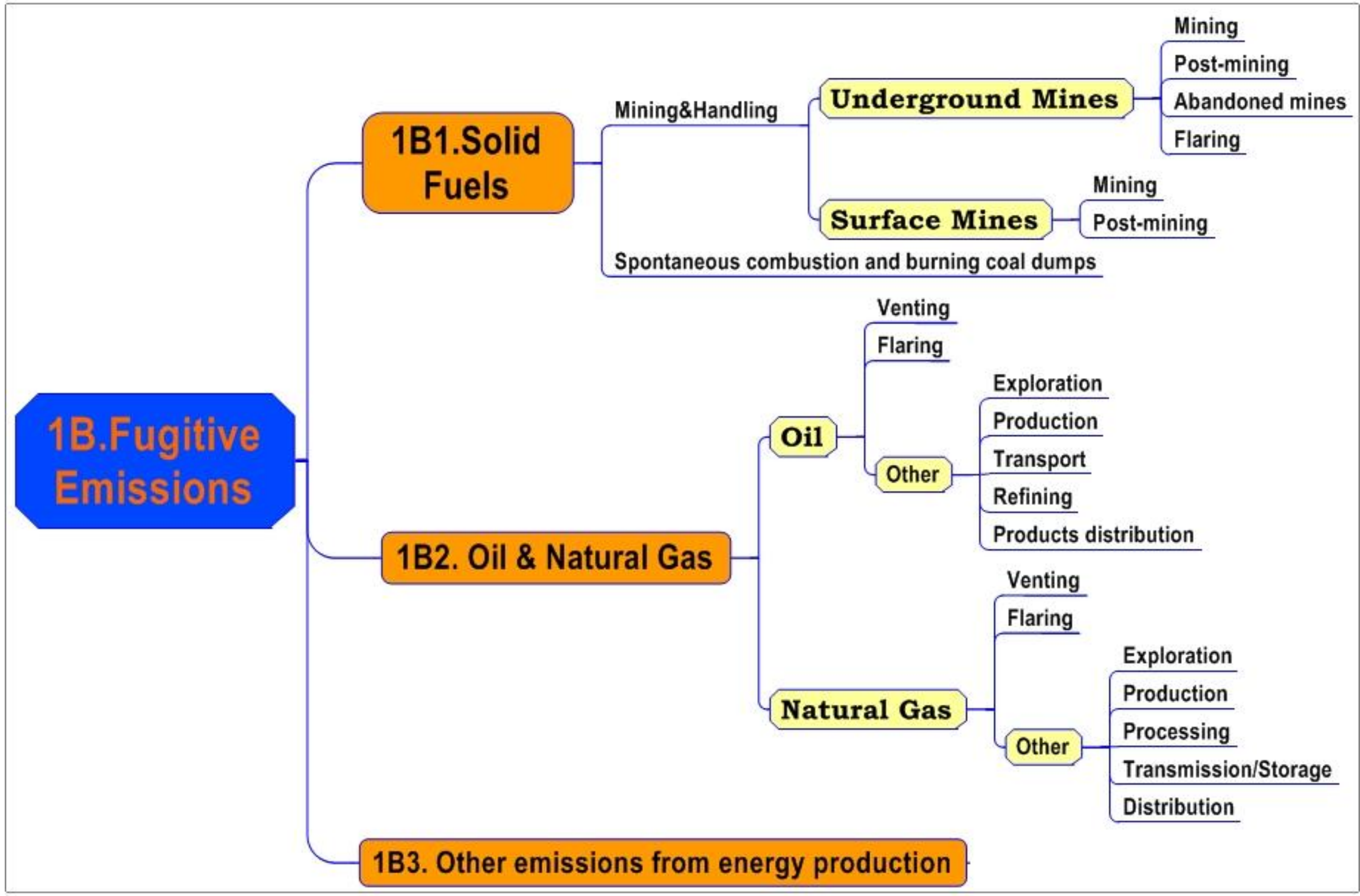
Emissions from fossil fuel combustion

Other methodological issues for energy sector

- Biomass combustion
  - CO_2 emissions are not included in the national total. They are reported separately (information item)
  - CH_4 and N_2O emissions are reported in the national total
  - Net carbon emissions are accounted for in the AFOLU sector
  - Peat is treated as a fossil fuel
- Aviation and Shipping (water-borne navigation)
  - Domestic emissions included in the national total
    (Domestic trips - journeys between points in one country)
  - International emissions reported separately as “Bunker Fuels”
    (International trips - between countries)

Fugitive emissions
Methodological approach

- ***Fugitive emissions*** are intentional or unintentional release GHG which may occur during the extraction, processing and delivery of fossil fuels to the point of final use.
- Majority of emissions are CH_4 from:
  - Coal mines
  - Refinery leaks
  - Gas distribution pipelines
- Simple Emission Factor methods at Tier 1 are used. Higher Tiers need more details on technologies and age of plant/mines etc.



Source: CGE Training Materials, 2006 IPCC GL

Fugitive emissions
Coal mining

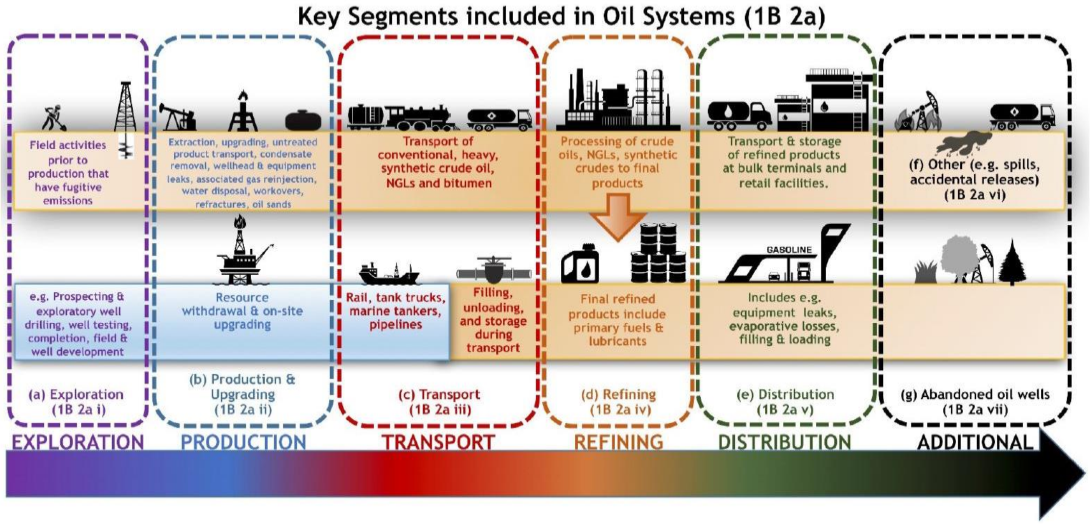
- The major stages for the emission of greenhouse gases for both underground and surface coal mines are:
  - **Mining emissions** – These emissions result from the liberation of stored gas during the breakage of coal, and the surrounding strata, during mining operations.
  - **Post-mining emissions** – Emissions, during subsequent handling, processing and transportation of coal. These emissions occur more slowly than during the coal breakage stage.
  - **Low temperature oxidation** - Once coal is exposed to oxygen in air, it oxidizes to produce CO_2. However, the rate of formation of CO_2 by this process is low.
  - **Uncontrolled combustion** – On occasions, when the heat produced by low temperature oxidation is trapped, the temperature rises and an active fire may result. This is commonly known as uncontrolled combustion and is the most extreme manifestation of oxidation. Uncontrolled combustion may be natural or anthropogenic. It is characterised by rapid reactions, sometimes visible flames and rapid CO_2 formation.
  - **Exploration emissions** – These emissions result from boreholes drilled through carbonaceous strata for the purposes of coal exploration. This is distinct from gas drainage boreholes which form part of a degasification system.
- Abandoned coal mines may also continue to emit methane (from left over coals).

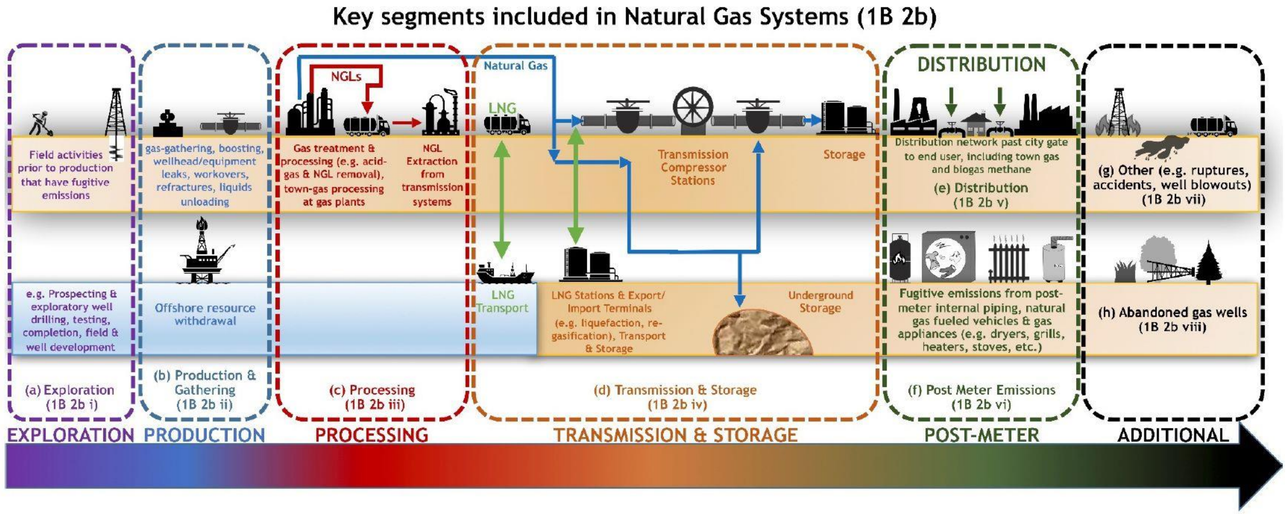
✓ **See 2019 Refinement to the 2006 IPCC Guidelines (Vol 2., Chapter 4)**

Fugitive emissions

Oil and natural gas

- The sources include, but are not limited to, equipment leaks, evaporation and flashing losses, venting, flaring and accidental releases (e.g., pipeline dig-ins, well blow-outs and spills).
  - Venting and flaring emission sources are engineered or intentional (e.g., vents from tanks, seal and process vents and flare systems).
  - Leak emissions (e.g. working losses from tanks, and leaks from other equipment) are unintentional (or uncontrolled).





✓ **See 2019 Refinement to the 2006 IPCC Guidelines ([Vol 2., Chapter 4])**

Fugitive emissions
Methodological updates

2019 Refinement to the 2006 IPCC Guidelines (Vol 2., Chapter 4)

- *Fugitive CH4 and CO2 emissions from mining, processing, storage and transportation of coal*:
  - Includes guidance on fugitive CO_2 emissions from underground and surface mines including CO_2 from methane utilization or flaring from underground coal mines.
  - Adds year specific default input values for fugitive CH_4 emissions from abandoned underground mines for period 2017 - 2050 (previously the series of default values ended at 2016)
- *Fugitive emissions from oil and natural gas systems:*
  - Includes updates to EF to reflect the range of technologies and practices in use, including for unconventional oil and gas exploration (provides additional information on the appropriate selection of factors).
  - Includes methods and emission factors for abandoned wells.
- *Fugitive emissions from fuel transformation*:
  - Includes a new section covering methods for fugitive emissions from charcoal production, biochar production, coke production (including flaring), wood pellet production, gasification transformation processes (coal to liquids, gas to liquids, biomass to liquids, and biomass to gas).

Carbon dioxide Transport, injection and storage
Methodological approach

- The 2006 IPCC GL provide emission estimation guidance for carbon dioxide transport, injection and geological storage (CCGS) only.
- Subdivided in four systems:
  1. **Capture and compression system**. The systems boundary includes capture, compression and, where necessary, conditioning, for transport.
  2. **Transport system.** Pipelines and ships are considered the most likely means of large-scale CO2 transport. The upstream systems boundary is the outlet of the compression/conditioning plant in the capture and compression system. The downstream systems boundary is the downstream end of a transport pipeline, or a ship offloading facility
  3. **Injection system.** The injection system comprises surface facilities at the injection site, e.g. storage facilities, distribution manifold at end of transport pipeline, distribution pipelines to wells, additional compression facilities, measurement and control systems, wellhead(s) and the injection wells. The upstream systems boundary is the downstream end of transport pipeline, or ship offloading facility. The downstream systems boundary is the geological storage reservoir.
  4. **Storage system**. The storage system comprises the geological storage reservoir.

Carbon dioxide Transport, injection and storage

Methodological approach

- CO_2 can be captured via pre-combustion, post-combustion and oxy-fuel capture activities and also at some industrial processes (e.g., in cement industry).
- CO_2 transport can be organized mainly by pipelines (and ships).
- CO_2 can be stored onshore and offshore in deep saline formations, depleted (partially depleted) oil and gas fields with or without enhanced oil/gas recovery, and in coal seams with or without enhanced coalbed methane recovery.
  - The 2006 IPCC GL does not include Tier 1 or Tier 2 methodology, due to insufficient empirical evidence to produce emission factors that could be applied to leakage from geological storage reservoirs.
  - However a site-specific Tier 3 approach can be developed.

Time series consistency

- GHG Inventory provides information on historical emissions trends and tracks the effects of strategies to reduce emissions at the national level.
- Annual estimates should be comparable
- Emissions and removals in time series should be estimated consistently
  - Use of the same method and data sources in all years, where possible
  - But not always possible for the entire time series, due to a lack of data
- Cases to ensure time series consistency
  - Recalculations due to methodological changes and refinements
    - Available data have changed
    - The previously used method is not consistent with the IPCC guidelines for that category
    - A category has become key
    - The capacity for inventory preparation has increased
    - Correction of errors…
  - Adding new categories

Time series consistency
Resolving data gaps

- Data availability issues:
  - Periodic data
  - Changes and gaps in data availability
- Splicing techniques – combining or joining of more than one method to form a complete time series

✓ We need to ensure quality of time series
  - Apply quality checks to entire time series

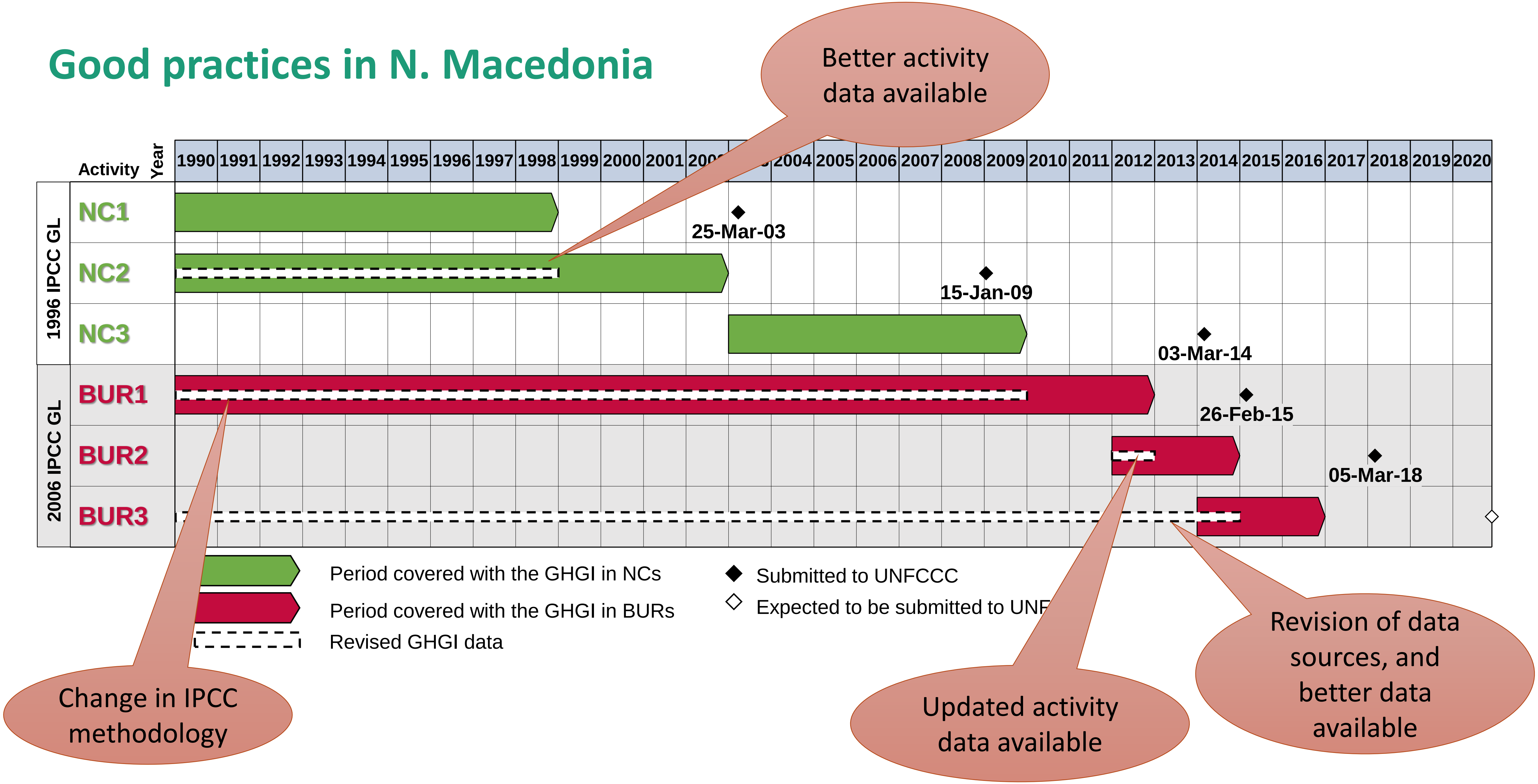
✓ All decisions, methods and reasons should be documented

TABLE 5.1
SUMMARY OF SPLICING TECHNIQUES

Approach	Applicability	Comments
Overlap	Data necessary to apply both the previously used and the new method must be available for at least one year, preferably more.	• Most reliable when the overlap between two or more sets of annual estimates can be assessed. • If the trends observed using the previously used and new methods are inconsistent, this approach is not *good practice*.
Surrogate Data	Emission factors, activity data or other estimation parameters used in the new method are strongly correlated with other well-known and more readily available indicative data.	• Multiple indicative data sets (singly or in combination) should be tested in order to determine the most strongly correlated. • Should not be done for long periods.
Interpolation	Data needed for recalculation using the new method are available for intermittent years during the time series.	• Estimates can be linearly interpolated for the periods when the new method cannot be applied. • The method is not applicable in the case of large annual fluctuations.
Trend Extrapolation	Data for the new method are not collected annually and are not available at the beginning or the end of the time series.	• Most reliable if the trend over time is constant. • Should not be used if the trend is changing (in this case, the surrogate method may be more appropriate). • Should not be done for long periods.
Other Techniques	The standard alternatives are not valid when technical conditions are changing throughout the time series (e.g., due to the introduction of mitigation technology).	• Document customised approaches thoroughly. • Compare results with standard techniques.

Time series consistency

Good practices in N. Macedonia

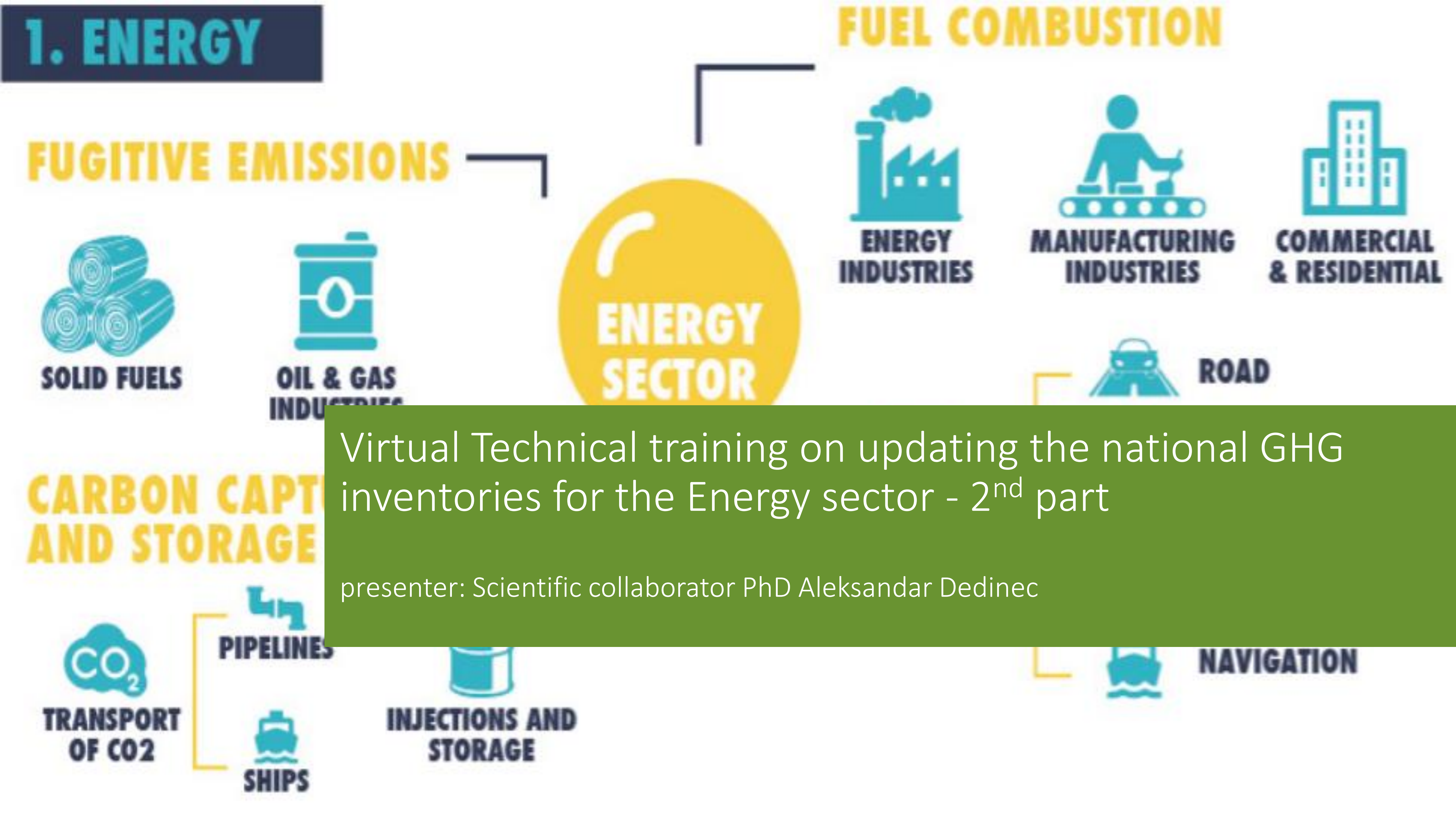


Data collection and time series consistency

- **Methodological principles – *Good practices* (*2006 IPCC GL*):**
  - Focus on the collection of data needed to improve estimates of key categories which are the largest, have the greatest potential to change, or have the greatest uncertainty.
  - Choose data collection procedures that iteratively improve the quality of the inventory in line with the data quality objectives.
  - Put in place data collection activities (resource prioritisation, planning, implementation, documentation etc.) that lead to continuous improvement of the data sets used in the inventory.
  - Collect data/information at a level of detail appropriate to the method used.
  - Review data collection activities and methodological needs on a regular basis, to guide progressive, and efficient, inventory improvement.
  - Introduce agreements with data suppliers to support consistent and continuing information flows.

Virtual Technical training on updating the national GHG inventories for the Energy sector - 2nd part

presenter: Scientific collaborator PhD Aleksandar Dedinec



Contents

- Reference vs sectoral approach
- Key category analyses
- Uncertainty
- QA/QC

Reference vs sectoral a

- 1. Let's start from the energy balanc
- 2. Divided in two parts:
- General part

European Union (27 countries) ktoe 2018	Total	Solid fossil fuels	Manufac-tured gases	Peat and peat products	Oil s and san
+ Primary production	634 751.4	116 090.5	Z	2 865.9	4
+ Recovered & recycled products	1 747.5	650.9	Z	0.0	
+ Imports	1 350 483.5	104 696.4	0.0	77.6	
- Exports	464 688.8	12 946.5	0.0	8.6	
+ Change in stock	285.7	1 766.4	0.0	-575.9	-
= Gross available energy	**1 522 579.4**	**210 257.7**	**0.0**	**2 359.0**	**4**
- International maritime bunkers	43 312.7	0.0	0.0	0.0	
= Gross inland consumption	**1 479 266.6**	**210 257.7**	**0.0**	**2 359.0**	**4**
- International aviation	40 906.4	Z	Z	Z	
= Total energy supply	**1 438 360.2**	**210 257.7**	**0.0**	**2 359.0**	**4**

- Detailed consumption

- Main idea of the GHG inventory?
- Transfer the energy balance data int

European Union (27 countries) ktoe 2018	Total	Solid fossil fuels	Manufac-tured gases	Peat and peat products	Oil shale and oil sands	Oil and petroleum products	Natural gas	Renewables and biofuels	Non-renewable waste	Nuclear heat	Heat	Electricity
Transformation input	**1 374 943.1**	**212 154.2**	**7 918.3**	**2 072.4**	**4 626.9**	**705 053.6**	**95 441.4**	**137 783.1**	**9 281.5**	**195 737.9**	**1 581.6**	**3 292.0**
+ Electricity & heat generation	594 611.8	142 366.9	7 918.3	1 975.2	2 367.6	14 534.8	93 581.6	121 974.4	9 281.5	195 737.9	1 581.6	3 292.0
+ Coke ovens	35 158.2	34 669.9	0.0	0.0	194.0	294.3	0.0	0.0	Z	Z	Z	Z
+ Blast furnaces	30 271.5	30 186.1	0.0	0.0	0.0	43.5	41.9	0.0	Z	Z	Z	Z
+ Gas works	946.7	511.4	0.0	0.0	428.5	0.3	6.5	0.0	Z	Z	Z	Z
+ Refineries & petrochemical industry	690 059.8	Z	Z	Z	Z	690 059.8	Z	Z	Z	Z	Z	Z
+ Patent fuel plants	11.9	11.9	0.0	0.0	0.0	0.0	Z	0.0	0.0	Z	Z	Z
+ BKB & PB plants	4 243.2	4 146.0	0.0	97.2	0.0	Z	Z	0.0	0.0	Z	Z	Z
+ Coal liquefaction plants	1 636.8	0.0	0.0	0.0	1 636.8	Z	Z	Z	Z	Z	Z	Z
+ For blended natural gas	473.7	Z	0.0	Z	Z	120.7	Z	353.0	Z	Z	Z	Z
+ Liquid biofuels blended	15 123.3	Z	Z	Z	Z	Z	Z	15 123.3	Z	Z	Z	Z
+ Charcoal production plants	236.8	Z	Z	Z	Z	Z	Z	236.8	Z	Z	Z	Z
+ Gas-to-liquids plants	0.0	Z	Z	Z	Z	Z	0.0	Z	Z	Z	Z	Z
+ Not elsewhere specified	2 169.3	262.0	0.0	0.0	0.0	0.3	1 811.5	95.5	0.0	Z	Z	Z
Transformation output	**1 062 857.0**	**29 681.3**	**19 124.7**	**66.2**	**Z**	**688 750.9**	**383.6**	**15 198.8**	**Z**	**Z**	**56 337.8**	**253 313.7**
+ Electricity & heat generation	309 651.4	Z	Z	Z	Z	Z	Z	Z	Z	Z	56 337.8	253 313.7
+ Coke ovens	32 486.0	25 933.8	6 552.2	Z	Z	Z	Z	Z	Z	Z	Z	Z
+ Blast furnaces	12 085.5	0.0	12 085.5	Z	Z	Z	Z	Z	Z	Z	Z	Z
+ Gas works	463.8	0.0	463.8	Z	Z	Z	Z	Z	Z	Z	Z	Z
+ Refineries & petrochemical industry	685 826.0	Z	Z	Z	Z	685 826.0	Z	0.0	Z	Z	Z	Z
+ Patent fuel plants	7.9	7.9	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z
+ BKB & PB plants	3 805.9	3 739.6	Z	66.2	Z	Z	Z	Z	Z	Z	Z	Z
+ Coal liquefaction plants	0.0	Z	Z	Z	Z	0.0	Z	Z	Z	Z	Z	Z
+ Blended in natural gas	383.6	Z	Z	Z	Z	Z	383.6	Z	Z	Z	Z	Z
+ Liquid biofuels blended	15 115.4	Z	Z	Z	Z	Z	Z	15 115.4	Z	Z	Z	Z
+ Charcoal production plants	83.4	Z	Z	Z	Z	Z	Z	83.4	Z	Z	Z	Z
+ Gas-to-liquids plants	1 598.3	Z	Z	Z	Z	1 598.3	Z	Z	Z	Z	Z	Z
+ Not elsewhere specified	1 349.9	0.0	23.3	0.0	Z	1 326.6	Z	Z	Z	Z	Z	Z
Energy sector	**67 922.0**	**695.7**	**5 331.8**	**15.3**	**0.0**	**25 091.1**	**13 013.1**	**588.8**	**32.3**	**Z**	**4 407.9**	**18 746.0**
+ Own use in electricity & heat genera	13 439.3	10.2	16.6	0.0	0.0	42.3	77.5	8.5	0.0	Z	1 239.3	12 044.7
+ Coal mines	1 414.9	309.1	36.5	0.0	0.0	77.5	22.1	0.8	0.0	Z	111.4	857.5
+ Oil & natural gas extraction plants	3 689.9	Z	Z	Z	Z	19.0	3 043.0	0.0	Z	Z	22.3	605.5
+ Patent fuel plants	0.9	0.0	0.0	0.0	0.0	Z	Z	0.0	0.0	Z	0.8	0.1
+ Coke ovens	3 520.1	174.9	2 964.8	0.0	0.0	0.2	127.7	10.0	4.1	Z	108.1	130.3
+ BKB & PB plants	994.7	181.5	0.0	15.3	0.0	Z	Z	3.3	0.0	Z	362.3	432.3
+ Gas works	17.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0	Z	0.3	13.2
+ Blast furnaces	1 930.1	1.4	1 720.7	0.0	0.0	0.5	56.8	0.0	14.3	Z	14.4	122.1
+ Petroleum refineries (oil refineries)	38 495.6	18.6	22.0	0.0	0.0	24 715.3	9 295.0	58.9	13.9	Z	1 494.8	2 877.2
+ Nuclear industry	95.3	Z	Z	Z	Z	Z	Z	Z	Z	Z	0.0	95.3
+ Coal liquefaction plants	203.1	0.0	178.0	0.0	0.0	Z	Z	Z	Z	Z	9.1	16.0
+ Liquefaction & regasification plants (	125.6	Z	Z	Z	Z	Z	122.3	Z	Z	Z	0.3	3.0
+ Gasification plants for biogas	491.2	Z	Z	Z	Z	Z	Z	485.1	0.0	Z	6.2	0.0
+ Gas-to-liquids (GTL) plants	0.0	Z	Z	Z	Z	Z	0.0	Z	Z	Z	0.0	0.0
+ Charcoal production plants	0.0	Z	Z	Z	Z	Z	Z	0.0	0.0	Z	0.0	0.0
+ Not elsewhere specified (energy)	3 504.3	0.0	393.2	0.0	0.0	236.2	268.7	18.6	0.0	Z	1 038.7	1 548.8
Distribution losses	**22 900.8**	**53.3**	**530.8**	**0.0**	**0.0**	**13.4**	**1 412.5**	**83.7**	**0.2**	**Z**	**5 092.1**	**15 714.8**
Available for final consumption	**1 035 451.4**	**27 035.9**	**5 343.8**	**337.5**	**38.1**	**421 766.0**	**215 117.1**	**98 813.7**	**4 401.0**	**0.0**	**46 276.9**	**216 321.3**
Final non-energy consumption	**91 142.5**	**1 584.6**	**18.9**	**0.0**	**67.4**	**74 553.9**	**14 917.7**	**0.0**	**Z**	**Z**	**Z**	**Z**
Final energy consumption	**939 681.9**	**22 535.9**	**5 341.1**	**462.1**	**22.0**	**345 079.2**	**200 766.0**	**98 902.1**	**4 401.0**	**Z**	**46 199.5**	**215 972.9**
+ Industry	242 166.7	12 545.4	5 336.9	168.4	22.0	25 037.4	75 197.1	22 361.6	4 194.3	Z	15 062.5	82 240.9
+ Iron & steel	26 567.8	2 890.7	5 083.2	0.0	0.0	573.6	7 956.5	11.8	2.7	Z	403.7	9 645.4
+ Chemical & petrochemical	49 136.4	2 622.9	100.8	2.6	0.0	7 968.1	16 947.2	303.9	427.0	Z	6 228.8	14 535.0
+ Non-ferrous metals	9 970.2	338.0	35.0	0.0	0.0	387.2	3 571.0	3.2	10.1	Z	156.0	5 469.7
+ Non-metallic minerals	33 712.1	3 906.8	67.2	1.1	22.0	5 641.4	13 072.5	1 624.1	3 459.9	Z	337.5	5 579.6
+ Transport equipment	7 665.4	156.2	32.4	0.0	0.0	216.4	2 332.7	17.5	0.1	Z	572.1	4 338.0
+ Machinery	17 431.5	78.4	7.4	0.1	0.0	993.5	5 901.8	122.0	11.4	Z	592.4	9 724.5
+ Mining & quarrying	3 799.3	164.7	9.5	0.0	0.0	907.2	746.3	79.3	1.7	Z	139.6	1 751.0
+ Food, beverages & tobacco	27 559.3	1 410.1	0.0	0.7	0.0	1 541.7	12 759.9	1 083.0	26.7	Z	1 280.3	9 456.9
+ Paper, pulp & printing	32 030.7	754.1	0.0	158.0	0.0	681.5	6 157.8	12 996.8	202.0	Z	2 045.6	9 035.0
+ Wood & wood products	8 686.2	39.9	0.0	5.7	0.0	202.1	568.1	4 985.9	26.2	Z	622.9	2 235.5
+ Construction	9 020.1	45.6	0.0	0.0	0.0	5 052.0	1 493.6	220.1	3.8	Z	32.7	2 172.3
+ Textile & leather	3 720.3	30.5	0.0	0.0	0.0	166.2	1 743.3	24.0	2.2	Z	159.4	1 594.6
+ Not elsewhere specified (industry)	12 580.2	107.5	1.4	0.3	0.0	706.5	1 946.4	602.6	20.5	Z	2 491.6	6 703.3
+ Transport	286 777.6	0.9	0.0	0.0	0.0	262 637.1	3 556.8	15 515.7	0.0	Z	Z	5 067.0
+ Rail	5 458.2	0.9	0.0	0.0	0.0	1 253.0	Z	26.3	0.0	Z	Z	4 178.0
+ Road	267 714.9	Z	Z	Z	Z	250 457.2	1 637.1	15 476.9	0.0	Z	Z	143.8
+ Domestic aviation	6 363.5	Z	Z	Z	Z	6 363.5	Z	0.0	Z	Z	Z	Z
+ Domestic navigation	4 244.6	0.0	0.0	0.0	0.0	4 237.7	Z	6.9	0.0	Z	Z	Z
+ Pipeline transport	2 088.6	Z	Z	Z	Z	0.0	1 911.8	0.0	Z	Z	Z	176.9
+ Not elsewhere specified (transport	907.8	0.0	0.0	0.0	0.0	325.8	8.0	5.6	0.0	Z	Z	568.4
+ Other	410 737.6	9 989.6	4.2	293.7	0.0	57 404.7	122 012.1	61 024.8	206.7	Z	31 136.9	128 665.0
+ Commercial & public services	133 600.9	815.5	2.2	11.3	0.0	10 944.7	39 865.7	8 810.7	206.7	Z	9 567.8	63 376.3
+ Households	245 194.9	8 076.4	2.0	217.9	0.0	28 330.6	78 735.7	47 909.4	0.0	Z	21 259.3	60 663.6
+ Agriculture & forestry	27 250.5	951.4	0.0	64.6	0.0	15 448.6	3 322.5	2 840.6	0.0	Z	251.0	4 371.9
+ Fishing	1 335.5	0.0	0.0	0.0	0.0	1 216.3	1.2	59.9	0.0	Z	0.0	58.0
+ Not elsewhere specified (other)	3 355.8	146.3	0.0	0.0	0.0	1 464.5	86.9	1 404.2	0.0	Z	58.8	195.2
Statistical differences	**4 627.0**	**2 915.5**	**-16.2**	**-124.6**	**-51.4**	**2 132.9**	**-566.6**	**-88.4**	**0.0**	**0.0**	**77.5**	**348.4**
Gross electricity production	252 920.5	51 213.3	2 729.5	509.5	806.5	4 715.0	42 256.7	83 301.8	1 872.8	65 515.3	Z	Z
Gross heat production	54 644.6	12 686.3	884.4	789.6	54.2	1 993.9	19 718.8	15 342.1	3 033.6	98.4	Z	43.2

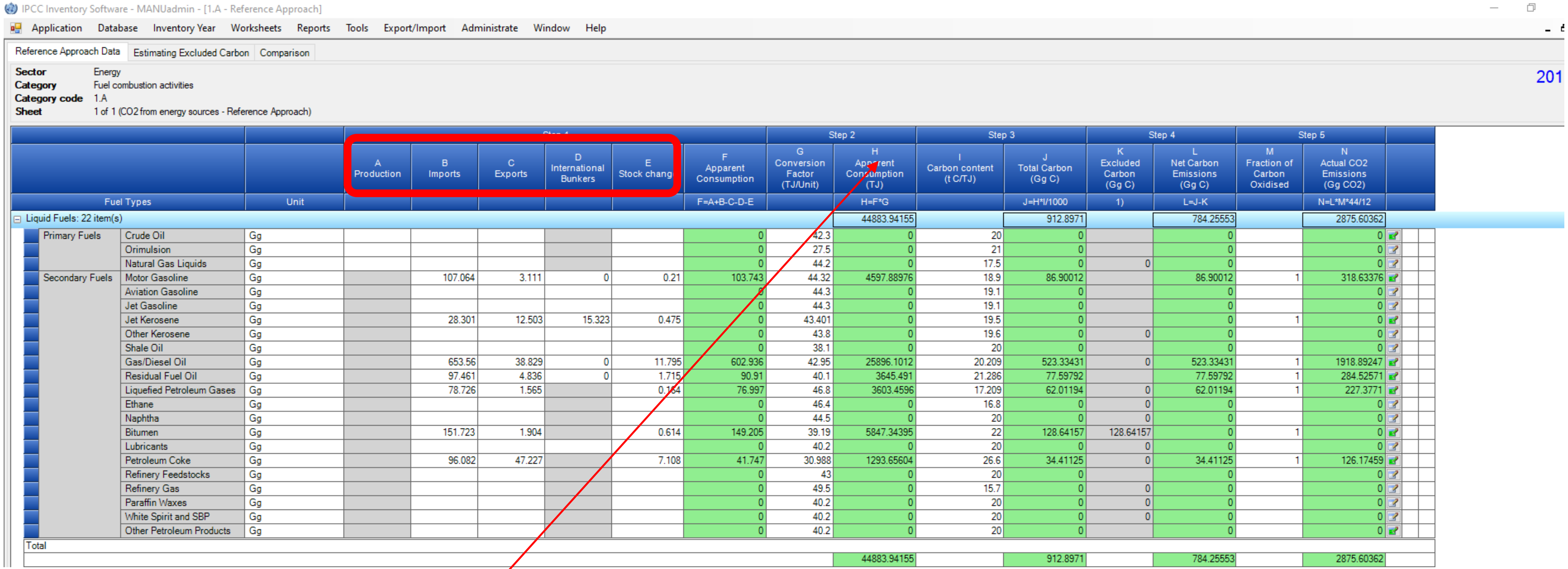
Reference vs sectoral approach

- **Reference approach is top-down approach (Supply data) – Tier 1**
- Very fast GHG inventory could be created
- For countries with no detailed sectoral data

- **Sectoral approach is a bottom-up approach (sectoral data – disaggregation of input data) – Tier 1-3**

Reference vs sectoral approach

- 1. Interface of the reference approach

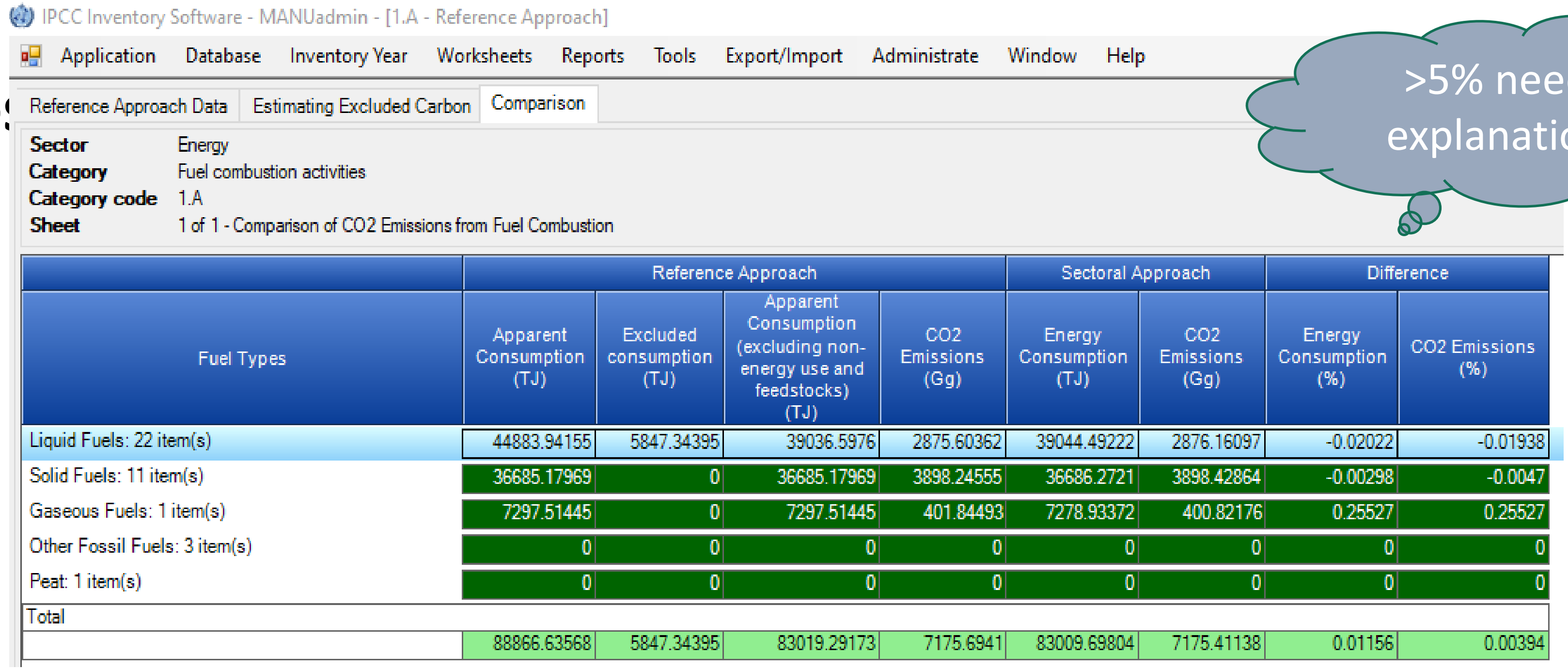


Fuel Types		Unit	A Production	B Imports	C Exports	D International Bunkers	E Stock chang	F Apparent Consumption	G Conversion Factor (TJ/Unit)	H Apparent Consumption (TJ)	I Carbon content (t C/TJ)	J Total Carbon (Gg C)	K Excluded Carbon (Gg C)	L Net Carbon Emissions (Gg C)	M Fraction of Carbon Oxidised	N Actual CO2 Emissions (Gg CO2)
			Step 1						Step 2		Step 3		Step 4		Step 5	
								F=A+B-C-D-E		H=F*G		J=H*I/1000	1)	L=J-K		N=L*M*44/12
Liquid Fuels: 22 item(s)										44883.94155		912.8971		784.25553		2875.60362
Primary Fuels	Crude Oil	Gg						0	42.3	0	20	0		0		0
	Orimulsion	Gg						0	27.5	0	21	0		0		0
	Natural Gas Liquids	Gg						0	44.2	0	17.5	0	0	0		0
Secondary Fuels	Motor Gasoline	Gg		107.064	3.111	0	0.21	103.743	44.32	4597.88976	18.9	86.90012		86.90012	1	318.63376
	Aviation Gasoline	Gg						0	44.3	0	19.1	0		0		0
	Jet Gasoline	Gg						0	44.3	0	19.1	0		0		0
	Jet Kerosene	Gg		28.301	12.503	15.323	0.475	0	43.401	0	19.5	0		0	1	0
	Other Kerosene	Gg						0	43.8	0	19.6	0	0	0		0
	Shale Oil	Gg						0	38.1	0	20	0		0		0
	Gas/Diesel Oil	Gg		653.56	38.829	0	11.795	602.936	42.95	25896.1012	20.209	523.33431	0	523.33431	1	1918.89247
	Residual Fuel Oil	Gg		97.461	4.836	0	1.715	90.91	40.1	3645.491	21.286	77.59792		77.59792	1	284.52571
	Liquefied Petroleum Gases	Gg		78.726	1.565		0.164	76.997	46.8	3603.4596	17.209	62.01194	0	62.01194	1	227.3771
	Ethane	Gg						0	46.4	0	16.8	0	0	0		0
	Naphtha	Gg						0	44.5	0	20	0	0	0		0
	Bitumen	Gg		151.723	1.904		0.614	149.205	39.19	5847.34395	22	128.64157	128.64157	0	1	0
	Lubricants	Gg						0	40.2	0	20	0	0	0		0
	Petroleum Coke	Gg		96.082	47.227		7.108	41.747	30.988	1293.65604	26.6	34.41125	0	34.41125	1	126.17459
	Refinery Feedstocks	Gg						0	43	0	20	0		0		0
	Refinery Gas	Gg						0	49.5	0	15.7	0	0	0		0
	Paraffin Waxes	Gg						0	40.2	0	20	0	0	0		0
	White Spirit and SBP	Gg						0	40.2	0	20	0	0	0		0
	Other Petroleum Products	Gg						0	40.2	0	20	0		0		0
Total										44883.94155		912.8971		784.25553		2875.60362

European Union (27 countries)	Total	Solid fossil fuels	Manufac-tured gases	Peat and peat products	Oil shale and oil sands	Oil and petroleum products	Natural gas	Renewables and biofuels	Non-renewable waste	Nuclear heat	Heat	Electricity
+ Primary production	634 751.4	116 090.5	Z	2 865.9	4 797.0	24 487.5	59 170.5	217 298.4	13 286.9	195 737.9	1 016.9	Z
+ Recovered & recycled products	1 747.5	650.9	Z	0.0	0.0	1 096.6	Z	0.0	Z	Z	Z	Z
+ Imports	1 350 483.5	104 696.4	0.0	77.6	0.0	865 222.2	329 615.4	18 373.1	472.4	Z	5.8	32 020.5
- Exports	464 688.8	12 946.5	0.0	8.6	0.0	347 630.4	59 394.1	13 410.5	37.0	Z	1.8	31 260.0
+ Change in stock	285.7	1 766.4	0.0	-575.9	-132.0	4 156.9	-4 748.5	-173.9	-7.3	Z	Z	Z
= Gross available energy	**1 522 579.4**	**210 257.7**	**0.0**	**2 359.0**	**4 665.0**	**547 332.7**	**324 643.3**	**222 087.2**	**13 715.0**	**195 737.9**	**1 020.8**	**760.5**
- International maritime bunkers	43 312.7	0.0	0.0	0.0	0.0	43 253.2	42.8	16.7	Z	Z	Z	Z

Reference vs sectoral approach

- **Combination of both methods – check for errors**
- **http**
-



IPCC Inventory Software - MANUadmin - [1.A - Reference Approach]

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

Reference Approach Data | Estimating Excluded Carbon | Comparison

Sector Energy
Category Fuel combustion activities
Category code 1.A
Sheet 1 of 1 - Comparison of CO_2 Emissions from Fuel Combustion

	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)	44883.94155	5847.34395	39036.5976	2875.60362	39044.49222	2876.16097	-0.02022	-0.01938
Solid Fuels: 11 item(s)	36685.17969	0	36685.17969	3898.24555	36686.2721	3898.42864	-0.00298	-0.0047
Gaseous Fuels: 1 item(s)	7297.51445	0	7297.51445	401.84493	7278.93372	400.82176	0.25527	0.25527
Other Fossil Fuels: 3 item(s)	0	0	0	0	0	0	0	0
Peat: 1 item(s)	0	0	0	0	0	0	0	0
Total								
	88866.63568	5847.34395	83019.29173	7175.6941	83009.69804	7175.41138	0.01156	0.00394

>5% need explanation

Reference vs sectoral approach

- **The reason for different GHG emission – different emission factors by sectors, refinery, losses, fugitive emissions etc.**

IPCC Inventory Software - MANUadmin - [1.A - Reference Approach]

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

Reference Approach Data | Estimating Excluded Carbon | Comparison

Sector Energy
Category Fuel combustion activities
Category code 1.A
Sheet 1 of 1 - Comparison of CO2 Emissions from Fuel Combustion

	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)	39086.03833	1452.94454	37633.09378	2791.0448	35535.70086	2607.2179	5.90221	7.05069
Solid Fuels: 11 item(s)	54216.08532	0	54216.08532	5730.56966	54215.70357	5730.55138	0.0007	0.00032
Gaseous Fuels: 1 item(s)	4022.27055	0	4022.27055	221.49035	3991.38325	219.78951	0.77385	0.77385
Other Fossil Fuels: 3 item(s)	0	0	0	0	0	0	0	0
Peat: 1 item(s)	0	0	0	0	0	0	0	0
Total								
	97324.3942	1452.94454	95871.44966	8743.10481	93742.78768	8557.55879	2.27075	2.16821

Reference vs sectoral approach

- Let’s make a short tour of the reference approach in the IPCC software

-
- Reference vs sectoral approach
- Key category analyses
- Uncertainty
- QA/QC

Key category analyses

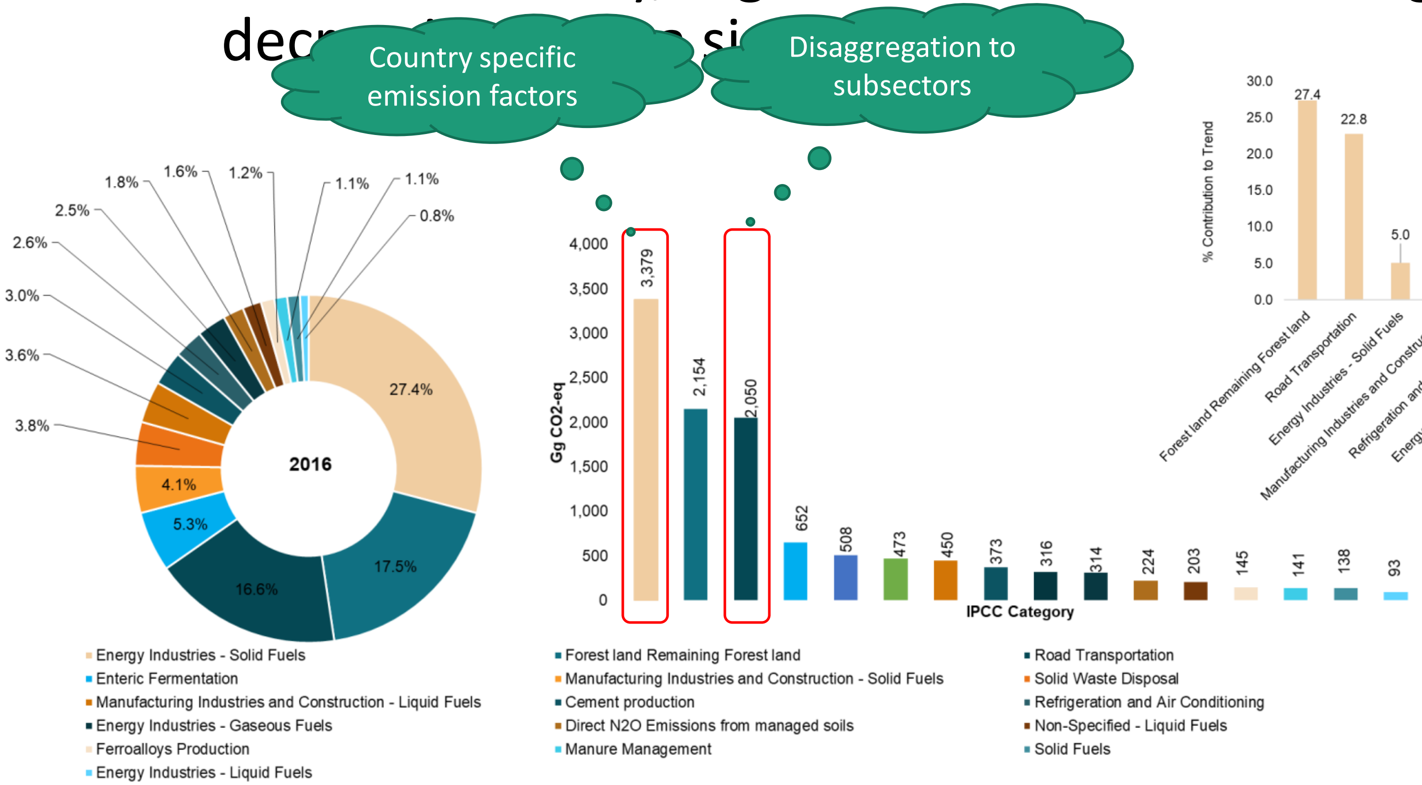
- Key categories – second tool in the IPCC software
- Why it is needed?

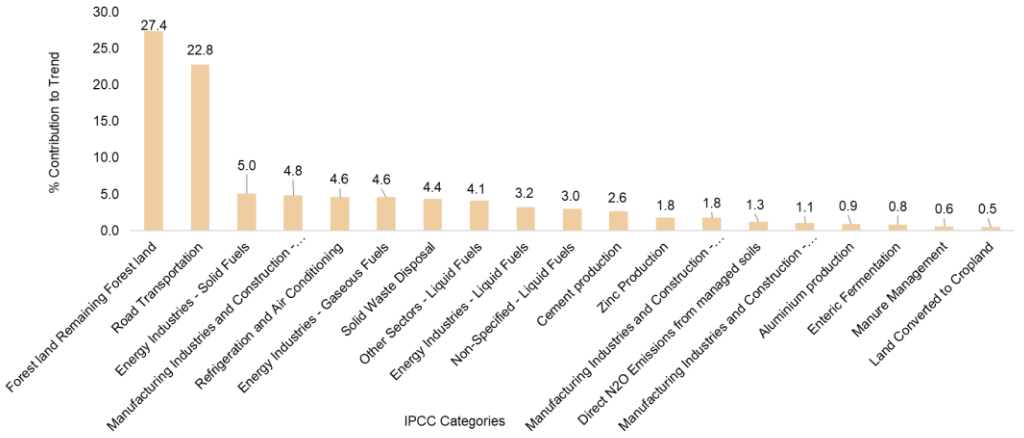
- To identified the categories with highest impact on the country GHG inventory.
- To allocate the country potential to the most important categories not on the categories with lowest impact.
- To implement higher Tier on the most important categories and improve the quality of the inventory

- You do not have a lot of resources for QA/QC? Make it only for the key categories

Key category analyses

- Two types
  - Absolute level
  - The trend (The purpose of this trend assessment is to emphasize the categories whose trend is significantly different from the trend of the overall inventory, regardless whether the category trend is increasing or dec… si…

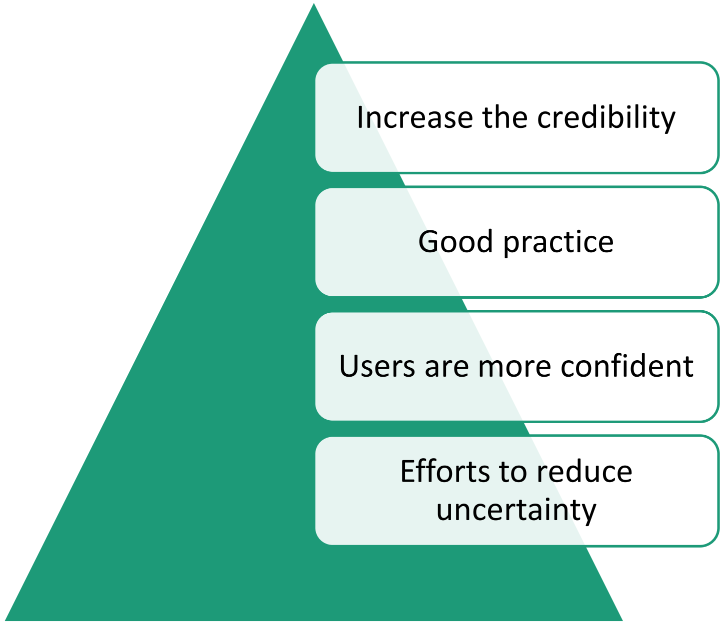


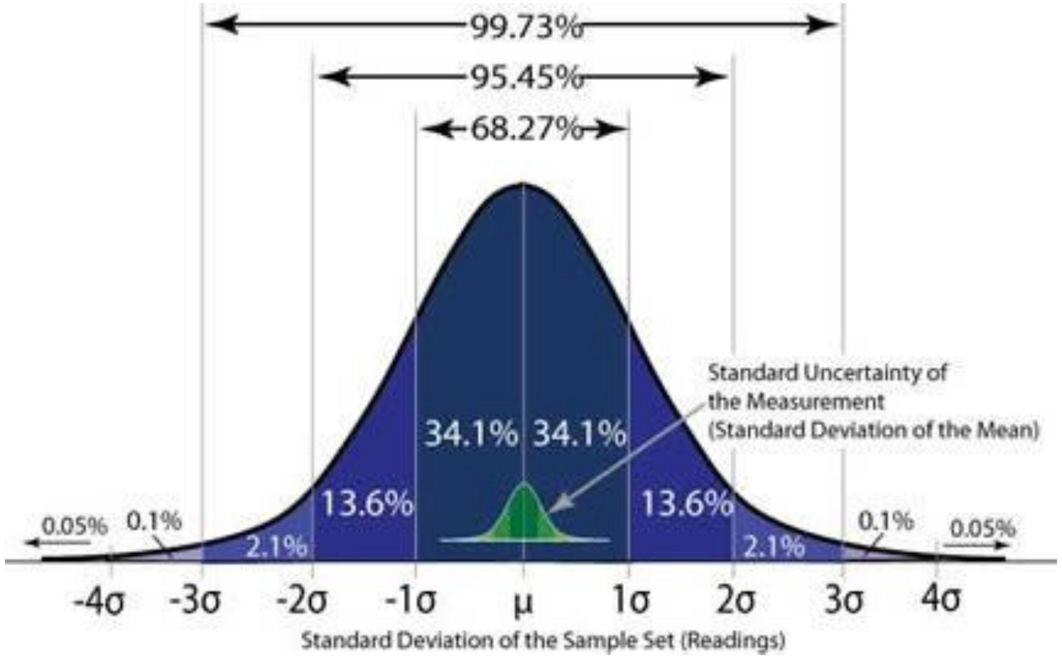


- Reference vs sectoral approach
- Key category analyses
- Uncertainty
- QA/QC

Uncertainty

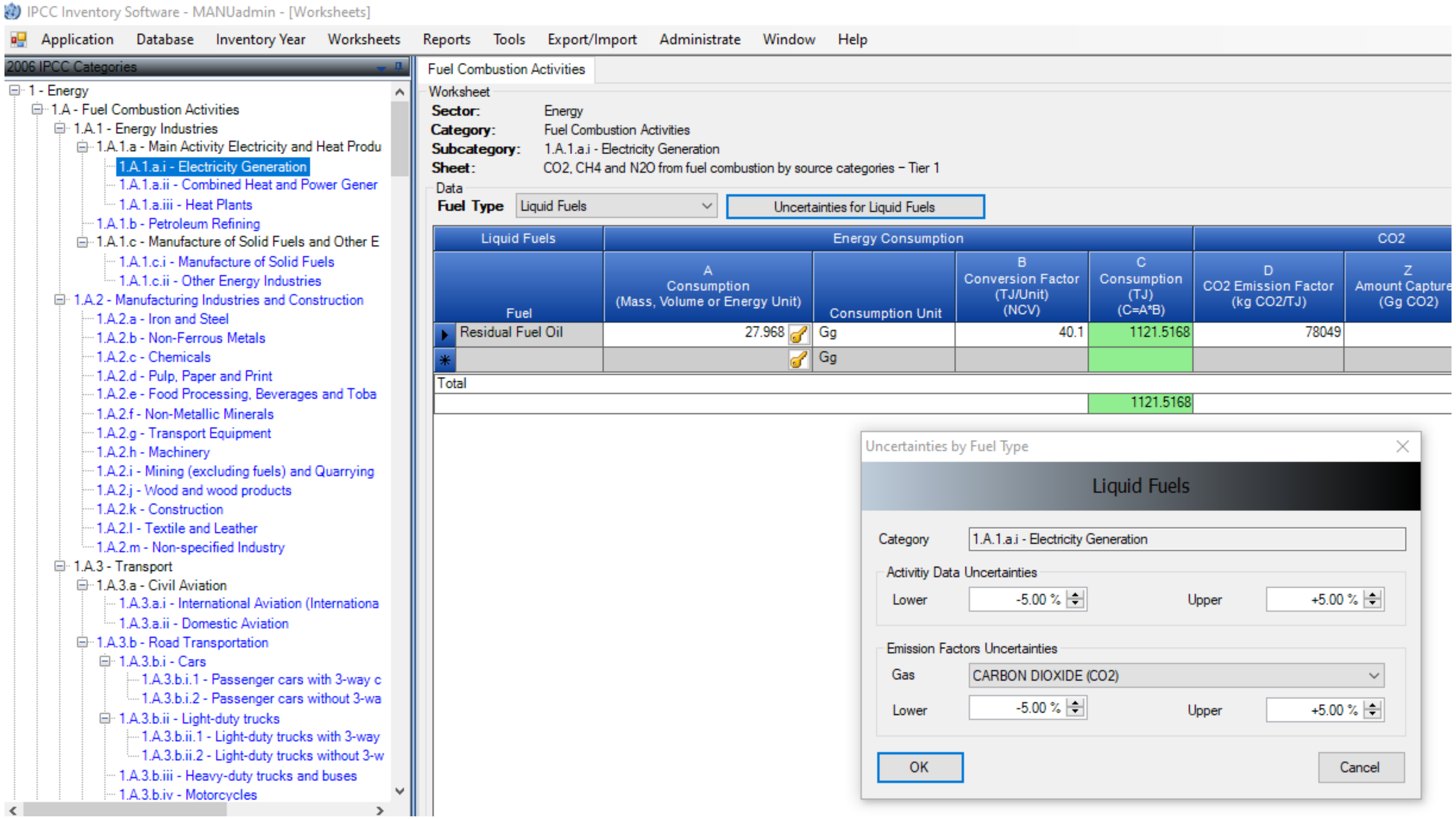
- In each analysis, the accuracy of input data is very important because they dictate the precision of the results.
- How many of us can say that we are 100% in the data that we are using in for GHG inventory creation?
- In most of the cases at least default emission factors are used





Uncertainty

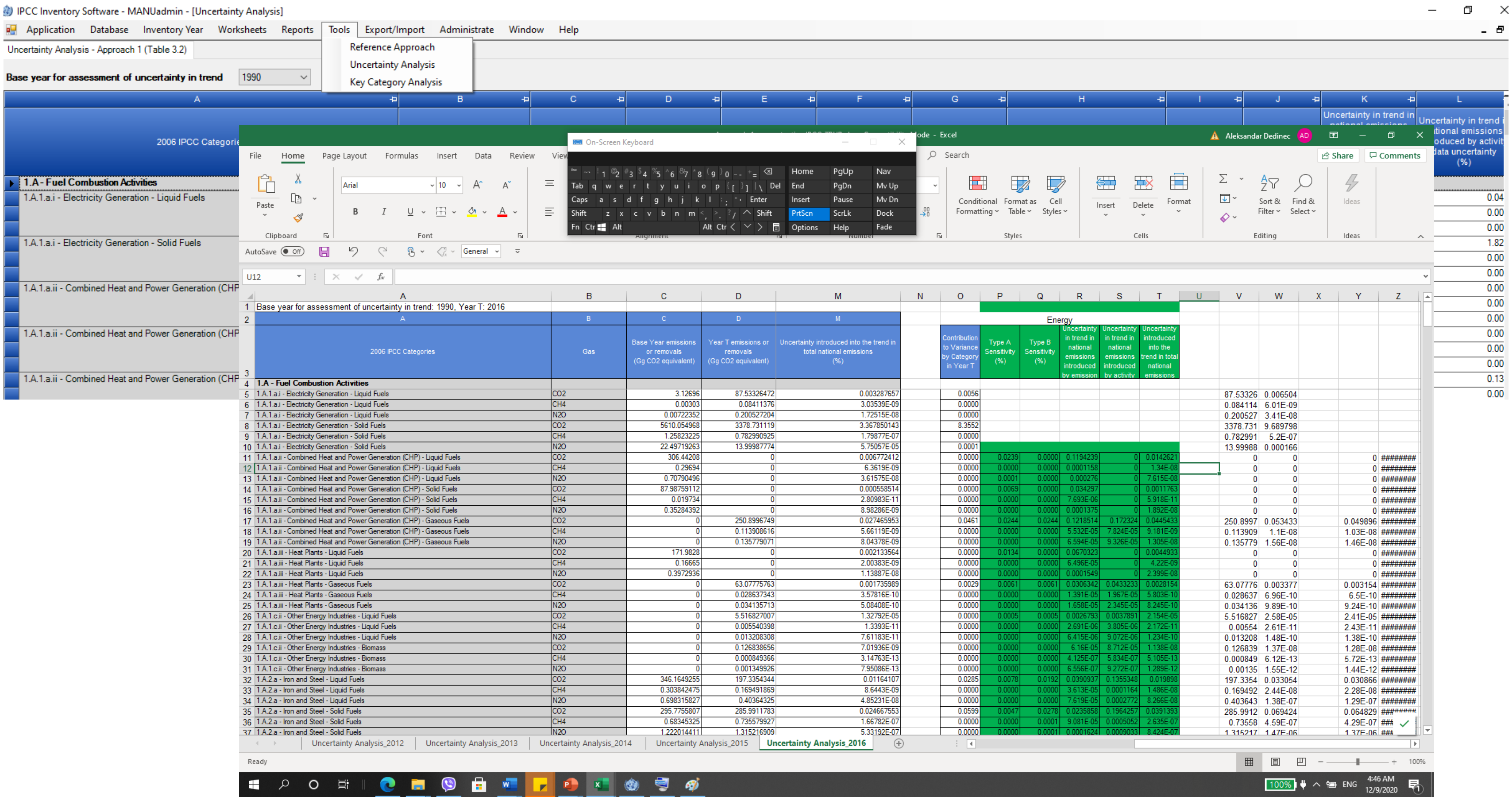
-
- First step – define the uncertainty for the activity data and emission factors.



Uncertainty

- Two basic approaches :
- Error Propagation - very easy, already implemented in the IPCC Inventory Software, calculates the uncertainty of the whole inventory for a given year, as well as uncertainty in trend between a year of interest and a base year.
- Monte Carlo - random values of the input variables are selected from within their probability density function and the corresponding output is calculated. This procedure is repeated many times or until the mean and the distribution of the output variables do not change. The input variables may include activity data, emission factors, conversion factors etc. and the output variable is the quantity of emissions.

Uncertainty

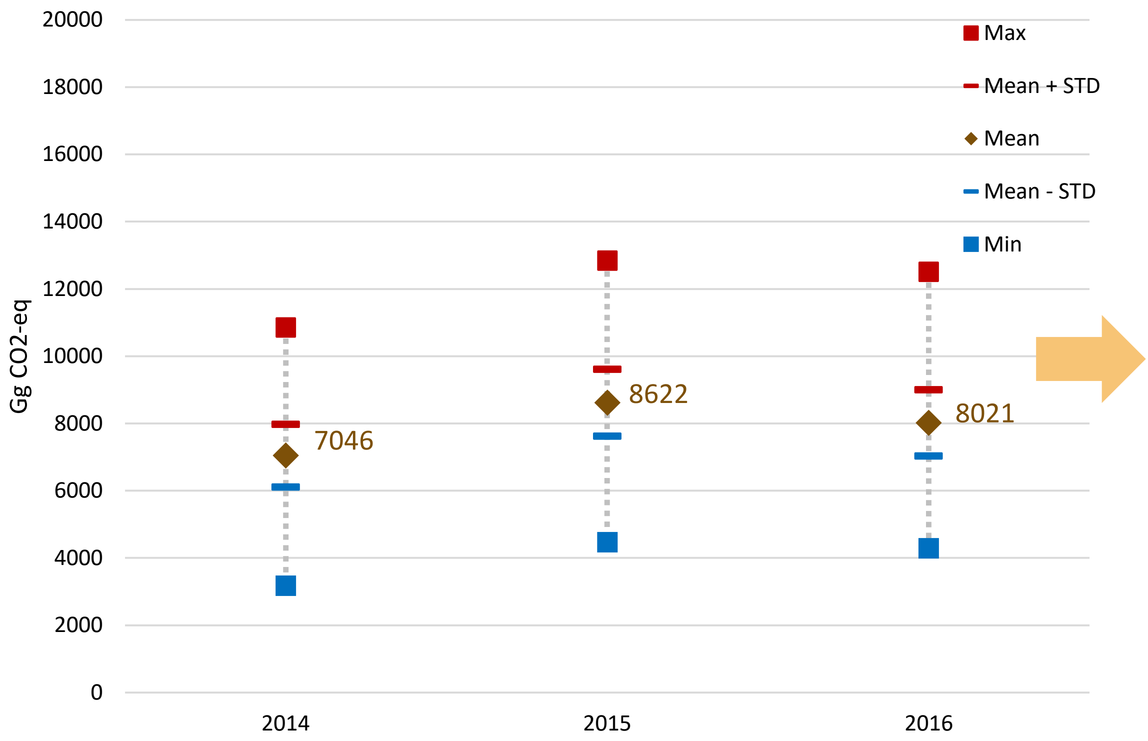


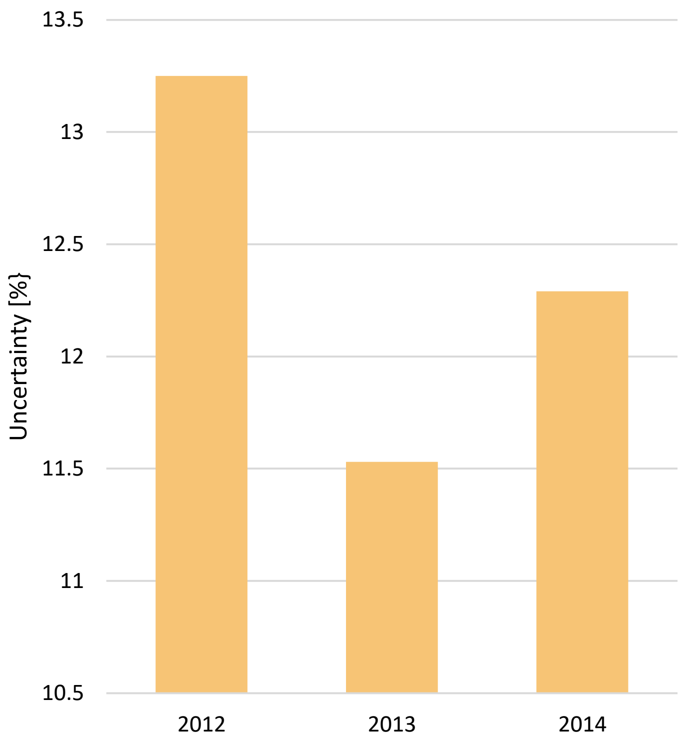
Uncertainty

Editor - C:\Users\akane\Google Drive\Trudovi\Kopaonik 2017\Uncertainty\w_4A_solid_waste.m

```matlab
function [total_emiss] = w_4A_solid_waste(worksheet_4A_msw, worksheet_4A_mcf_base, worksheet_4A_mcf, worksheet_4A_industrial, waste_parameters, year_in)

    worksheet_4A_msw.total_msw(isnan(worksheet_4A_msw.total_msw))=0;
    worksheet_4A_msw.garden(isnan(worksheet_4A_msw.garden))=0;

    docf=waste_parameters.doc_fraction;
    ch4_f=waste_parameters.ch4_fraction;
    delay_time=waste_parameters.delay_time;

        worksheet_4A_mcf.weight_mfc=(worksheet_4A_mcf.swds1_dist.*worksheet_4A_mcf_base.swds1_mcf(1)+...
        worksheet_4A_mcf.swds2_dist.*worksheet_4A_mcf_base.swds2_mcf(1)+...
        worksheet_4A_mcf.swds3_dist.*worksheet_4A_mcf_base.swds3_mcf(1)+...
        worksheet_4A_mcf.swds4_dist.*worksheet_4A_mcf_base.swds4_mcf(1)+...
        worksheet_4A_mcf.swds5_dist.*worksheet_4A_mcf_base.swds5_mcf(1))./100;

    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    %% Paper

    doc_paper=waste_parameters.doc_paper;
    k_paper=waste_parameters.mgr_paper;
    M_paper=15;

    half_time_paper=log(2)/k_paper;
    exp1_paper=exp(-k_paper);
    %exp2_paper=exp(-k_paper*((13-M_paper)/12));
    exp2_paper=1;

    %worksheet_4A_msw.paper_results=worksheet_4A_msw.population.*worksheet_4A_msw.waste_per_capita.*(worksheet_4A_msw.perc_to_swds./100).*(worksheet_4A_msw.paper./100);
    W_paper=worksheet_4A_msw.population.*worksheet_4A_msw.waste_per_capita.*(worksheet_4A_msw.perc_to_swds./100).*(worksheet_4A_msw.paper./100);

    w_paper_times_mcf=zeros(size(worksheet_4A_msw.record_id));
    for i=1:length(worksheet_4A_msw.record_id)
       w_paper_times_mcf(i,1)=W_paper(i,1).*worksheet_4A_mcf.weight_mfc(find(worksheet_4A_mcf.w_year==worksheet_4A_msw.w_year(i) & worksheet_4A_mcf.w_composition_type_id==1));
    end

    d_paper=w_paper_times_mcf.*doc_paper.*docf;

    b_paper=d_paper.*exp2_paper;

    c_paper=d_paper.*(1-exp2_paper);

    worksheet_4A_msw.H_paper(find(worksheet_4A_msw.w_year==1950),1)=b_paper(find(worksheet_4A_msw.w_year==1950));

    for year=1951:max(worksheet_4A_msw.w_year)
        ind=find(worksheet_4A_msw.w_year==year);
```

Uncertainty



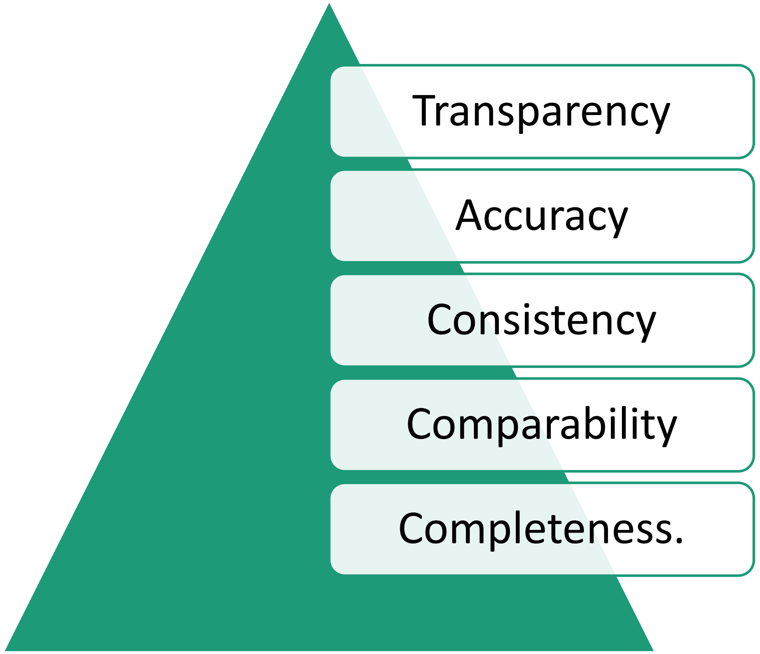


- Reference vs sectoral approach
- Key category analyses
- Uncertainty
- QA/QC

QA/QC

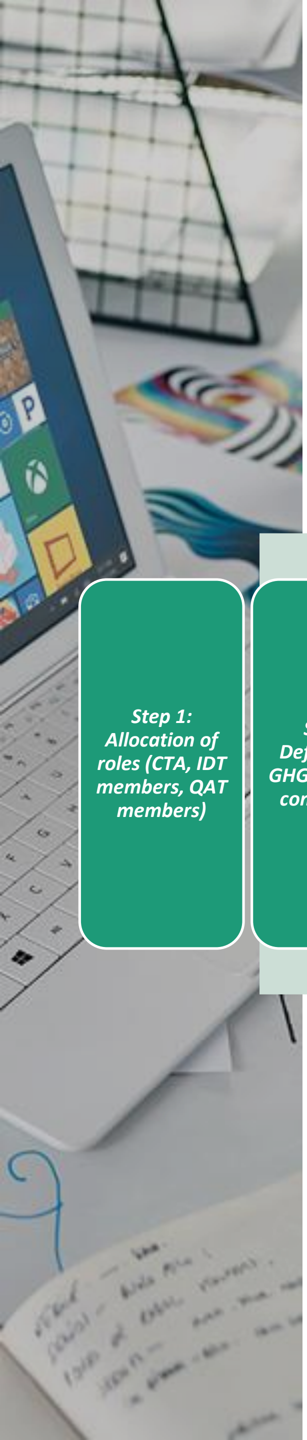
- Why? Who?
- QA/QC – Person not directly involved in the GHG sectoral emissions development

- https://www.mentimeter.com/s/243e42749edf8ff54167e7000dee2aa3/d769ddc2e8d1/editQC



QA/QC

Data Type	QA Activity	Remarks / Comments / Examples
Activity Data Check	Check for transcription, typographical error and error transposition.	Compare the national data source with the inventory data contained in the IPCC Inventory Software
	Compare with official published data	Compare the national energy related data (the data of the Energy balances published by the SSO and the data published by ESM), the annual data on industrial production (published by SSO) and the national waste related data (the Waste related data published by the SSO and the Regional Waste studies published by MOEPP) with the AD contained in the IPCC Inventory Software
	Identify and fix outliers in data inputs (including checking the inclines and spikes in the trend)	Data which don’t fall under the realistic range and are suspected as inaccurate are assessed and if necessary are removed and replaced with data from international sources or derived from expert judgment
	Compare with other international data	Compare the Energy related data with the data published by the IEA
	Check the documentation of all sources, data format and assumptions for easy reference	Keeping records on the data source and assumptions used in each data sheet of the IPCC Inventory Software.
	Assure if the Party is able to provide an overview of the overall waste generation and treatment in the country	Assure that an overview of waste generation and treatment is provided and AD on all types of solid waste been collected (MSW, sludge, industrial and other waste)
	Ensure that the AD are provided in the appropriate units	Check the background table for each category and ensure the consistency and the accuracy of the AD units
	Check if the activity data for estimating of the GHG emissions are equal for the activity data used to estimate the emissions of precursors and indirect emissions	Export the activity data from each worksheet in the IPCC 2006 database and compare with the AD provided in the tables for estimation of the emissions of precursors and indirect emissions
Emission factors	Check the implied emission factors (time series)	Ensure consistency check of the use of the EF
	Double check in regards to the country specific EF published in the EFDB and compare with the EF of the other countries	Ensure that the country specific EF in use are in the ranges provided by the IPCC guidelines
	Check if the EFs used for estimation of the emissions of precursors and indirect emissions are consistent, comparable and transparently documented	Check if the EFs used for estimation of the emissions of precursors and indirect emissions are in line with the EMEP/CORINAIR Emission Inventory Guidebook. In case CS EFs are used, check the background materials, the estimation methodology, the EF range and the comparability with other national reports
Calculation by the IPCC Inventory Software	Cross check all steps involved in the calculation	Ensure that all steps used for determining, estimating and deriving data are accurate, transparent and internally consistent
	Check the documentation of sources and correct use of units	Check if the documentation template records are appropriately fulfilled
	Check completeness of the data coverage	Ensuring that all relevant gases for all the activities were covered
	Check if the excluded other non-energy use of fuels from activity data in energy sector is reported under the IPPU sector (in case emissions occurs from these non-energy uses)	Ensuring that the excluded from the Energy sector is accounted in the sector IPPU
Results (emissions)	Check the differences between the recalculated estimates and verify if proper justifications for the recalculated estimates are provided	Identification of changes, revisions and reallocations in order to improve accuracy and the transparency of the emission estimates
	Identify and fix outliers in the results	Checking for inconsistency of the emission trends and levels
	Check the difference between the sectorial and the reference approach in the Energy Sector	Ensure consistency between the emission estimates and the allocation of carbon in the sectoral and in the reference approach
	Check the completeness, use of notation keys and confidential information	Check if complete estimates are provided and if notation keys are used where no estimates are provided
	Creativeness of the use of the notation keys	Check if the appropriate notation keys are in use
Documentation	Verify the assumptions, corrections, data and sources	Ensure consistency, transparency, facilitate repeatability and easy retrieval
	Check the improvement list, recommendations and encouragements provided (internal and external)	Check if the recommendations and the encouragements of the technical assessments / reviews have been taken into consideration and implemented



QA/QC

- The process in a nutshell (MK good practice)

1. *Step 1: Allocation of roles (CTA, IDT members, QAT members)*
2. *Step 2: Defining the GHG Inventory components*
3. *Step 3: Activity data collection*
4. *Step 4: Data input, documenting and calculating of emissions (Tier 1 QC procedures undertaken in parallel)*
5. *Step 5: QA at sectoral level*
6. *Step 6: Compilation of overall inventory*
7. *Step 7: QA of overall inventory summary*
8. *Step 8: Conduct key category analyses*
9. *Step 9: Uncertainty management (as decided)*
10. *Step 10: QA of key sources analysis and uncertainty management*
11. *Step 11: Drafting the sectoral chapters of NIR*
12. *Step 12: Draft summary inventory chapter*
13. *Step 13: QA of NIR*
14. *Step 14: Reporting*

Step 2:

- Input data collecting mechanisms
- Time series
- Emission factors (National/IPCC defaults)
- Methodologies for emission calculation

Thank you for your attention

Questions?