United Nations
Climate Change

UNFCCC BTR REVIEW TRAINING: COURSE B

TECHNICAL REVIEW OF NATIONAL INVENTORY REPORTS OF ANTHROPOGENIC EMISSIONS BY SOURCES AND REMOVALS BY SINKS OF GHG

SUB COURSE B2: ENERGY SECTOR

FIRST EDITION
September 2023

GHG Inventory Review Training Course

Energy Sector

United Nations Framework Convention on Climate Change

Abbreviations and acronyms

2006 IPCC Guidelines	2006 IPCC Guidelines for National Greenhouse Gas Inventories
2019 Refinement to the 2006 IPCC Guidelines	2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories
AD	activity data
C	carbon
CCS	carbon dioxide capture and storage
CEM	continuous emission monitoring
CH_4	methane
CNG	compressed natural gas
CO	carbon monoxide
CO_2	carbon dioxide
CRT	common reporting table
ECBM	enhanced coal bed methane
EEA	European Environment Agency
EF	emission factor
EGR	enhanced gas recovery
EMEP	European Monitoring and Evaluation Programme (Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe)
EOR	enhanced oil recovery
ETF	enhanced transparency framework under the Paris Agreement
EU ETS	European Union Emissions Trading System
GHG	greenhouse gas
HDT	heavy-duty trucks
HFC	hydrofluorocarbon
IE	included elsewhere
IEF	implied emission factor
IPCC	Intergovernmental Panel on Climate Change
IPPU	industrial processes and product use
LDT	light-duty trucks
LNG	liquefied natural gas
LPG	liquefied petroleum gas
LTO	landing and take-off
LULUCF	land use, land-use change and forestry
MPGs	modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement, set out in the annex to decision 18/CMA.1
N_2O	nitrous oxide
NA	not applicable
NCV	net calorific value
NE	not estimated
NF_3	nitrogen trifluoride

NID	national inventory document
NMVOC	non-methane volatile organic compound
NO	not occurring
NO_X	nitrogen oxides
PFC	perfluorocarbon
QA/QC	quality assurance/quality control
SF_6	sulfur hexafluoride
SO_X	sulfur oxides
TCCCA	transparency, completeness, consistency, comparability and accuracy
TERR	technical expert review report
TERT	technical expert review team
VKT	vehicle kilometres travelled

Table of Contents

List of Figures

Lesson 1. Introduction

1. Overview

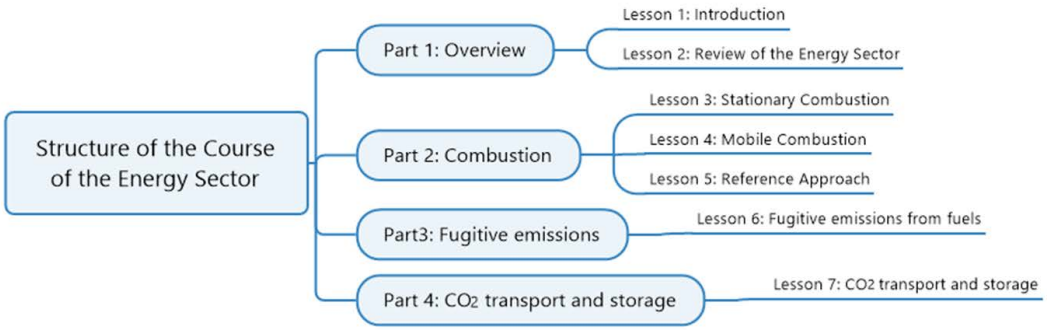
The course covers the technical review of the energy sector in the national GHG inventory. For inventory purposes, the energy sector is organized as three broad categories:

- Fuel combustion activities (category 1.A);
- Fugitive emissions from fuels (category 1.B);
- CO_2 transport and storage (category 1.C).

1.1. Course coverage

The course contains seven lessons, each of which has four parts reflecting the structure of the sector, as shown in the figure 1.1 below.

A. Figure 1.1 Structure of the course



1.2. Learning objectives

This lesson provides information on the basic background documentation for the review of the energy sector emission estimates and provides an initial quiz that will enable you to test your knowledge of the 2006 IPCC Guidelines.

1.3. Expected time needed to complete lesson 1

- For trainee reviewers with experience in compilation of energy sector GHG emission inventories: 30–45 minutes
- For trainee reviewers with less experience in compilation of energy sector GHG emission inventories: 60–80 minutes

2. Documentation

2.1. Reference documentation related to the enhanced transparency framework under the Paris Agreement

The main guidance and overarching principles related to the technical expert review of national GHG inventories according to the MPGs set out in the annex to decision 18/CMA.1 are discussed in the "Overview and cross-cutting" course (lesson 1, topic 2, and lesson 2, topic 3) (decision 18/CMA.1 is available at https://unfccc.int/documents/193408).
Annex I to decision 5/CMA.3 contains the set of CRTs (the tables are available at https://unfccc.int/documents/311076).
In the course you will learn more about reporting on the energy sector in the NID, the outline of which is contained in annex V to decision 5/CMA.3 (https://unfccc.int/documents/460951).

2.2. Methodological background

The relatively compact volume 2 of the 2006 IPCC Guidelines covers specific methodological guidance for the compilation of a GHG inventory of the energy sector. General cross-cutting issues on data collection, methodological choice, time-series consistency and QA/QC are covered in volume 1 of the 2006 IPCC Guidelines and are considered in the "Overview and cross-cutting" course.

Note that where there is inconsistent guidance between the 2006 IPCC Guidelines and the MPGs (including CRTs), the guidance in the MPGs is to be followed.

Three broad categories of the energy sector are covered in the 2006 IPCC Guidelines:

- Category 1.A: stationary combustion (chapter 2); mobile combustion (chapter 3) and the reference approach (chapter 6);
- Category 1.B: fugitive emissions (chapter 4);
- Category 1.C: CO_2 transport, injection and geological storage (chapter 5).

In addition, the introduction (chapter 1) of volume 2 delineates the organization of the energy sector, providing a clear definition of the categories and subcategories and their coverage regarding activities. It also contains definitions, default NCVs and default carbon contents for all fuels, and specific guidance on cross-cutting issues for the energy sector.

If you do not have volume 1 and volume 2 of the 2006 IPCC Guidelines, you can download them from these links:
Volume 1: www.ipcc-nggip.iges.or.jp/public/2006gl/vol1.html
Volume 2: www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html
During the course, the 2006 IPCC Guidelines are referred to many times – have them handy all the time and consult them as necessary.

In addition to the originally published English version of the 2006 IPCC Guidelines, there are five other language versions (Arabic, Chinese, French, Russian and Spanish). However, corrections to the 2006 IPCC Guidelines

(corrigenda) are only made by the IPCC in the English online version, hence you are recommended to consult the English version when drawing any final conclusions during your assessments of GHG inventory information. Because the corrections are made from time to time, you must have access to the latest version of the 2006 IPCC Guidelines to ensure that you reflect all corrigenda since 2007.

Technical knowledge of methodologies in the 2006 IPCC Guidelines is a prerequisite to taking part in the "Overview and cross-cutting" course and this course on the energy sector. These courses have been devised for technical experts of national GHG inventories who would like to become expert reviewers under the ETF. Therefore, this course does not replace the need to be experienced with methods and guidance reported as good practice in the 2006 IPCC Guidelines. Experience in compiling the energy sector inventory of a national GHG inventory is certainly an asset.

3. Initial quiz

This initial quiz tests your knowledge of the 2006 IPCC Guidelines. If you feel you are not experienced enough with them but are still interested in becoming an expert reviewer, you will need to make an extra effort to study the methodological guidance in the 2006 IPCC Guidelines for the energy sector and relevant materials in volume 1 of these guidelines, in addition to studying this course.
Answer each question by selecting only one of the options. The correct answer and the corresponding explanation can be found at the end of this section. For further information, a reference to the corresponding section(s) of the 2006 IPCC Guidelines is also provided.

3.1. Questions

1. Volume 2 of the 2006 IPCC Guidelines provides methodologies for estimating the emissions from the energy sector of the gas(es):
   - A. CO_2 only
   - B. CO_2, CH_4 and N_2O
   - C. CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3
   - D. CO_2, CH_4, N_2O, CO, NO_x, NMVOC and SO_x
   - E. None of the above

2. Which is the most important factor determining the amount of CO_2 emissions from fuel combustion?
   - A. Combustion characteristics, such as technology type and the size of equipment, vintage of the combustion technology, and maintenance of the equipment
   - B. Carbon content of the fuel
   - C. Pollution control equipment
   - D. None of the above

3. The 2006 IPCC Guidelines provide three methodological tiers for estimating emissions from fuel combustion, which can be summarized as follows:
   - A. The three tiers are based on national energy statistics and differ in the EFs used

B. Strictly, tier1 and tier 2 are fuel-based approaches and the main difference is in the EFs used
C. Tier 3 methods are based on detailed emission models or measurements and data at the individual plant level
D. B and C

4. For stationary combustion, the 2006 IPCC Guidelines provide the following tier 1 default EFs:
   A. Category-specific EFs for CH_4 and N_2O for each fuel
   B. Category-specific CO_2, CH_4 and N_2O EFs for the different stationary combustion technologies and typical fuels used under each category
   C. For each fuel, the same CO_2 EF is indicated for all stationary combustion categories
   D. A and C

5. Emissions from electricity self-production (i.e. autoproduction) by a steel production plant should be allocated to the "public electricity and heat production" category.
   True
   False

6. When should Parties use the reference approach?
   A. As an alternative to the sectoral approach to estimate and report CO_2, CH_4 and N_2O emissions from fuel combustion activities
   B. As an alternative to the sectoral approach to estimate and report CO_2 emissions from fuel combustion activities and fugitive emissions from fuels
   C. As the preferred method to estimate and report CO_2 emissions from fuel combustion activities
   D. None of the above

7. Since the aim of the reference approach is to provide an estimate of CO_2 emissions from fuel combustion, the algorithm excludes the amount of carbon that does not lead to fuel combustion emissions from the total carbon input into the country's productive system. Excluded carbon from fuel combustion comprises:
   A. The carbon emitted in a sector of the inventory other than the energy sector
   B. The carbon stored in a product manufactured from the fuel
   C. A and B

8. How should emissions from the combustion of municipal solid waste in waste incinerators and in combustors that recover useful thermal energy be reported?
   I. All non-CO_2 and CO_2 emissions from fossil carbon should be reported under the energy sector
   II. All non-CO_2 and CO_2 emissions from fossil carbon should be reported under the waste sector
   III. CO_2 emissions from biogenic carbon should be reported as a memo item
   IV. CO_2 emissions from fossil carbon should be reported under the energy sector and CO_2 emissions from biogenic carbon under the waste sector
   A. Both II and III
   B. Both I and IV
   C. Both I and III

D. Both II and IV

9. The 2006 IPCC Guidelines provide a three-tiered approach to estimating GHG emissions from road transportation. The tier 1 and tier 2 approaches are fuel-based while the tier 3 approach is based on vehicle activity level (e.g. VKT). It is good practice to estimate all emissions from road transportation using a VKT approach.
   True
   False

10. Emissions from fuel combustion in off-road vehicles and mobile machinery are reported under several subcategories of the energy sector.
   True
   False

11. Emissions from international bunker fuels:
   A. Should not be calculated because they cannot be precisely allocated to a particular Party
   B. Should be calculated and added to the national total emission estimates
   C. Should be calculated but should not be added to the national total emission estimates – they should be reported separately as memo item
   D. None of the above

12. The main GHG emission sources for both underground and surface coal mines are (1) mining, (2) post-mining activities, (3) low-temperature oxidation and (4) uncontrolled combustion. CH_4 may be also emitted from abandoned coal mines. The 2006 IPCC Guidelines provide methodologies for estimating emissions from the following emission sources under coal mining and handling:
   A. Abandoned underground mines
   B. Abandoned underground and surface mines
   C. Mining and post-mining activities for both underground and surface coal mines
   D. All emitting sources cited for both underground and surface coal mines
   E. A and C

13. Fugitive emissions from oil and natural gas comprise only unintentional releases to the atmosphere that occur during the different activities of the oil and gas industry and that do not originate from fuel burning.
   True
   False

14. The 2006 IPCC Guidelines provide only a tier 3 methodology for estimating emissions from CO_2 injection and geological storage under CCS activities.
   True
   False

3.2. Answer key

1. **The correct answer is B**. Volume 2 of the 2006 IPCC Guidelines concentrates on emission estimates of direct GHG gases (CO_2, CH_4 and N_2O), which are emitted by energy systems.

Although paragraph 51 of the MPGs indicates that each Party should provide information on CO, NO_X, NMVOCs and SO_X, the 2006 IPCC Guidelines do not cover these gases. Chapter 7 of volume 1 of the 2006 IPCC Guidelines refers the reader to the relevant methodology chapters in the *EMEP/EEA air pollutant emission inventory guidebook* for these precursor gases (the most recent version of the guidebook is available at https://www.eea.europa.eu/themes/air/air-pollution-sources-1/emep-eea-air-pollutant-emission-inventory-guidebook/emep).

To learn more about the relationship between the 2006 IPCC Guidelines and inventory approaches to estimating precursor gases, see section 1.3.1.3 of the Guidelines (vol. 2, chap. 1).

Fluorinated gases (HFCs, PFCs, SF_6 and NF_3) are estimated only for activities occurring under the IPPU sector and are therefore not addressed in volume 2 of the 2006 IPCC Guidelines.

2. **The correct answer is B**. CO_2 emissions from fuel combustion primarily depend on the carbon content of the fuel given that during combustion, most carbon is immediately emitted as CO_2. Although a small fraction of the carbon in the fuel is emitted as non-CO_2 gases (CH_4, CO and NMVOCs), for inventory purposes, the carbon in these gases is integrated into the overall calculation of CO_2 emissions, intentionally double counting the carbon in the non-CO_2 gases.

To learn more about emissions from fuel combustion, see section 1.3.1 (p.1.6) of the 2006 IPCC Guidelines (vol. 2, chap. 1,).

3. **The correct answer is D**. The tier 1 methodology is fuel-based, and emissions are estimated using fuel combustion data that usually come from national energy statistics and default EFs. The 2006 IPCC Guidelines provide tier 1 default EFs for CO_2, CH_4 and N_2O for all relevant fuels included in the Guidelines.

The tier 2 methodology is also fuel-based, and emissions are estimated using fuel statistics as in the tier 1 methodology, but the EFs used are country-specific rather than default values.

Tier 3 methods are not fuel-based. Detailed emission models or measurements and data at the individual plant level are used to estimate emissions from fuel combustion under stationary or mobile sources. Note that although these methods do not use fuel statistics as AD, the estimates of modelled or plant-specific fuel consumption must be reconciled with the consumption data reported in the national energy statistics.

To learn more about the IPCC tiered approach to estimating emissions from fuel combustion, see section 1.3.1.1 (pp.1.6–1.9) of the 2006 IPCC Guidelines (vol. 2, chap. 1).

4. **The correct answer is D**. CO_2 emission estimates are based on the carbon content of the fuel and for the default EFs, the oxidation factor is taken as equal to 1. Therefore, the CO_2 default EF for each fuel is the same across all categories. In contrast, CH_4 and N_2O emissions depend on the combustion technologies used and therefore the tier 1 default CH_4 and N_2O EFs are specific to different stationary combustion categories, representing on average the main combustion technologies for each category.

To learn more about the IPCC default EFs for stationary combustion categories, see section 2.3.2.1 (pp.2.14–2.23) of the 2006 IPCC Guidelines (vol. 2, chap. 2).

5. **The correct answer is 'False'**. Autoproduction of electricity and/or heat occurs when an industrial facility, for supporting its primary activity, generates electricity and/or heat for its own use or for sale, but not as its main business. The 2006 IPCC Guidelines attribute emissions from autoproduction to the industrial or commercial branches in which the generation of electricity and/or heat occurred, rather than to public electricity and heat production (subcategory 1.A.1.a). In this case, associated emissions from electricity generation at the steel production plant should be reported under iron and steel (subcategory 1.A.2.a).

However, the most important issue here is not allocation of emissions, but completeness and transparency of reporting. In cases where a clear separation between autoproducers and main activity producers of electricity, combined heat and power plants, or heat plants is not clear, emissions from all facilities should be accounted for under the most appropriate category in a complete manner. Further, the Party's allocation should be transparently described in the NID.

To learn more about the allocation of emissions from electricity and heat production, see the definitions of subcategory 1.A.1.a electricity and heat production (main activity) and category 1.A.2 manufacturing industries and construction in table 2.1 (pp.2.7–2.10) of the 2006 IPCC Guidelines (vol. 2, section 2.2). Also, box 2.1 in section 2.2 (p.2.11) contains information on autoproducers.

6. **The correct answer is D**. The IPCC reference approach is a top-down approach used to estimate emissions of CO_2 from combustion activities on the basis of energy supply statistics and key physical properties of the fuels, namely calorific value and carbon content. Because of its formulation, fugitive emissions cannot be estimated by the reference approach. And because non-CO_2 emissions are technology-dependent, they cannot be estimated using such a simple approach that only considers the physical properties of the fuels.

According to the MPGs (para. 36), each Party should compare the national estimates of CO_2 emissions from fuel combustion with those obtained using the reference approach, as contained in the 2006 IPCC Guidelines, and report the results of this comparison in its national inventory report.

Lesson 5 of this energy sector course covers the reference approach. To learn more about it, see the 2006 IPCC Guidelines (vol. 2, chap. 6).

7. **The correct answer is C**. Excluded carbon is either emitted in another sector of the inventory (typically the IPPU sector) or stored in a product. The amount of carbon in fuels used as feedstock, reductant or non-energy products serves as input data for the calculation of excluded carbon by the reference approach and as key information to avoid double counting or omission of emissions estimated by the sectoral approach.

To learn more about excluded carbon, see section 6.6 (pp.6.7–6.10) of the 2006 IPCC Guidelines (vol. 2, chap. 6).

8. **The correct answer is C**. When waste is incinerated without any energy recovery, emissions should be reported under the waste sector. When energy is recovered at waste combustion facilities, emissions should be reported under the energy sector. In this case, the total non-CO_2 emissions from the combustion of both the fossil and biogenic carbon in waste materials should be considered and reported. Only CO_2 emissions resulting from the incineration of fossil carbon in waste (e.g. plastics, synthetic textiles, synthetic rubber and waste oil) should be included in the energy sector and consequently in national total emissions. CO_2 emissions from the combustion of any biogenic carbon in waste (e.g. paper, food waste and wooden materials) should be reported as a memo item under CO_2 emissions from biomass under the energy sector. The memo items are not included in national total emissions.

Learn more in the 2006 IPCC Guidelines (vol. 2) about:

- The allocation of emissions between the energy and waste sectors, as well as the linkages of the energy sector with other inventory sectors (section 2.3.3.3 (pp.2.32–2.33))
- The allocation of CO_2 and non-CO_2 emissions from biomass combustion for energy purposes (section 2.3.3.4 (pp.2.33–2.34)).

9. **The correct answer is 'False'**. Considering the almost exclusive dependence on carbon content of fuels for CO_2 emissions from fuel combustion and the technology dependence of the associated non-CO_2 emissions, the 2006 IPCC Guidelines indicate that CO_2 emissions are best estimated using a fuel-based approach while the VKT approach is appropriate for estimating non-CO_2 emissions.

To learn more about the methodological approaches to estimating GHG emissions from road transportation, see section 3.2.1 (pp.3.10–3.16) of the 2006 IPCC Guidelines (vol. 2, chap. 3).

10. **The correct answer is 'True'**. The IPCC mobile combustion subcategory off-road (1.A.3.e.ii) includes off-road emissions from ground activities in airports and harbours and other off-road activities not otherwise reported under agriculture (1.A.4.c) or manufacturing industries and construction (1.A.2). Emissions arising from off-road and other mobile machinery in industry should, if possible, be considered as a separate subcategory under 1.A.2. Emissions from fuels combusted in traction vehicles on farmland and in forests are reported under subcategory 1.A.4.c.ii off-road vehicles and other machinery.

To learn more about off-road transportation, see section 3.3 of the 2006 IPCC Guidelines (vol. 2, chap. 3) and for the definitions of the above-mentioned subcategories, see table 2.1 (pp.2.8–2.9) and table 3.1.1 (p.3.9) in the Guidelines.

11. **The correct answer is C**. GHG emissions from fuel use in ships or aircraft for international transport should not be included in the national totals. They should be reported separately as a memo item.

To learn more about the allocation of emissions from international civil aviation and international waterborne navigation, consult table 3.1.1 (pp.3.8–3.10) of the 2006 IPCC Guidelines (vol. 2, chap. 3). You may also wish to review the criteria for differentiating between domestic and international journeys in table 3.5.4 (p.3.51) for waterborne navigation and table 3.6.6 (p.3.65) for aviation of the 2006 IPCC Guidelines (vol. 2, chap. 3).

12. **The correct answer is E**. The 2006 IPCC Guidelines contain guidance on estimating CH_4 emissions from mining and post-mining activities for underground and surface coal mines. For abandoned mines, only a methodology for underground mines is provided. The other potential emitting sources are not covered.

To learn more about the gaps in methodologies relating to estimating coal mining emissions, see section 4.1.6 (p.4.30) of the 2006 IPCC Guidelines (vol. 2, chap. 4).

13. **The correct answer is ´False'**. Fugitive emissions comprise intentional and unintentional releases. They also include emissions from flaring, which involves combustion. Flaring (i.e. the controlled burning of natural gas and other gaseous streams in an open flame) and venting (i.e. the controlled discharge of gases directly into the atmosphere) are common practices in the oil and gas industry. In addition to venting and flaring, other types of primary fugitive emission sources occur across the diverse segments of the oil and gas industry. These fugitive emissions include those from equipment leaks, evaporation losses, accidental releases (e.g. from well blowouts, pipeline breaks, tanker accidents, tank explosions, gas migration to the surface around the outside of wells, surface casing vent blows) and leakage from abandoned wells.

To learn more about the different types of sources of fugitive emissions across the oil and gas industry, see section 4.2.1 (pp.4.32–4.33) of the 2006 IPCC Guidelines (vol. 2, chap. 4).

14. **The correct answer is 'True'**. Emissions for category 1.C.2. injection and storage, are specific to each CCS project and estimates are developed according to the tier 3 methodology. This is the only activity under the energy sector for which the 2006 IPCC Guidelines do not provide tier 1 or tier 2 methods. Note that the 2006 IPCC Guidelines provide a tier 1 method to estimate emissions from CO_2 pipeline transport, a likely component of a CCS project.

To learn more about the estimation of emissions from CO_2 transport, injection and geological storage, see chapter 5 of the 2006 IPCC Guidelines (vol. 2).

Lesson 2. General approach to reviewing the reporting on the energy sector

1. Introduction

This lesson addresses the main characteristics of the energy sector in the national GHG inventory and a general approach to its review.

1.1. Learning objectives

By the end of this lesson, you should be able to:

- Identify the most important categories and gases for the energy sector;
- Identify key areas to watch out for when reviewing the energy sector reporting, in particular possible double counting or omissions of emissions;
- Understand how to apply the general assessment of cross-cutting issues in the review of the energy sector.

1.2. Expected time needed to complete lesson 2

- For readers with experience in compilation of energy sector GHG inventories: 40–60 minutes

For readers with less experience in compilation of energy sector GHG inventories: 80–120 minutes

2. Overview of the sector

2.1. Fuels and types of fuels

The energy sector GHG inventory is the main subject of this course and fuels are the only type of materials treated in the inventory of the energy sector. Emissions resulting from the extraction, conversion, transport, commercialization and use of fuels are the focus of this course. Emissions may arise from these activities through combustion of fuels or without combustion (e.g. fugitive emissions). Fuels are organized into six main types, differentiated by their origin into fossil and non-fossil fuels.

Fossil fuels:

- Liquid (crude oil and petroleum products);
- Solid (coal and coal products);

- Gaseous (natural gas);
- Other fossil fuels (waste, including the non-biomass fraction of municipal waste).

Non-fossil fuels:

- Peat;
- Biomass (solid, liquid and gaseous, as well as the biomass fraction of municipal waste).

To learn more about fuel types, see:

- Table 1.1 in the 2006 IPCC Guidelines (vol. 2, chap. 1, pp.1.12–1.16) for the definitions of fuel types used in those Guidelines
- CRT 1.A(b) ("Sectoral background data for energy: CO_2 from fuel combustion activities – reference approach (IPCC worksheet fuel combustion activities)")

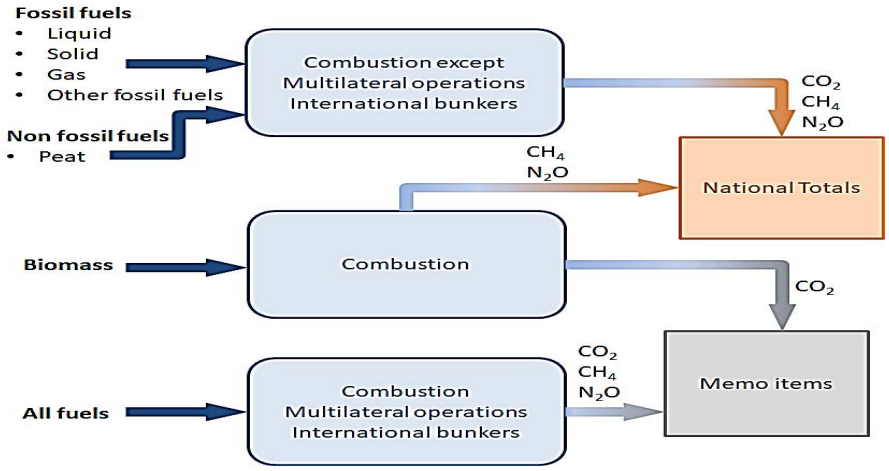
2.2. Gases

Emissions from energy activities include:

- Greenhouse gases (GHGs):
  - Carbon dioxide (CO_2);
  - Methane (CH_4);
  - Nitrous oxide (N_2O);
- Precursors of ozone and inorganic aerosols:
  - Nitrogen oxides (NO_X);
  - Carbon monoxide (CO);
  - Non-methane volatile organic compounds (NMVOCs);
  - Sulfur oxides (SO_X).

GHG emissions from combustion are allocated according to the associated fuel – fossil fuel, peat or biomass – as shown in figure 2.1. Emissions under memo items are reported for information purposes only.

B. Figure 2.1 Allocation of CO2 and non-CO2 emissions from combustion

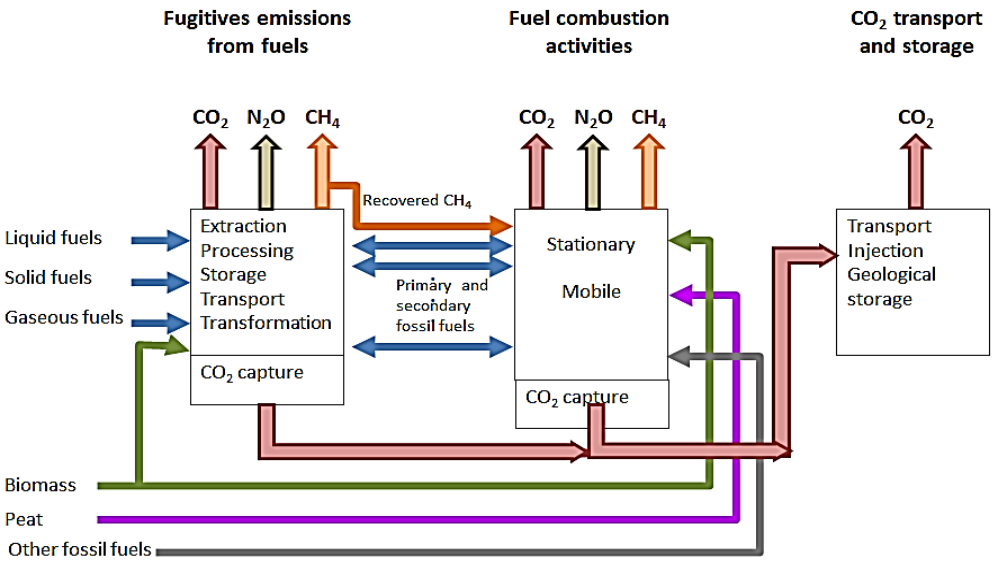


2.3. Structure of the energy sector

The structure of the energy sector can be summarized as follows (see also figure 2.2):

- The material flows of fuels across the sector;
- The release of GHGs;
- The capture of CO_2;
- The transport, injection and geological storage of CO_2.

C. Figure 2.2. Structure of the energy sector



More information on activities, emissions and removal flows is presented in box 2.1.

Box 2.1. Fuels and emission and removal flows in the energy sector

Main activities in the energy sector include: (i) exploration and extraction of primary energy resources; (ii) conversion of primary energy into more usable forms in refineries and power plants; (iii) storage and transportation of fuels; (iv) combustion of fuels in stationary and mobile devices for energy purposes and (v) removal of CO_2 and subsequent storage in geological reservoirs (CO_2 capture and storage – CCS).

Fuel combustion converts chemical energy into another type of usable energy (heat), which subsequently can be converted to other forms of energy such as mechanical (power or momentum). It is the main CO_2 source worldwide. It occurs both in stationary and mobile combustion devices. CH_4 and N_2O emissions from combustion are much smaller than those of CO_2.

The 2006 IPCC Guidelines provide the following definition of fuel combustion for energy purposes, which serves as a guiding principle to allocate emissions from fuel combustion activities under the energy sector:

> *'For inventory purposes, fuel combustion may be defined as the intentional oxidation of materials within an apparatus that is designed to provide heat or mechanical work to a process, or for use away from the apparatus.'*

The term fugitive emissions is broadly applied to all GHG emissions from coal, oil and natural gas systems that do not arise from fuel combustion and occur during the extraction, treatment, transport and distribution of fossil fuels (coal, natural gas and oil) and biomass (e.g. charcoal production). Fugitive emissions can be either intentional (e.g. for safety or environmental protection reasons) or unintentional (e.g. from GHG leaking from equipment). The major GHG in these emissions is CH_4.

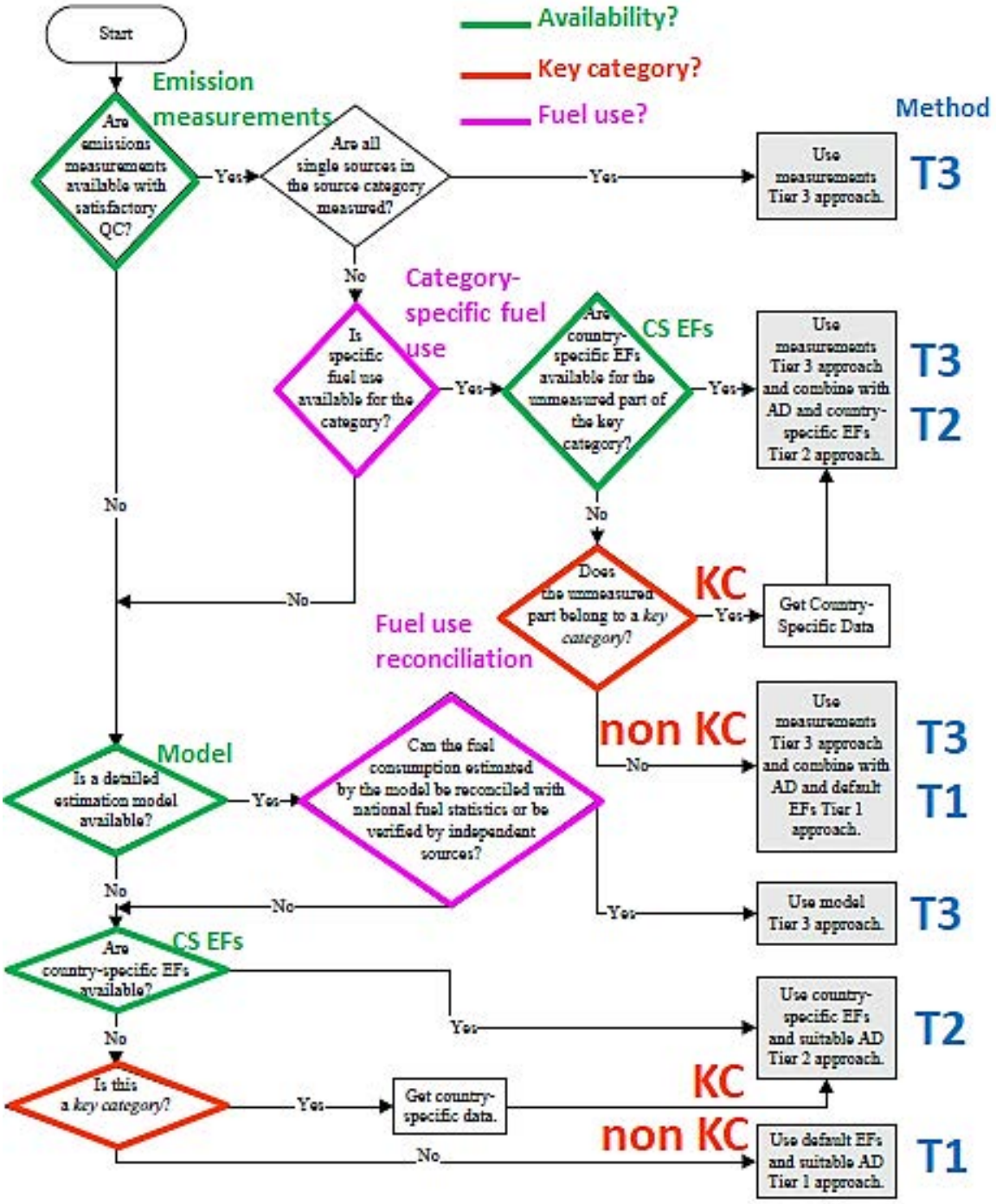
The other major category is associated with the CCS system. It consists of four main consecutive steps: (i) capture and compression of CO_2, (ii) transport to a storage location, (iii) injection, and (iv) disposal in a geological storage site for long-term isolation from the atmosphere. Emissions can occur in any of the four segments but only the emission from the last three steps are allocated under category 1.C CO_2 transport and storage while the removal of CO_2 is considered under the energy or the IPPU sectors, depending on the facility where the CO_2 removal occurred.

2.4. Choice of estimation method

The choice of a tier 1, tier 2 or tier 3 method to estimate GHG emissions is country-specific and determined by (1) whether the emissions are being estimated for a key category and (2) the level of detail in the available data.

Consider the decision tree to estimate emissions from combustion (figure 1.2 in the 2006 IPCC Guidelines (vol. 2, chap. 1, p.1.9), reproduced below as figure 2.3). Although the question on key category comes last, it is the most important one because, in general, it is not good practice to estimate emissions for a key category using a tier 1 approach.

D. Figure 2.3. Generalized decision tree for estimating emissions from fuel combustion



Note: This figure is reproducing figure 1.2 of the 2006 IPCC Guidelines (vol. 2, chap. 1, p.1.9). Comments and colours have been added to indicate the essential decision framework.

Selection of a tier 1 (T1), tier 2 (T2) or tier 3 (T3) method depends on whether the category is key (KC) or non-key (non KC) and the availability of data and methods (country-specific, plant-specific or models). Checking fuel use reconciliation is needed when reviewing the use of tier 3 methods.
Keep in mind the provision in paragraph 23 of the MPGs, which relates to the choice of estimation approach:
"A Party may be unable to adopt a higher tier method for a particular key category owing to lack of resources. In such cases, the Party may use a tier 1 approach, and shall clearly document why the methodological choice was not in line with the corresponding decision tree of the 2006 IPCC Guidelines."
When a tier 1 method has been used for a key category, you must look for the documentation on method choice provided by the Party, evaluate the difficulties that the Party has faced in attempting to apply a higher-tier method, check if moving to a higher tier approach has been considered and if the Party has evaluated the effort and resources needed and estimated a time frame for this task. If a tier 1 method has been used for a key category and the choice of methodology has not been clearly documented, then this finding must be reflected in your review.

2.5. Categories

The organization of the categories and subcategories of the energy sector in the CRTs closely follows, with some exceptions, the sector split adopted by the 2006 IPCC Guidelines (see box 2.2).

Box 2.2. Categories and sub-categories in the energy sector as defined in the 2006 IPCC guidelines

For details on the structure of the energy sector, consult the following tables in volume 2 of the 2006 IPCC Guidelines:

Table 2.1 Detailed sector split for stationary combustion (chapter 2, pages 2.7-2.10):

Table 3.1.1 Detailed sector split for the transport sector (chapter 3, pages 3.8-3.10)

Table 4.1.1 Detailed sector split for emissions from mining, processing, storage and transport of coal (chapter 4, page 4.8)

Table 4.2.1 Detailed sector split for emissions from production and transport of oil and natural gas (chapter 4, pages 4.33-4.35)

Table 5.1 Source categories for CCS (chapter 5, page 5.7)

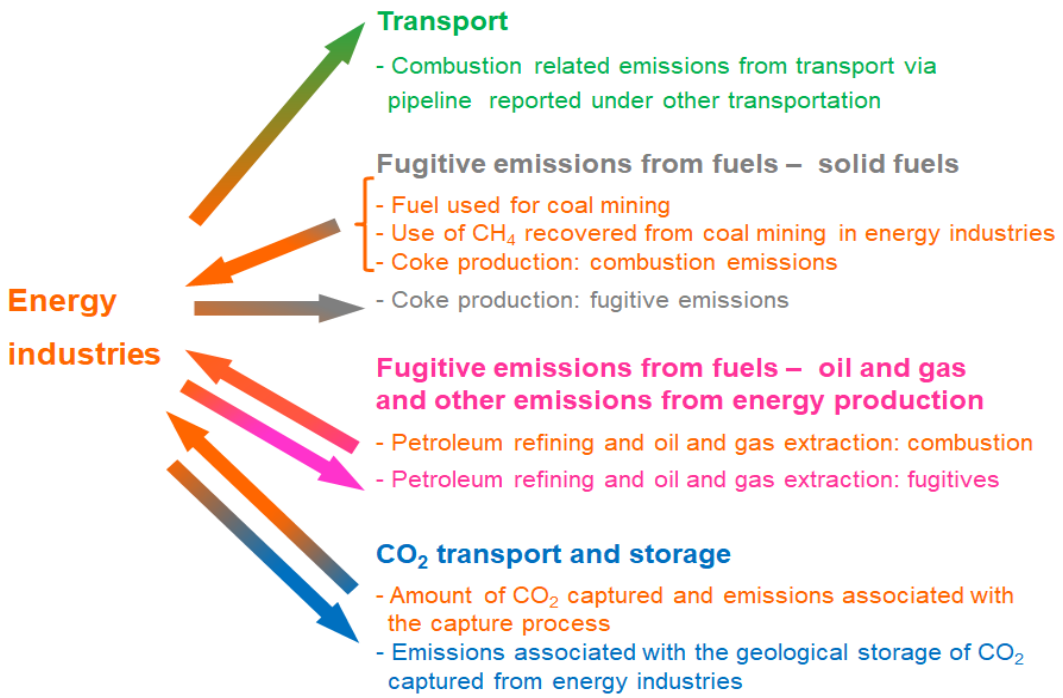
Most of the differences between the categories and subcategories in the CRTs and those in the 2006 IPCC Guidelines relate to the category or subcategory names and used codes, for example, 1.A.3.a domestic aviation (CRTs) corresponds to 1.A.3.a.ii domestic aviation (2006 IPCC Guidelines), while 1.A.3.a civil aviation in the 2006 IPCC Guidelines refers to emissions from international and domestic civil aviation, including take-offs and landings. In addition to changes in nomenclature, there is a different level of disaggregation for the subcategory other under manufacturing industries and construction and a different structure for oil and natural gas and other emissions from energy production. The specific differences are discussed in lessons 3, 4 and 6.

The organization of categories and subcategories in the CRTs is the mandatory structure for reporting emissions and removals.

2.6. Relationships among categories of the energy sector

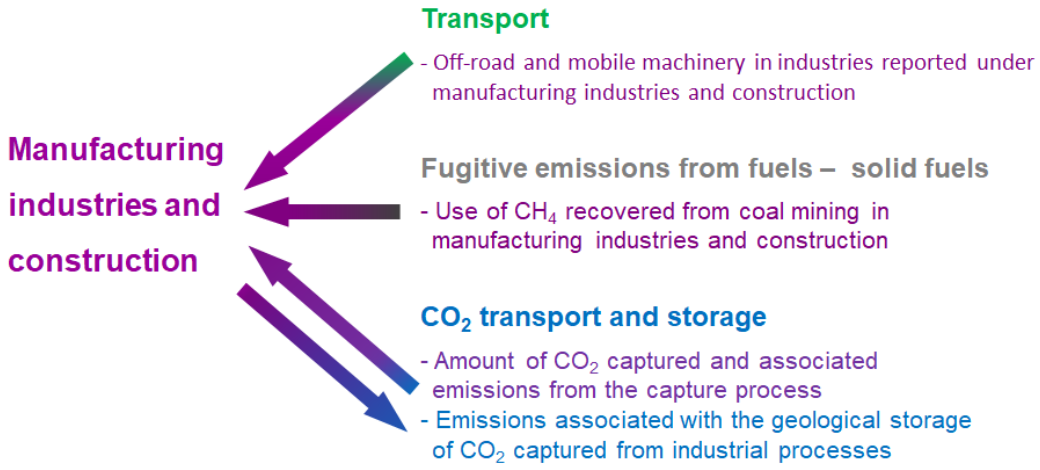
Activities under several energy sector categories interact with one another. In your review, you must assess whether both double counting and omission of emissions were avoided in estimating and reporting on emissions associated with these connected categories. The main relationship of each energy sector category with other energy sector categories is summarized in figures 2.4–2.9. Arrows and colours indicate allocations.

E. Figure 2.4. Relationship of energy industries (category 1.A.1) to other energy sector categories



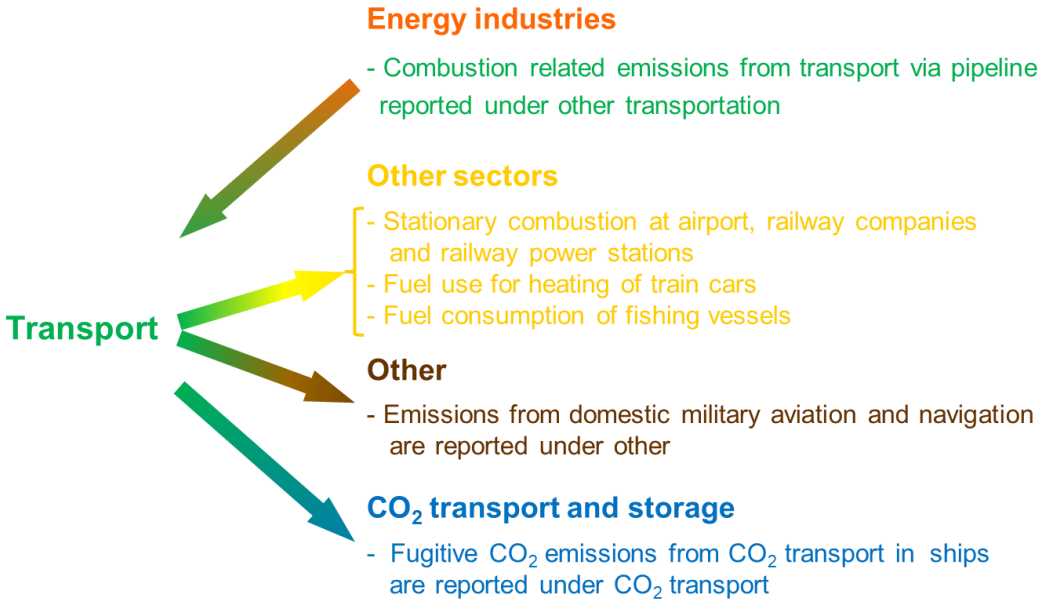
Note: Colour code: orange for energy industries; green for transport; grey for fugitive emissions – solid fuels; magenta for fugitive emissions – oil and gas; and blue for CO_2 transport and storage. Arrows indicate the allocation of emissions.

F. Figure 2.5. Relationship of manufacturing industries and construction (category 1.A.2) to other energy sector categories



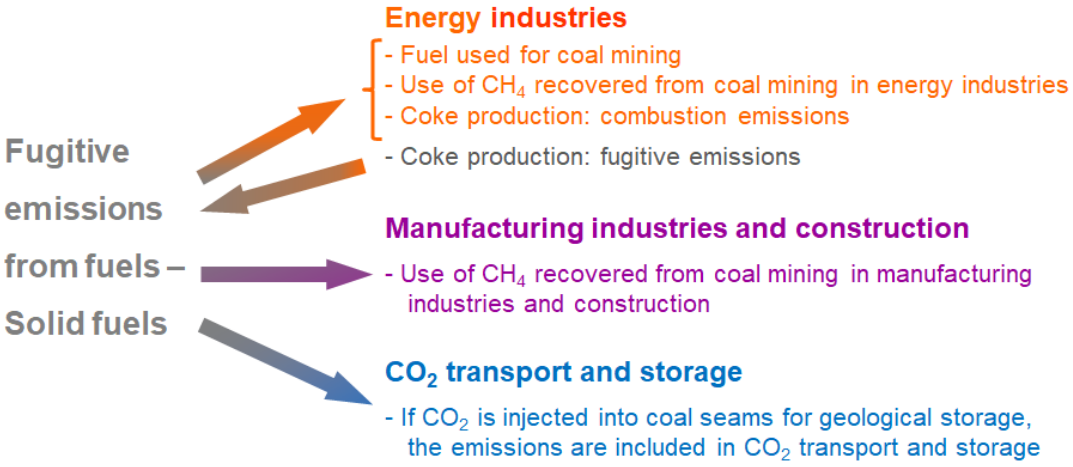
Note: Colour code: violet for manufacturing industries and construction; green for transport; grey for fugitive emissions – solid fuels; and blue for CO_2 transport and storage. Arrows indicate the allocation of emissions.

G. Figure 2.6. Relationship of transport (category 1.A.3) to other energy sector categories



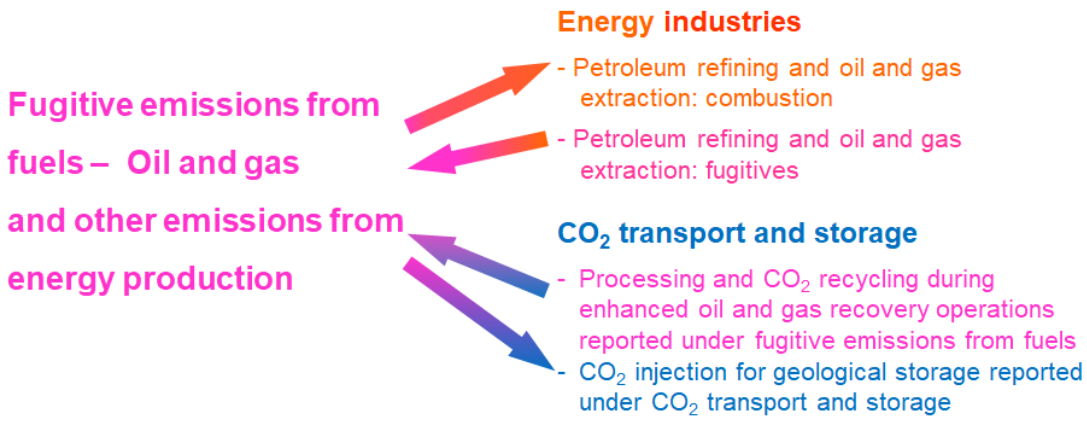
Note: Colour code: orange for energy industries; green for transport; yellow for other sectors; brown for other; and blue for CO_2 transport and storage. Arrows indicate the allocation of emissions.

H. Figure 2.7. Relationship of fugitive emissions from fuels – solid fuels (category 1.B.1) to other energy sector categories



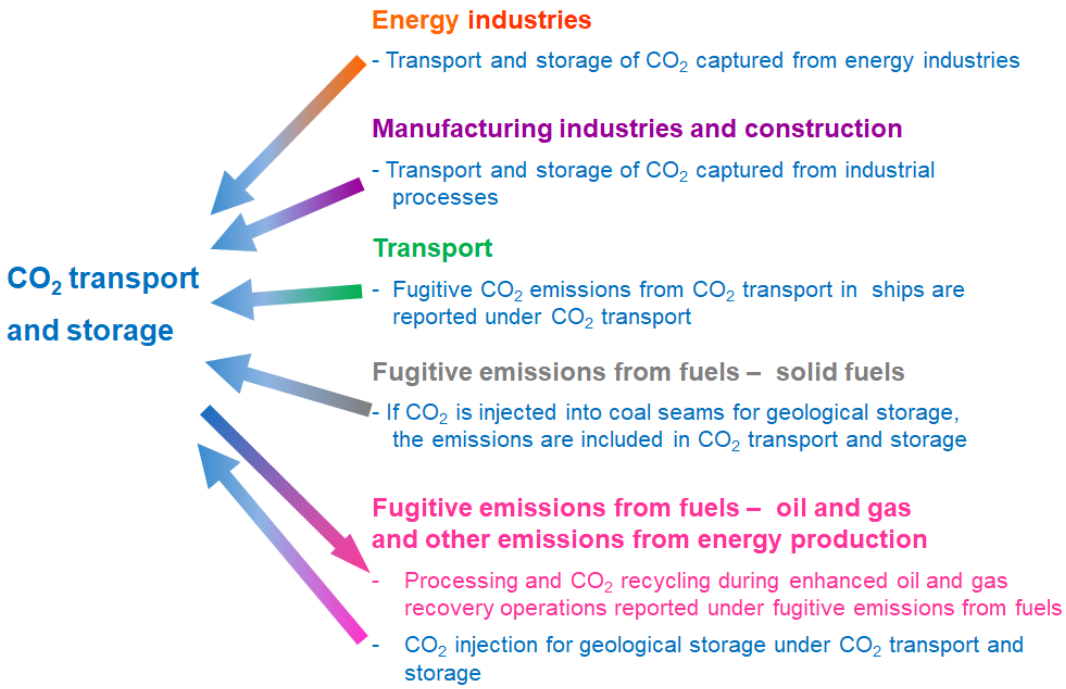
Note: Colour code: orange for energy industries; violet for manufacturing industries and construction; grey for fugitive emissions – solid fuels; and blue for CO_2 transport and storage. Arrows indicate the allocation of emissions.

I. Figure 2.8. Relationship of fugitive emissions from fuels – oil and gas and other emissions from energy production (category 1.B.2) to other energy sector categories



Note: Colour code: orange for energy industries; magenta for fugitive emissions – oil and gas; and blue for CO_2 transport and storage. Arrows indicate the allocation of emissions.

J. Figure 2.9. Relationship of CO_2 transport and storage (category 1.C) to other energy sector categories



Note: Colour code: orange for energy industries; violet for manufacturing industries and construction; green for transport, grey for fugitive emissions – solid fuels; magenta for fugitive emissions – oil and gas; and blue for CO_2 transport and storage. Arrows indicate the allocation of emissions.

2.7. Indirect CO_2 emissions

If a Party has decided to estimate and report on indirect CO_2 emissions, in your review, check that:

- The national totals are reported with and without indirect CO_2 emissions;
- Double counting of emissions has not occurred.
  - For tier 1 estimates of CO_2 emissions from combustion, the CO_2 EFs account for all carbon in the fuel and therefore indirect CO_2 emissions are already included in the CO_2 emission estimates. In this case, the carbon in emissions of CO, CH_4 or NMVOCs from combustion should not be double counted through the estimation of indirect CO_2 from these gases.
  - For higher-tier levels, the amount of carbon in CO, CH_4 and NMVOCs could have been accounted for and in this case, indirect CO_2 emissions may be included in the national totals. Verify if the amount of carbon emitted in non-CO_2 gases has been excluded from the country-specific CO_2 EFs. Consider that the amount of carbon in direct and indirect CO_2 emissions cannot be higher than the amount of carbon contained in the fuel. In addition, check if the Party has documented the derivation of the country-specific EFs.

To learn more about precursor gases and indirect emissions, see chapter 7 of the 2006 IPCC Guidelines (vol. 1) and paragraphs 51–52 of the MPGs.

3. Cross-sectoral issues

3.1. Connection of the energy sector to other inventory sectors

There are a number of connections between the energy sector and the other inventory sectors, namely (see also figure 2.10):

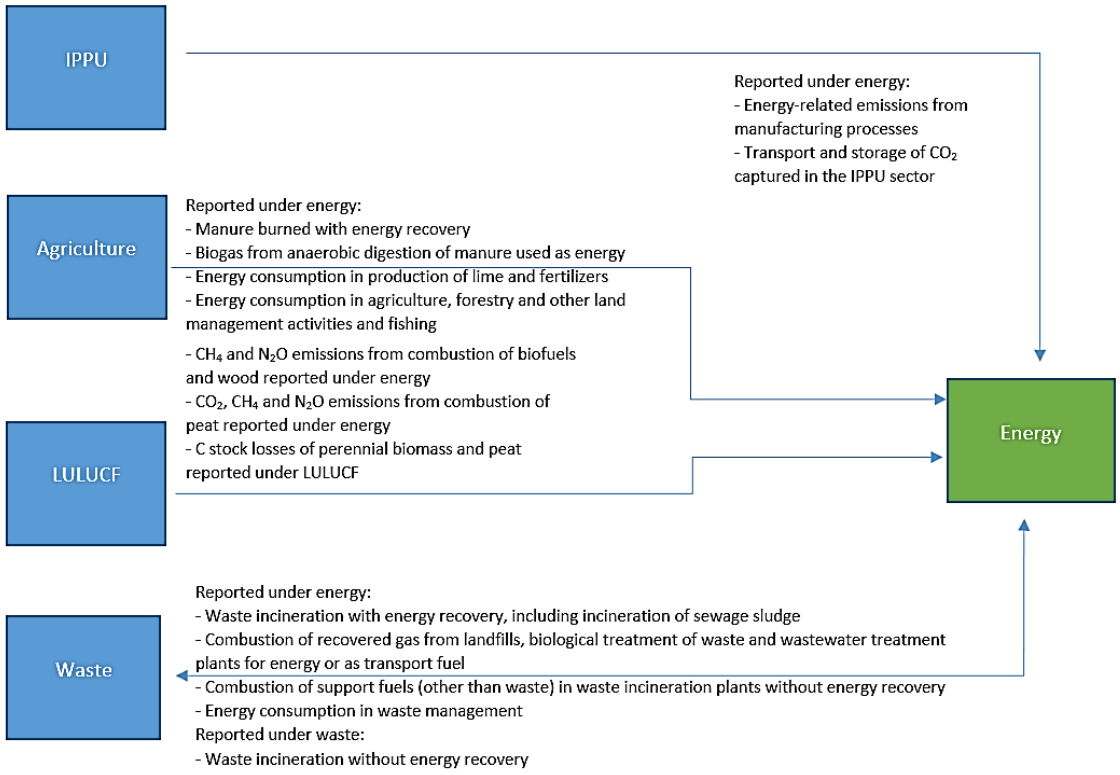
- IPPU (figure 2.11);
- Agriculture (figure 2.12);
- LULUCF (figure 2.13);
- Waste (figure 2.14).

These connections occur through:

- The production and use of fossil fuels and biomass;
- The geological storage of CO_2 captured from industrial processes.

In your review, you must assess whether both double counting or omission of emissions were avoided in estimating and reporting on emissions associated with these connections.

K. Figure 2.10. Relationship of the energy sector to other inventory sectors

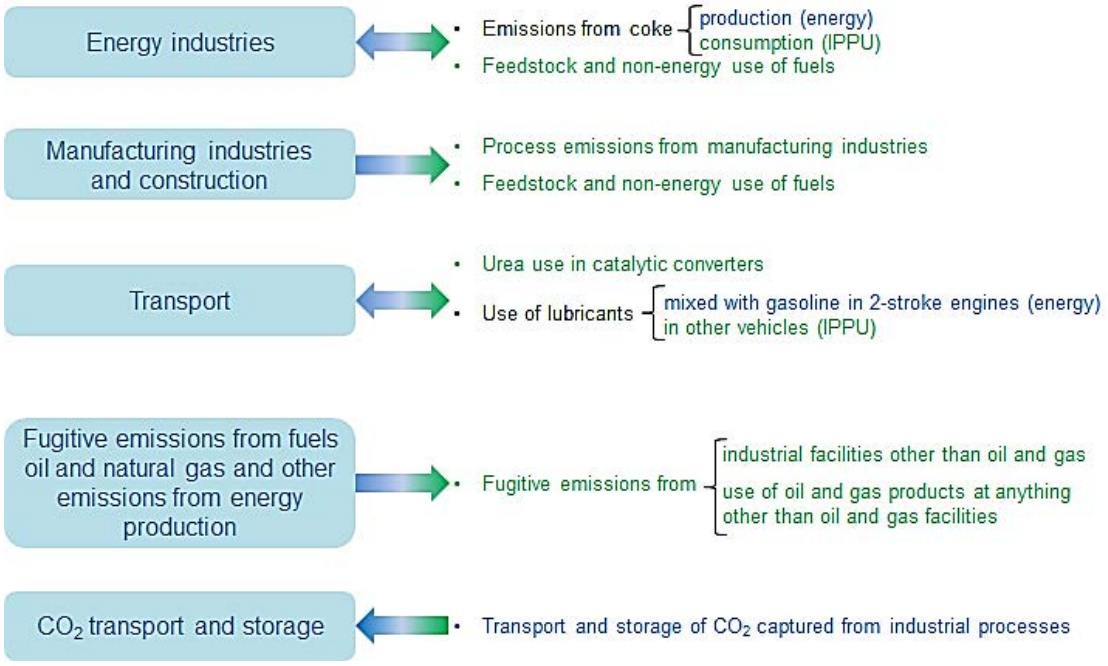


3.2. Connection: energy from/to IPPU

The connection between these sectors occurs mainly through:

- The use of fuels as feedstock and reductants;
- The non-energy use of fuels;
- The transport and storage of CO_2 captured from industrial processes.

L. Figure 2.11. Relationship between the **energy sector** and the **IPPU sector**

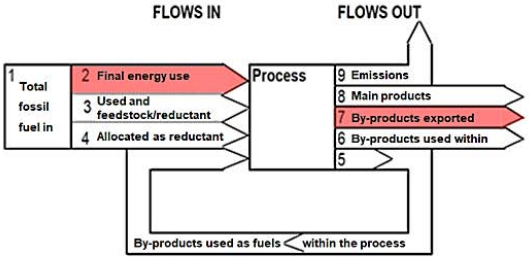


When fuels are used only for energy purposes (production of heat and power) in industrial processes, the separation of energy emissions from industrial process emissions is rather straightforward (combustion emissions are reported in the energy sector). In other cases, you must pay attention to how these emissions have been estimated and reported (see box 2.3 for more information).

Box 2.3. Separation of emissions between energy and IPPU

The 2006 IPCC Guidelines provide guidance on allocating emissions to the energy or the IPPU sector when fuels are used for different purposes in industrial processes. The main principle is formulated in volume 2, chapter 1.2 as follows:

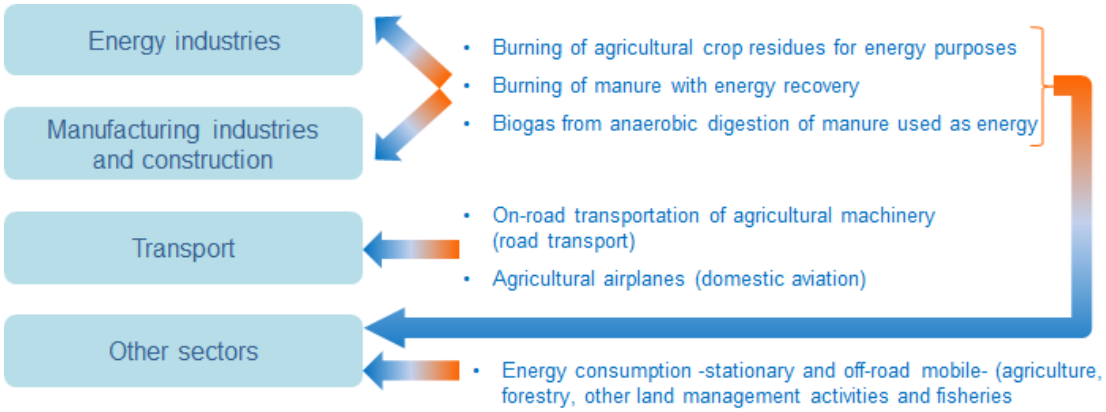
"Combustion emissions from fuels obtained directly or indirectly from the feedstock for an IPPU process will normally be allocated to the part of the source category in which the process occurs. These source categories are normally 2B and 2C. However, if the derived fuels are transferred for combustion in another source category, the emissions should be reported in the appropriate part of Energy Sector source categories (normally 1A1 or 1A2)."



Volume 3, chapter 1 (IPPU) provides further guidance in box 1.1 and section 1.3.2: of all flows out from an industrial process shown above, only flow 7 (by-products exported to other categories) concerns the energy sector, if it contains fuels derived out of the IPPU sector to be used for energy purposes. Emissions from fuel use for energy purpose (flow 2) are allocated under the IPPU sector.

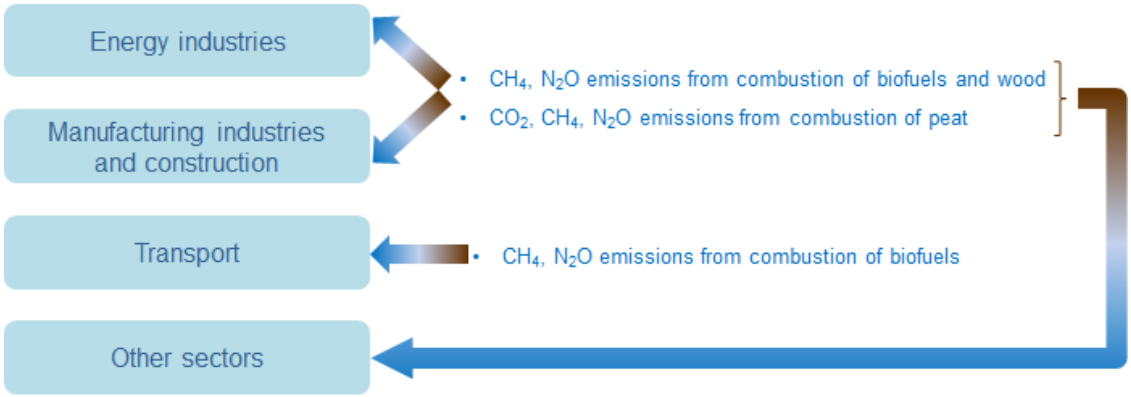
3.3. Connection: energy from agriculture

M.Figure 2.12. Relationship between the energy sector and the agriculture sector



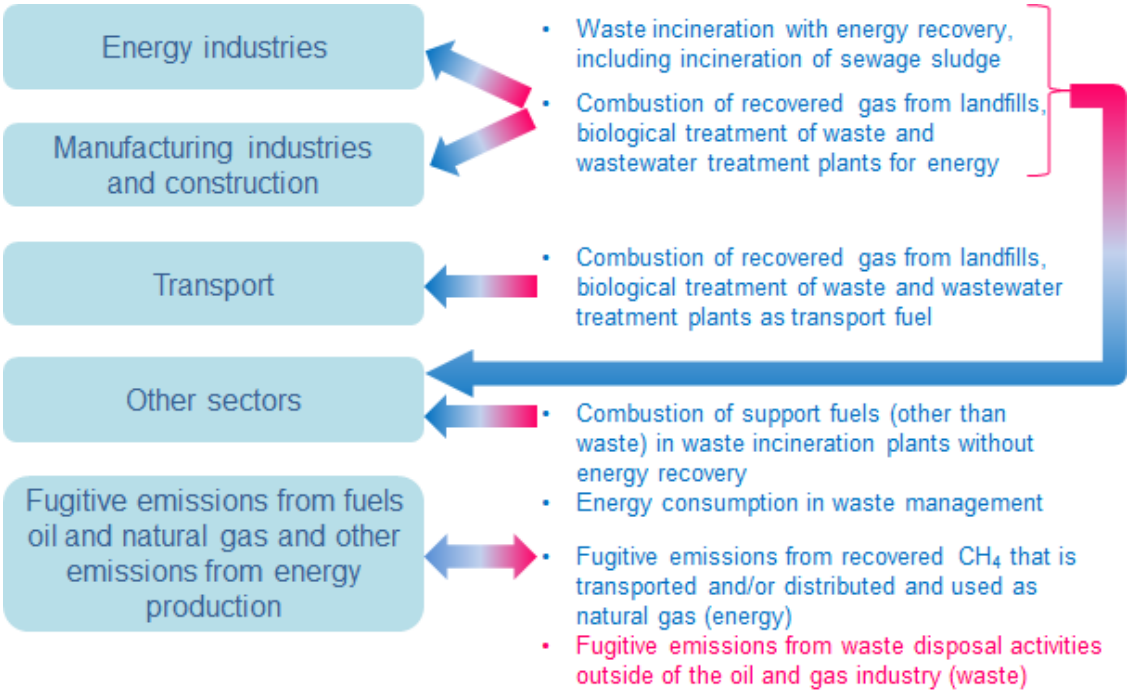
3.4. Connection: energy from LULUCF

N. Figure 2.13. Relationship between the energy sector and the LULUCF sector



3.5. Connection: energy from/to waste

O. Figure 2.14. Relationship between the energy sector and the waste sector



When reviewing emissions from waste incineration, you should check (1) the assessment of the carbon content of waste and (2) the biogenic and non-biogenic waste differentiation and the corresponding allocation of CO_2 emissions (memo item for biogenic and under stationary combustion for non-biogenic) (for more information, see box 2.4).

Box 2.4. Energy and waste

Reporting of CO_2 emissions from the incineration of waste with energy recovery:

- CO_2 from the biogenic part of waste is an information item;
- CO_2 from the non-biogenic part is reported under energy (combustion of other fossil fuels).

Recovered gas (CH_4):

- CH_4 can be recovered from waste disposal sites, anaerobic digestion at biogas facilities and wastewater treatment, and utilized in several devices for energy purposes;
- Recovered CH_4 from waste treatment follows the same approach as the CH_4 recovered from coal mining;
- Recovered CH_4 is transported and/or distributed and used together or as natural gas, therefore the fugitive emissions are dealt with in the oil, natural gas and other emissions from energy production category.

4. Common reporting tables and tasks of the review

4.1. Overview of the energy sector common reporting tables

The CRTs for the electronic reporting of the information in the national inventory reports of anthropogenic emissions by sources and removals by sinks of GHGs were covered in lesson 4 of the "Overview and cross-cutting" course. The specific CRTs for the energy sector are summarized in table 2.1, which indicates the lessons of this course where the corresponding reporting categories are covered.

Table 2.1. Common reporting tables specific to the energy sector

CRTs	Coverage in this course
Table 1 Sectoral report for energy	Lessons 3, 4, 6 and 7
Table 1.A(a) Sectoral background data for energy **Sheets 1, 2 and 4** **Sheets 3**	 Lesson 3 Lesson 4
Table 1.A(b) CO_2 from fuel combustion activities – reference approach **Table 1.A(c) Comparison of CO_2 emissions from fuel combustion** **Table 1.A(d) Feedstocks, reductants and other non-energy use of fuels**	Lesson 5
Table 1.B.1 Solid fuels **Table 1.B.2 Oil, natural gas and other emissions from energy production**	Lesson 6
Table 1.C CO_2 Transport and storage	Lesson 7
Table 1.D International aviation and international navigation (international bunkers) and multilateral operations	Lesson 4

Keep in mind that sectoral background data for energy CRTs (1.A(a), 1.B.1, 1.B.2, 1.C and 1.D) contain data reported by Parties on GHG emissions (kt), AD (fuel consumption in TJ for fuel combustion, amount of fuel produced in Mt for fugitive emissions from solid fuels, in other units elected by the Party for fugitive emissions from oil and gas, or in kt for CO_2 transported or injected) and the resulting IEFs (in t/TJ for CO_2 and in kg/TJ for CH_4 and N_2O for fuel combustion, in kg/t for fugitive emissions from solid fuels, in kg/unit for fugitive emissions from oil and gas, or in kg/kt for CO_2 transported or injected). IEFs are calculated as the ratio between reported emissions and the corresponding AD.

Many CRTs for the energy sector contain drop-down lists. Parties that need flexibility may collapse the rows below each list up to the corresponding category or subcategory upper level.

4.2. Main tasks in the review process

The main tasks of the reviewer are preparation, assessment and drafting. These are treated in section 3 of lesson 4 of the "Overview and cross-cutting" course. Communication is also a relevant skill needed by GHG inventory reviewers. The tasks, with a focus on the energy sector, are covered in this course.

5. Practical exercises

In these exercises you will:

- Review the information reported by a Party on estimates for key categories and methodology choice;
- Compare the information reported against the relevant paragraphs of the MPGs;
- Make an initial list of preliminary findings for your review regarding the relationship between key categories and estimation methods.

These exercises reflect the first step in your assessment of the methodology choices made by a Party to estimate emissions for key categories. Depending on the information available in the NID, actions by the TERT, including formulating clarification questions to the Party, may be necessary. This will be covered in the next lessons.

5.1. Exercise 1: determine the key categories for the energy sector identified by the Party

Tables 2.2 and 2.3 show the results of the key category analysis for the energy sector performed by the Party using IPCC approach 1 and reported in chapter 1 of its NID. The tables summarize the numerical results reported in annex I to the NID.

Table 2.2. Results for the energy sector of the key category analysis by the Party (without LULUCF)

IPCC Source category	Direct GHG	Level	Trend
1A1a. Public electricity and heat production	CO2	✓	✓
1A2e. Food processing, beverages and tobacco	CO2	✓	✓
1A2f. Non-metallic minerals	CO2	✓	✓
1A2g. Other (please specify)	CO2	✓	✓
1A3a. Domestic aviation	CO2		✓
1A3b. Road transportation	CO2	✓	✓
1A3b. Road transportation	N2O		✓
1A4a. Commercial/institutional	CO2	✓	
1A4b. Residential	CO2	✓	✓
1A4c. Agriculture/forestry/fishing	CO2	✓	

Table 2.3. Results for the energy sector of the key category analysis by the Party (with LULUCF)

IPCC Source category	Direct GHG	Level	Trend
1A1a. Public electricity and heat production	CO2	✓	✓
1A2e. Food processing, beverages and tobacco	CO2	✓	✓
1A2f. Non-metallic minerals	CO2	✓	✓
1A2g. Other (please specify)	CO2	✓	✓
1A3a. Domestic aviation	CO2		✓
1A3b. Road transportation	CO2	✓	
1A3b. Road transportation	N2O		✓
1A4a. Commercial/institutional	CO2	✓	
1A4b. Residential	CO2	✓	✓
1A4c. Agriculture/forestry/fishing	CO2	✓	

On the basis of the information in tables 2.2 and 2.3, make a complete list of the key categories for the energy sector identified by the Party.

5.2. Exercise 2: key categories identified by the Party in the national inventory document and key categories reported in common reporting table 7

What are the similarities and differences in the key categories for the energy sector resulting from the key category analysis performed by the Party and reported in the NID (tables 2.2 and 2.3 above) and the key category analysis reported in CRT 7? The results for the energy sector the key category analysis reported in CRT are summarized in table 2.4.

Table 2.4. Extract of the energy sector of the results of the key category analysis in CRT 7

KEY CATEGORIES OF EMISSIONS AND REMOVALS	Gas	Criteria used for key source		Key category excluding LULUCF	Key category including LULUCF
		L	T		
1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO2	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO2	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO2	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil	CO2	X	X	X	X
1.A.3.a Domestic Aviation	CO2		X	X	X
1.A.3.b Road Transportation	CO2	X	X	X	X
1.A.3.b Road Transportation	N2O		X		X
1.A.4 Other Sectors - Liquid Fuels	CO2	X	X	X	X

5.3. Exercise 3: key categories identified by the Party and methodology choice

Assess the methods used by the Party to estimate the emissions for key categories in the energy sector, as reported in the NID and summarized in table 2.5. Remember that your review should be based on the Party's assessment discussed in exercises 1 and 2 above.
For your review, take into account:

- The generalized decision tree for estimating emissions from fuel combustion in the 2006 IPCC Guidelines (vol. 2, chap. 1, figure 1.2, p.1.9);
- Paragraphs 20–23 and 39 of the MPGs.

Considering the information reported by the Party and the framework provided by the 2006 IPCC Guidelines and the MPGs, make a list of your preliminary findings and the associated information that you need to look for in the NID to assess each identified issue.

Table 2.5. Summary of methodology choices made by the Party

IPCC Source category	GHG	EF	Method
1A1a. Public electricity and heat production	**CO_2**		
liquid fuels		CS	CS
1A2e. Food processing, beverages and tobacc	**CO_2**		
liquid fuels		D	T1
1A2f. Non-metallic minerals	**CO_2**		
liquid fuels		CS	CS
solid fuels		CS	CS
other fossil fuels		D	T1
1A2g. Other (please specify)	**CO_2**		
liquid fuels		D	T1
1A3a. Domestic aviation	**CO_2**		
jet kerosene		D	T1
1A3b. Road transportation	**CO_2, CH_4, N_2O**		
gasoline		M	T3
diesel oil		M	T3
LPG		D	T1
biomass, biomass		D	T1
1A4a. Commercial/institutional	**CO_2**		
liquid fuels		D	T1
1A4b. Residential	**CO_2**		
liquid fuels		D	T1
1A4c. Agriculture/forestry/fishing	**CO_2**		
liquid fuels		D	T1

5.4. Answer key

1. The complete set of key categories results from the combination of the key categories identified by the Party with and without LULUCF. For this particular case, the complete set of key categories coincides with that of key categories without LULUCF.
2. Both assessments used IPCC approach 1 for key category analysis. The differences are in the level of disaggregation used by fuel type. The key category analysis in CRT 7 follows the aggregation level indicated in table 4.1 of the 2006 IPCC Guidelines (vol. 1, chap. 4, pp.4.8–4.12):
   - Main categories for stationary combustion (1.A.1, 1.A.2, 1.A.4 and 1.A.5);
   - Main subcategories under transport (1.A.3.a, 1.A.3.b, 1.A.3.c, 1.A.3.d and 1.A.3.e) and fugitive emissions (1.B.1, 1.B.1.a and 1.B.2.b);
   - Gases (CO_2, CH_4 and N_2O);
   - Main fuel types for stationary combustion.

   The Party disaggregated stationary categories further by subcategory, but it did not disaggregate by main fuel type.

Therefore, the differences are in the level of aggregation of the key categories identified. Also, the Party did not disaggregate by fuel (therefore, key categories are for all fuels used) while the key categories for stationary combustion reported in CRT 7 are for certain main fuel types only.

3. Three preliminary findings and the information to look for are listed below.

3.1. Tier 1 method was used to estimate emissions for the following key categories:

- Food processing, beverages and tobacco – CO_2 – liquid fuels
- Non-metallic minerals – CO_2 – other fossil fuels
- Other – CO_2 – liquid fuels
- Domestic aviation – CO_2 – jet kerosene
- Road transportation – CO_2, N_2O – LPG
- Commercial/institutional – CO_2 – liquid fuels
- Residential – CO_2 – liquid fuels
- Agriculture/forestry/fishing – CO_2 – liquid fuels

Look in the NID for an explanation as to why the Party was unable to implement higher-tier methods for key categories (see para. 23 of the MPGs).

3.2. Country-specific methods were used to estimate CO_2 emissions for the following stationary combustion subcategories:

- Public electricity and heat production – liquid fuels
- Non-metallic minerals – liquid fuels
- Non-metallic minerals – solid fuels

Look in the NID for a description of the country-specific method, data and/or parameters selected (see para. 22 of the MPGs). Given that these are stationary combustion categories, it is likely that the country-specific method was based on measurements of carbon content and NCV of the fuels. In such a case, information is needed on the coverage of the different facilities in

the country and the associated fuel use information (see the generalized decision tree for estimating emissions from fuel combustion in the 2006 IPCC Guidelines (vol. 2, chap. 1, figure 1.2, p.1.9)).

3.3. A model was used to estimate CO_2, CH_4 and N_2O emissions from road transportation using gasoline and diesel oil.
Look in the NID for a description of the model, data and/or parameters selected (see para. 22 of the MPGs). Given that it is likely that the model used to estimate these emissions would be a distance travelled method, information on fuel use reconciliation would be needed (see the decision tree for steps in estimating emissions from road transportation in the 2006 IPCC Guidelines (vol. 2, chap. 3, figure 3.2.1, p.3.11)).

6. Self-check quiz

1. Emissions from the combustion of fuels derived from feedstocks used in an industrial process are always reported under the IPPU sector and not under the energy sector.
   True
   False

2. Energy industries – liquid fuels – CO_2 was identified by a Party as a key category. Emissions were estimated using plant-facility data of carbon contents and NCVs measured for 75 per cent of the facilities. For the remaining facilities, the Party used a tier 1 approach. The estimation method is:
   A. In line with the 2006 IPCC Guidelines, because the use of measurements (tier 3) in combination with a tier 2 or tier 1 estimate within the same activity is allowed
   B. In line with the 2006 IPCC Guidelines, because specific fuel use is available for the category and therefore a hybrid tier 3–tier 1 approach can be implemented
   C. Not in line with the 2006 IPCC Guidelines, because a higher-tier approach (tier 2, tier 3 or hybrid tier 2–tier 3) should be used for key categories

3. For inventory purposes, a key distinction of fuels refers to whether they are of fossil or biogenic origin. CO_2 emissions from the combustion of fossil fuels are reported under the energy sector and are part of the national GHG emission totals, while CO_2 emissions from biomass or biogenic fuels are reported only as memo item and are not part of the national GHG emission totals. Rigorously, peat is not a fossil fuel; therefore, CO_2 emissions from the combustion of peat are not part of the national GHG emission totals.
   True
   False

4. Recovered gas (CH_4) from waste-related activities has several connections between the waste sector and the energy sector. These include:
   A. Combustion of recovered CH_4 in energy industries
   B. Use of recovered CH_4 as a fuel by vehicles (mixed with natural gas)
   C. Use of drained CH_4 from coal mine degasification systems of underground mines
   D. Recovered CH_4 injected in natural gas distribution systems
   E. A, B and D

5. The IEFs reported in CRT 1.A(a) (sheets 1, 2, 3 and 4), 1.B.1, 1.B.2 and 1.C:
   A. Represent the mean of the EFs used for each GHG in each subcategory
   B. Are calculated dividing the emissions of each GHG by representative AD
   C. Are not adequate for comparative purposes

6.1. Answer key

1. **The correct answer is 'False'**. Normally, these emissions are allocated under the IPPU sector, except in cases for which the fuels derived from the use of feedstocks in industrial processes are transferred to the energy sector for its use.

To learn more on combustion of fuels derived from feedstocks, see section 1.2 (vol. 2, chap.1, pp.1.5–1.6) and section 1.3.2 (vol. 3, chap. 1, pp.1.13–1.15) of the 2006 IPCC Guidelines.

2. **The correct answer is C**. The use of a tier 1 method to estimate emissions for key categories is not in accordance with the 2006 IPCC Guidelines. Although a hybrid tier 3–tier 1 approach is contemplated in the generalized decision tree for estimating emissions from fuel combustion; the use of a tier 1 approach would be appropriate when the unmeasured fraction of sources within the category does not belong to a key category, which is not the case here.

Note, however, that the MPGs (para. 23) indicate that a Party may use a tier 1 method instead of the recommended method in the 2006 IPCC Guidelines (higher tier for key categories) where national circumstances do not allow the use of a higher-tier method. In this case, the Party must provide in the NID an explanation as to why it was unable to implement a method in accordance with the 2006 IPCC Guidelines.

To learn more on methods to estimate emissions for key categories, see section 1.3.1.2 (vol. 2, chap. 1, pp.1.8–1.9) of the 2006 IPCC Guidelines.

3. **The correct answer is 'False'**. GHG emission characteristics from peat combustion have been shown in life-cycle studies to be comparable with those of fossil fuel combustion. Therefore, the 2006 IPCC Guidelines have included CO_2 emissions from combustion of peat in the national emissions as those for fossil fuels.

4. **The correct answer is E**. The combustion of recovered CH_4 from waste activities for energy purposes in stationary devices (option A) or road vehicles (option B) is reported under energy, as are the fugitive emissions from the distribution of recovered CH_4 because, once this recovered CH_4 is injected in natural gas distribution systems, it is indistinguishable from the circulating natural gas.
   Recovery of CH_4 from underground coal mines (option C) belongs to the energy sector. Since this activity does not belong to the waste sector, it obviously does not provide any connection between the two sectors.

5. **The correct answer is B**. IEFs are calculated automatically in CRTs by dividing reported GHG emissions by the corresponding AD reported by the Party. IEFs do not correspond to the mean of EFs used, but in certain cases (when emissions are estimated as the product of AD and an EF) may represent the weighted average of the EFs used. IEFs are most useful in evaluating

comparability of EFs (by category) used by different Parties and also comparability of used EFs with the IPCC default EFs.

7. Key points to remember

This lesson covered the main topics of the review of the energy sector of a national GHG inventory and its organization. These include:

- The three main categories of the energy sector and their relationships:
  - Fuel combustions activities;
  - Fugitive emissions from fuels;
  - CO_2 transport and storage;
- The types of fuels and the reporting requirements for the associated GHG emissions;
- CRTs for the energy sector contain data reported by Parties on GHG emissions, AD and resulting IEFs;
- The relationship between key categories, data availability and choice of methodology;
- The connections of the energy sector to the four other inventory sectors and the need to avoid omissions or double counting of emissions.

Lesson 3. Stationary combustion

1. Introduction

This lesson addresses the review of emission estimates for the stationary combustion categories.

1.1. Learning objectives

By the end of this lesson, you should be able to:

- Understand the key tasks to be undertaken in reviewing a Party's reporting of emissions for stationary combustion;
- Identify whether a Party's reporting of emissions for stationary combustion is consistent with the requirements in the MPGs;
- Be able to draft key recommendations that would allow a Party to address the issues identified for the stationary combustion categories.

1.2. Expected time needed to complete lesson 3

- For readers with experience in compilation of energy sector GHG inventories: 70–100 minutes
- For readers with less experience in compilation of energy sector GHG inventories: 120–200 minutes

2. Category overview and methodology information

2.1. Stationary combustion categories

Stationary combustion refers to all fuel combustion activities (i.e. fuels combusted for the purposes of creating usable energy) reported under category 1.A fuel combustion, excluding those reported under category 1.A.3 transport. Stationary combustion is divided into four categories, as presented in the 2006 IPCC Guidelines:

- Energy industries (category 1.A.1);
- Manufacturing industries and construction (category 1.A.2);
- Other sectors (category 1.A.4);
- Other (category 1.A.5).

Emissions from certain transport modes (off-road vehicles on farmland or in forests, and inland, coastal and deep-sea fishing) are reported under the category 1.A.4 other sectors. All remaining aviation and marine emissions not specified elsewhere (such as those from fuel delivered to the country's military and fuel delivered within that country but used by the militaries of other countries that are not

engaged in multilateral operations), as well as other emissions from mobile sources not included elsewhere, are reported under the category 1.A.5 other. However, 1.A.4 other sectors and 1.A.5 other are both combustion categories under stationary combustion.

For a complete list and definitions of stationary combustion categories, see table 2.1 of the 2006 IPCC Guidelines (vol. 2, chap. 2, p.2.7).

2.2. Estimation methods

For stationary combustion, the 2006 IPCC Guidelines provide a three-tiered approach to estimate emissions. The main features of each tier can be roughly summarized as:

- **tier 1**: default;
- **tier 2**: country-specific;
- **tier 3**: plant-specific or technology-specific.

Good practice in choosing the estimation method following the considerations in the decision trees is determined by national circumstances, which include the level of detail in the available data. In your assessment reviewing a key category is an important consideration. For key categories, Parties should make every effort to use a recommended method, in accordance with the generalized decision tree for stationary combustion in the 2006 IPCC Guidelines. However, if Parties are unable to collect or determine the required data for a higher tier, a tier 1 approach can be used, although this is not accommodated in the generalized decision tree for stationary combustion. In this case, the MPGs indicate that the Party must clearly document why the methodological choice was not in line with the corresponding decision tree of the 2006 IPCC Guidelines. You should first check the methodological choice made for key categories and if the choice is not in line with good practice, you should look for the explanations given in the NID, assess the issue and, if appropriate, provide the corresponding recommendation in the TERR.

To learn more about what the guidelines indicate when a recommended method has not been used, see section 4.1.2 (vol. 1, chap. 4, p.4.5) of the 2006 IPCC Guidelines and paragraph 23 of the MPGs. The generalized decision tree for stationary combustion is shown in figure 2.1 (vol. 2, chap. 2, p.2.15) of the 2006 IPCC Guidelines.

2.3. CO_2 and non-CO_2 emissions from stationary combustion

The generalized decision tree for stationary combustion applies to estimating CO_2, CH_4 and N_2O emissions. CO_2 emissions from certain fuels used under some stationary combustion subcategories (for example, liquid, solid and/or gaseous fuels under electricity and heat production) are usually identified as key categories under the level and/or trend assessment. CH_4 and N_2O emissions from stationary combustion are rarely identified as key categories under the level assessment but they may be identified as such under the trend assessment. Annex 3.1 to this lesson provides information about the characteristics of CO_2 and non-CO_2 emissions from stationary combustion.

Tier 1 estimates

For non-key categories, estimates performed using the tier 1 approach are in line with good practice. For these estimates, in your review you need to:

- Check whether the EFs used are the default values provided in tables 2.2 to 2.5 of the 2006 IPCC Guidelines (vol. 2, chap. 2, pp.2.16–2.22), according to the subcategory considered;
- Assess the AD used to ensure that that no omissions or double counting have occurred.

Further details are discussed in sections 2.5, 2.6, 3.1 and 3.2 below.

Tier 2 estimates

The review of tier 2 emission estimates requires the country-specific information used to be assessed:

- Except for the oxidation factor, the country-specific CO_2 EF of a given fuel depends only on the properties of the fuel, meaning that you would normally check the selected country-specific CO_2 EF only once for each fuel, which is expected to be the same across the different stationary combustion subcategories. If this is not the case, you should investigate why different CO_2 EFs have been used for the same fuel;
- For tier 2 estimates of CH_4 and N_2O emissions, EFs depend not only on fuel properties but also on the technologies and practices employed under the different stationary combustion subcategories. In these cases, you should check that country-specific data were chosen or developed using a similar path of assessment to that for CO_2. In addition, for the subcategory concerned, you need to assess whether the EFs are representative of the average conditions of the technologies and practices used.

AD require practically the same checks as those for tier 1 estimates. Specific review considerations concerning the non-energy use of fuels, fuel types and subcategories are discussed in sections 3.1 and 3.2 below.

Estimates using tier 3 approach and hybrid approaches

Many Parties have been collecting an increasing volume of plant-specific data and using them to estimate GHG emissions or to verify/cross-check country-specific EFs. These plant-specific data typically consist of measurements carried out at the facility level, for example of carbon content, NCV and oxidation factor of fuels for deriving plant-specific CO_2 EFs or measurement of GHG concentrations and volumetric flow rates at a stack determined from periodic stack tests or CEM. From these data, plant-specific EFs are developed or emissions are directly estimated based on CEM records.

For plant-specific EFs (including for example NCVs), you need to check how they have been chosen or developed following a similar path to that used for assessing tier 2 EFs. Note that in many cases, these EFs are developed by data providers external to the inventory compiler, often in the context of emissions trading systems. In such cases, you need to assess the QC checks performed by the data providers or the inventory compiler on the plant-specific data. If no QC checks have been performed on country- or plant-specific EFs, you may encourage the Party to perform appropriate category-specific QC checks in accordance with paragraph 35 of the MPGs.

For emission estimates based on CEM data, check that (i) documentation on QC of the measurements carried out is available (note that operators of installations subject to emissions trading systems must ensure that CEMs comply with specified requirements, such as calibration, validation and QA/QC during operation and annual surveillance testing); (ii) the associated fuel consumption is available; and (iii) incomplete time coverage or missing data, if any, have been treated adequately.

If the Party has used a hybrid approach, which includes a measurement-based tier 3 method, assess how completeness has been ensured and double counting has been avoided when measurements are available only for a fraction of all single sources under the category of subcategory considered.

2.4. Reporting emissions in the common reporting table

It is useful to have a copy of the CRT at hand to study the energy course. The CRTs are available at https://unfccc.int/documents/311076.
CRT 1 (sectoral report for energy) provides information on reported emissions of each GHG and precursor gas not only for stationary combustion but also for all categories in the energy sector. More disaggregated information, including emissions of each GHG (in kilotonnes) per each of the six main fuel types (liquid, solid, gaseous and other fossil fuels, peat and biomass), is reported in CRT 1.A(a) (sectoral background data for energy). In both your study and your review do not miss footnotes 3 (biomass), 6 (gaseous fuels), 7 (other fossil fuels) and 8 (peat) provided at the bottom of CRT 1.A(a) (sheet 4).

Keep in mind the specifications for the different types of waste composing other fossil fuels provided in table 1.1 (vol. 2, chap. 1, p.1.12) of the 2006 IPCC Guidelines.

Stationary combustion categories are reported in CRT 1.A(a) (sheet 1), 1.A(a) (sheet 2) and 1.A(a) (sheet 4). In addition to the GHG emissions (in kilotonnes), the reported information includes AD (fuel consumption of each main fuel type in terajoules), the resulting implied IEFs (in t/TJ for CO_2 and in kg/TJ for CH_4 and N_2O) and the amount of CO_2 captured (in kilotonnes).
Each IEF is calculated as the ratio between reported emissions and the corresponding consumption of each fuel type.

Note that a Party may collapse rows below 1.A.1.b and 1.A.1.c to protect confidential business and military information. In such cases, check the explanation provided by the Party in the documentation box. Include a recommendation in the TERR if no explanation has been provided or it is unclear even if the rationale for collapsing the rows is discussed in the NID.

Reporting CO_2 capture in CRT 1.A(a)

Where CO_2 is captured from stationary combustion sources:

- The amount of CO_2 captured is reported in the last column of CRT sectoral background 1.A(a);
- The associated CO_2 emissions reported here are the final emissions after subtracting the amount of CO_2 captured.

CO_2 IEFs are estimated on the basis of the amount of CO_2 before capture (i.e. CO_2 emissions actually emitted to the atmosphere plus the amount of CO_2 captured).
The amounts of captured CO_2 reported in CRT 1.A(a) should be compatible with but not necessarily equal to those reported in CRT sectoral background 1.C CO_2 transport and storage.

2.5. Activity data

Fuel consumption statistics by fuel type and economic activities, which can be related to the IPCC stationary combustion categories and subcategories, are needed to estimate emissions using tier 1 and tier 2 approaches. Many Parties provide access to the national energy balance in the NID, typically in an annex and often associated with the discussion of the reference approach. Familiarizing yourself with the national energy statistics and additional information on amounts and types of fuels combusted that

were used by the Party to estimate emissions is key for a good review as you need to check the AD used for calculations.

Fuel statistics must account for the amounts of all fuels delivered to the market; however, often there are non-marketed fuels such as fuel wood, other biomass and waste fuels that are only partially or not accounted in national statistics. Investigate the likely use of this type of fuel and assess how the AD have been collected and reconciled with national statistics. Direct imports by final consumers and own use of fuels, if any, also deserve particular attention.

Although fuel consumption is not needed to estimate emissions based on CEM data, fuel consumption disaggregated by fuel type, economic activity and combustion technology is needed when implementing and reviewing tier 3 estimates. Check how detailed AD were used to avoid omissions or double counting and for data reconciliation between plant-specific fuel use and national energy statistics.

To learn more about AD for stationary combustion see sections 2.3.3.1 and 2.3.3.3 (vol. 2, chap. 2, pp.2.29 and 2.32, respectively) of the 2006 IPCC Guidelines.

2.6. Emission factors

The NID must include sufficient information at the most disaggregated level regarding the choice and development of EFs, including descriptions, assumptions, references and sources of information used for the EFs. If part or all of this information is missing or is not transparently reported, you must identify the reasons by asking the Party for an explanation during the review and provide the corresponding recommendation in the TERR.

Note that paragraphs 19(b) and (c) and 39–40 of the MPGs contain “shall” requirements regarding inventory preparation and reporting of EFs.

CO_2 EFs

EFs for stationary combustion are typically expressed in kg per TJ on an NCV basis. The 2006 IPCC Guidelines provide in table 1.4 (vol. 2, chap.1, p.1.23) default carbon content for 53 fuels, which is the basic fuel property used to derive the default CO_2 EFs, calculated assuming fully oxidized carbon (fraction of carbon oxidized = 1). Lower and upper limits of the 95 per cent confidence intervals of the EF values are also reported in table 1.4. This information is valuable for the reviewer, for example, when assessing the accuracy and comparability of country-specific CO_2 EFs. Specific review topics for country-specific CO_2 EFs are discussed in section 3.1.
For each fuel, the same default CO_2 EF is repeated in tables 2.2 to 2.5 of the 2006 IPCC Guidelines (vol. 2, chap. 2, pp.2.16–2.22) for all stationary combustion subcategories because of its unique dependence on carbon content.

Non-CO_2 EFs

CH_4 and N_2O emissions are strongly dependent on technology and operating practices. Nevertheless, the 2006 IPCC Guidelines provide in tables 2.2 to 2.5 (vol. 2, chap. 2, pp.2.16–2.22) tier 1 default EFs for these two GHGs for all stationary combustion categories. They allow estimating CH_4 and N_2O emissions

using only fuel consumption data at the category level. Lower and upper limits of the 95 per cent confidence intervals are reported for each IPCC default non-CO_2 EF value.
Some technology-specific CH_4 and N_2O EFs for the main stationary combustion categories are provided as examples in tables 2.6 to 2.10 of the 2006 IPCC Guidelines (vol. 2, chap. 2, pp.2.25–2.29). This information may be of some use to you when reviewing tier 2 or tier 3 estimates that have used country-specific or technology-specific EFs, respectively. However, note that these EFs correspond to technologies without any emission control in use in or before 2005. For updated information you may wish to consult the IPCC Emission Factor Database (https://www.ipcc-nggip.iges.or.jp/EFDB/main.php) and/or more recent sources of information.
The review of non-CO_2 EFs is discussed further in section 3.1 below.

2.7. CO_2 capture

One important issue regarding stationary combustion is the review of the CO_2 capture step of a CCS system that removes CO_2 from a stationary combustion source in any of its three possible approaches:

- post-combustion;
- pre-combustion;
- oxyfuel combustion.

CO_2 capture may also occur in oil and natural gas and industrial processes. These topics are covered in lesson 6 of this course and in lesson 4 of the IPPU course, respectively.
Few CCS systems have been thus far implemented worldwide, especially associated with stationary combustion. The 2006 IPCC Guidelines consider that the amount of CO_2 captured from a stationary combustion process and the complementary amount of CO_2 that is not removed and finally discharged to the atmosphere would be estimated using plant-specific data. No specific guidance is included in the 2006 IPCC Guidelines; however, some typical capture efficiency values for post- and pre-combustion systems are provided in table 2.11 (vol. 2, chap. 2, p.2.36). These values can be used as references for reviewing purposes. Check if the efficiency of the capture process (CO_2 captured/CO_2 captured + CO_2 emitted) is within the range of the corresponding technology. If that is not the case, ask the Party for clarification and include a recommendation in the TERR if the Party does not provide an adequate explanation.
Further information on reviewing the transport and storage phases of a CCS system are described in lesson 7.

3. Review approach

Under the three main tasks of the review approach (Prepare – Assess – Draft) this topic focuses on the assessment of stationary combustion categories.
Before starting to assess the categories, it is advisable to get an overall picture of the energy sector of the country under review. You can get a quick idea from CRT 1.A(b) (reference approach), which provides information on the production, imports, exports and consumption level of each conventional fuel and more aggregated information of non-conventional fuels. It is expected that more detailed information will be available in the NID and from the national energy balance.
Drafting is covered in the walk-through example of this topic in section 3.4 below.

3.1. Main review topics across categories

Emissions from fuel combustion (stationary and mobile) have some common features, which imply that they also have some review aspects in common. These are listed below together with some guiding review questions.

Country-specific emission factors

Carbon content and net calorific value of a fuel:

- How are fuel properties derived (e.g. based on literature values, measurements, surveys or expert judgment)? Remember that reporting the descriptions, assumptions, references and sources of information used for the EFs is a 'shall' requirement in the MPGs (para. 39). Check the information provided in the NID and, if this is insufficient or not transparent enough, ask the Party for further information and include a recommendation in the TERR.
- Have the NCV, carbon content and CO_2 EF been compared with the central values and ranges reported in tables 1.2, 1.3 and 1.4 of the 2006 IPCC Guidelines (vol. 2, chap.1)? What results were obtained? Do the country-specific values fall within the 95 per cent confidence interval? If not, has the Party provided an explanation about the differences? Can any additional comparisons be made?
- Are the reported values consistent with the physical properties of the fuel? See box 3.1 for an example.

Box 3.1. Consistency of physical properties of fuels

For example, according to the sources, processing and sale specifications of the fuel, *consumer-grade* or *pipeline quality* natural gas may contain 87-98 mol % methane (C1) and 1.5-9 mol % ethane (C2) as main hydrocarbons. The richer the natural gas is in C1 the lower the CO_2 EF will be, while the higher content of C2 (C3, C4) will result in higher CO_2 EF. Checking the country-specific CO_2 EF against average natural gas composition would provide with insight into the consistency of fuel properties with the selected or derived CO_2 EF.

- Are they representative of average conditions in the country for the inventory year? Are they periodically derived (to take into account possible variability across time)? For further information see box 3.2.

Box 3.2. Changes of physical properties of fuels over time

Parties would normally submit national GHG inventories containing annual time series starting from 1990, except for those developing country Parties that need flexibility in the light of their capacities with respect to provision in paragraph 59 of the MPGs. For such long time series, the physical properties of some fuels may change noticeably over time because of changes in regulation, fuel specifications, imports, etc. These changes would likely imply changes in the carbon content and NCV of some fuels, which would lead to changes in CO_2 EF. Scatter plots of CO_2 EF (kg /TJ) against NCV (TJ/Gg) may provide a quick assessment of the consistency of the selected values. They would usually cluster in a region within the limits of the ranges for the IPCC default values and often they may exhibit significant correlations. Values outside the region of clustered values may indicate some mistake or a typical behaviour, which should be investigated by the reviewer.

- If a country-specific CO_2 EF for a given fuel was derived under a certain category, was this CO_2 EF applied for all categories in which this fuel is combusted? If this is not the case, find out the

reasons for using different CO_2 EFs for the same fuel and provide a recommendation if necessary.

Non-CO_2 emission factors:

- Similar to the derivation of country-specific fuel properties, assess if the Party has provided sufficient information in the NID explaining how the country-specific CH_4 and N_2O EFs were selected or developed. If not, include a recommendation in the TERR.
- Are the country-specific CH_4 and N_2O EFs adequate to estimate annual emissions at the inventory level to which they are applied?
- Are they based on measurements at full load or are start-up or partial load conditions appropriately taken into account?
- If any non-CO_2 IEF has been detected as an outlier, identify whether there are one or more country-specific EFs that may be driving this behaviour. Note that the IEF is the ratio of estimated emissions and reported AD in the sectoral background tables, and therefore the selected EFs would not always be the cause of atypical values of the corresponding IEF. You can also compare the IEF identified with those reported by other Parties with similar circumstances (e.g. regional) and ask the Party to provide the rationale for the value of the EF or EFs that may be responsible for the atypical values of the IEF.

Activity data

Typically, all tiers use fuel sales/deliveries from national statistics (to estimate or verify emissions and to reconcile plant-specific data) as proxy of fuel combusted as AD. However, the following should be noted:

- Are AD based on fuel delivered rather than on fuel combusted? In this case, check how stock changes and the non-energy use of fuels have been taken into account;
- How has the Party considered the fuel stock held by companies in its inventory?

Feedstock and non-energy use of fuels

- Are combustion and process emissions from feedstock or reductant use of fuels correctly allocated between the energy and IPPU sectors following the guidance in the 2006 IPCC Guidelines (in particular vol.3, box 1.1. and section 1.3.2) that was discussed in section 3.3 of lesson 2? These emissions are mostly reported under the IPPU sector but if derived fuels from an industrial process are transferred for combustion in a stationary combustion category, check that the emissions have been reported correctly. If notation key “IE” was used, check if the appropriate explanation was provided in CRT 9 and the NID.
- Are the emissions associated with the use of fuels as reductants, which occurs in the production of metals, reported in line with IPCC good practice in the IPPU sector under the corresponding category of 2.C metal industry?

See annex 3.2 to this lesson for further guidance on completeness for the estimation and reporting of emissions from metal production and also the 2006 IPCC Guidelines (vol. 3, annex 3.3, p.A3.5)

- Is non-energy use of fuels (e.g. lubricants, paraffin wax and white spirit) excluded from energy AD? Is any energy use of this type of fuel (e.g. paraffin wax) accounted under stationary combustion?
- Are feedstock, reductant and other non-energy use excluded from the reference approach? In such cases, verify that the Party reported the corresponding information in CRT 1.A(d) and the NID.
- Has the Party transparently explained how it is ensured that no double counting or omission of emissions occurs?
- How has the non-energy use of fuels been considered in the IPPU sector? It is advisable to coordinate with the IPPU expert(s) the verification of estimation and reporting of this use of fuels.

Questions relative to different types of fuel

Biomass

- Check if CO_2 emissions from the combustion of biomass used as fuel are estimated and that CH_4 and N_2O emissions (but not CO_2) are included in the national totals. Check that, if occurring, CO_2 emissions from the combustion of biomass are reported in CRT 1.A(a) and notation keys such as “NA” or “NO” are not used for this purpose.
- Biofuels, particularly biodiesel, are increasingly used for stationary combustion, mostly in industrial and utility boilers. The same considerations for biomass used as fuel must be given to the review of biofuels and their blends. This is discussed in detail in lesson 4 (mobile combustion).
- Consider the possible use of non-marketed fuels discussed in section 2.5. Statistics from the Food and Agriculture Organization of the United Nations (FAOSTAT) on agriculture and forestry products may be of help in your review.
- Verify that CO_2 and non-CO_2 emissions from the combustion for energy purposes of non-traditional fuels with biogenic carbon content such as landfill gas, sludge gas, other biogas and the biomass fraction of solid waste have been estimated and reported adequately. Interaction with reviewers of the waste sector is often very helpful in reviewing the amounts and carbon content of these fuels.

Peat

- Check that CO_2, CH_4 and N_2O emissions are estimated and reported and included in the national totals.

Non-conventional fuels

The use of waste derived and other unconventional fuels (such as refinery gas, fuel oils and residues in refineries) may require special attention because of difficulties in obtaining AD and deriving EFs. In your assessment consider the following:

- If the original AD are provided in mass or volume units, how was this converted to energy units?
- How were the used NCVs calculated?
- How were the EFs selected or developed?

  For NCVs and EFs compare the values with the ranges of default values provided in tables 1.2 and 2.2–2.5 of the 2006 IPCC Guidelines (vol. 2, chap. 1, pp.1.18–1.19 and chap. 2, pp.2.16–2.23, respectively) if information on such unconventional fuels is available, and further request information from the Party when there are noteworthy discrepancies;
- For waste incineration with energy recovery, was appropriate consideration given to the biogenic and fossil fractions? For the fossil fraction, check that CO_2, CH_4 and N_2O emissions are estimated, reported and included in the national totals;
- Check that reporting in CRT 1.A(a) (sheet 4) was satisfactory regarding:
  - Providing information on the fuels included under other fossil fuels in the documentation box;
  - Reporting emissions from waste incineration with energy recovery subdivided into biogenic and fossil emissions as an information item.

CO_2 capture and CH_4 recovery

CO_2 captured

Although the CRTs provide a column to report the amount of CO_2 captured for all stationary combustion categories, it is expected that this removal of CO_2 would most likely occur in activities under energy industries or manufacturing industries and construction. Review features for you to consider include:

- Are the estimates based on plant-specific data?
- Is the reporting under CO_2 transport and storage compatible with but not necessarily equal to the amount of CO_2 captured reported in CRT 1.A(a)?

Recovered CH_4

If CH_4 recovered from coal mines, solid waste disposal or wastewater treatment is burned for energy purposes in activities reported under stationary combustion, consider the following:

- Are the emissions from combustion estimated and reported under the corresponding category?
- Is the amount of combusted recovered gas netted out from the corresponding energy or waste category?

3.2. Category-specific considerations

There are specific considerations to take into account in reviewing each stationary combustion category. Note that many of the common features discussed in the previous section are pertinent for most if not all stationary combustion categories.

Linkages among stationary combustion categories/subcategories and between stationary combustion categories/subcategories and other energy categories/subcategories, such as energy industries and fugitive emissions, were depicted in section 2.6 of lesson 2 while the linkages with other sectors in the GHG inventory were depicted in sections 3.1–3.6 of lesson 2. One key aspect to review when linkages occur is whether the Party has ensured that no double counting or omission of emissions occurred.

Before starting a detailed assessment of stationary combustion categories, you should have a good knowledge of the information reported by the Party about the fuels that are combusted under stationary combustion, AD sources, EF selection and choice of estimation methods. Specific issues for the review of each stationary combustion category are discussed below.

1.A.1 energy industries

CO_2 emissions from use of certain fuels in energy industries would be likely to be identified as key categories. Therefore, most of the considerations in topics 2 and 3 regarding decision trees and the choice of methods of this lesson would have to be taken into account in your assessment. These include:

- Use of higher-tier methods in accordance with the methodological guidance in the 2006 IPCC Guidelines. Explanations provided by the Party if a tier 1 method was used for key categories;
- Use of country-specific EFs;
- Consistent use of AD if hybrid methods are applied so that fuel consumption at the level of individual facilities is reconciled with national energy statistics;
- Feedstock and non-energy use of fuels;
- Use of biomass fuels and the possible connections with the agriculture and LULUCF sectors as depicted in sections 3.4 and 3.5 of lesson 2 with regard to the use of agricultural crop residues, manure, wood and wood waste for energy purposes;
- Use of non-conventional fuels and the connections with other energy categories and the waste sector;

Remember that the main links occur through derived fuels (such as refinery gas and oil residues) from petroleum refining and oil and gas extraction and the use of CH_4 recovered from coal mining.

- Relevant information if CO_2 is captured for CCS and/or CH_4 recovered is burned under this category.

In addition, a few considerations specific to the different subcategories within energy industries are treated below.

1.A.1.a public electricity and heat production

- Are only emissions from main activity producers allocated to this subcategory?

Keep in mind the definitions in table 2.1 (vol. 2, chap. 2, p.2.7) of the 2006 IPCC Guidelines:
"Main activity producers (formerly known as public utilities) are defined as those undertakings whose primary activity is to supply the public. They may be in public or private ownership. Emissions from own on-site use of fuel should be included. Emissions from autoproducers (undertakings which generate electricity/heat wholly or partly for their own use, as an activity that supports their primary activity) should be assigned to the sector where they were generated and not under 1 A 1 a. Autoproducers may be in public or private ownership."

- If there are autoproducers of electricity and/or heat, are the associated emissions allocated to the category where they were generated and not under subcategory 1.A.1.a? Note that autoproducers typically belong to industrial or commercial branches and their emissions are to be reported under the corresponding subcategory of manufacturing industries and construction (1.A.2) or commercial/institutional – stationary combustion (1.A.4.a.i).

1.A.1.b petroleum refining

- Does the reporting of AD and the corresponding emissions from petroleum refining consistently reflect the split between fuel combustion activities (1.A.1.b) and fugitive emissions (e.g. 1.B.2.a.4 refining and storage)?
- Are the emissions from petroleum refining and production of petrochemicals, if conducted in the same facility, adequately differentiated, in particular ensuring that no double counting or omission of emissions occur? Are mass and carbon balances available to verify this? If the balances are not available, ask the Party how the AD and the corresponding fuel combustion emissions were allocated to subcategories 1.A.1.b and 1.A.2.c chemicals and how it ensured that no double counting or omission of emissions occur. Include a recommendation in the TERR if necessary.

1.A.1.c manufacture of solid fuels and other energy industries

- Are all emissions from fuel combustion for the production of coke, brown coal briquettes and patent fuel reported under 1.A.1.c? Has the Party calculated and reported a carbon balance, in particular for coke production in integrated iron and steel mills, bearing in mind that emissions from fuel combustion in coke ovens within the iron and steel industry should be reported under 1.A.1.c and not within manufacturing industry? If the balance is not available, ask the Party how emissions from fuel combustion for the production of coke were allocated. Include a recommendation in the TERR if necessary.

- Are fugitive emissions from coke production distinguished from combustion emissions and reported under subcategory 1.B.1.b solid fuel transformation?
- For coke produced in an integrated iron and steel mill, are the emissions associated with coke production reported under the energy sector, while those associated with the use of coke in the process reported under the IPPU sector? Have additional QC procedures performed by the Party on this issue that you as reviewer can check?

1.A.1.c manufacture of solid fuels and other energy industries

- Does the reporting of emissions from oil and gas extraction reflect the split between stationary combustion emissions and fugitive emissions? This is, are combustion emissions reported under fuel combustion activities (1.A.1.c.ii oil and gas extraction) and fugitive emissions under the corresponding subcategories 1.B.2.a oil and/or 1.B.2.b natural gas?
- Are all combustion emissions from own-energy use for the production of charcoal and carbonizing of biofuels, as well as fuel used for coal mining, and from pre-combustion processing for CCS reported under 1.A.1.c?
- Are fuel combustion emissions from other energy industries such as gas liquefaction plants, oil shale extraction and shale oil treatment, nuclear fuel reprocessing and manufacture of liquid and gaseous fuels from “in situ” primary fuels reported under 1.A.1.c?

1.A.2 manufacturing industries and construction

General considerations for this category are practically the same as discussed for energy industries. Remember that off-road and mobile machinery used in industries are reported under this category. Specificities of the review for some subcategories under 1.A.2 are as shown below.

1.A.2.a iron and steel

- Is fuel combustion in coke ovens excluded from 1.A.2.a and reported under 1.A.1.c?
- For integrated iron and steel plants with on-site coke production, are energy emissions and IPPU emissions distinguished, ensuring that no double counting or omissions of emissions occur? See box 3.3 for more information.

Box 3.3. Allocation of emissions from combustion under iron and steel

Carbon combusted in the form of coke oven gas at an iron and steel plant and the resulting CO_2 and CH_4 emissions should be reported under the IPPU sector, unless the coke oven gas is sold off site, in which case, emissions are reported under the energy sector. Carbon combusted in the form of blast furnace gas at an on-site coke production facility and the resulting CO_2 and CH_4 emissions should be reported under the energy sector.

- Are gases from basic oxygen steel furnaces recovered and included with blast furnace gas? If not, how are these emissions reported?

1.A.2.c chemicals

- If steam cracking of petrochemical feedstock occurs, what procedure has been employed to identify the quantities of by-products used as fuel? See box 3.4 for more information.

Box 3.4. Allocation of emissions from combustion at petrochemical plants

In steam cracking of petrochemical feedstock, some by products (for example, propane in the bottom stream from the C3 splitter) are sent back to the furnaces for cracking or used as fuel. In these cases, the allocation of AD and the corresponding emissions from combustion must follow the guidance in the 2006 IPCC Guidelines (in particular box 1.1. and section 1.3.2 of volume 3) that was discussed in section 3.3 of Lesson 2.

1.A.4 other sectors

General considerations for this category are practically the same as discussed for energy industries. Specificities of the review for some subcategories under 1.A.4 are as shown below.

1.A.4.a commercial/institutional

- Are emissions from stationary combustion at airports, ports, train stations and railway power stations included in this subcategory?
- Are emissions from combustion of support fuels (other than waste) in waste incineration plants without energy recovery reported in this category?

Note that emissions from the combustion of waste in waste incineration plants without energy recovery are estimated and reported in the waste sector under category 5.C.1 (waste incineration).

1.A.4.c agriculture/forestry/fishing

- Are the emissions from fuel use for pumping, grain drying and horticultural greenhouses included?
- Regarding mobile emissions under this subcategory:
  - How is it ensured that there is no double counting between this subcategory and 1.A.3.e other transportation? It is important to assess that in gas/diesel oil balance (and to some extent in gasoline balance) there is an appropriate disaggregation allowing allocation of the fuel to subcategory 1.A.4.c so there is no double counting.
  - Are emissions from coastal and deep-sea fishing from vessels of all flags refuelled in the country included?
  - Are emissions from fuels combusted in off-road vehicles on farmland and in forests included?

Note that emissions from the use of agricultural vehicles on paved roads should be reported under road transportation.

3.3. Key points to consider when reviewing cross-cutting issues

Time-series consistency

- Variability in the properties of fuels that affect EFs and NCVs may be associated with:
  - Variations in the properties of primary fuels within the country and throughout the years (properties of secondary fuels exhibit less variability as they are delimited by market and regulatory constraints; however, in recent years environmental regulations such as those related to sulfur content may have had an impact on non-CO_2 emissions).
  - Different origin of imported fuels throughout the years.
- Use of consistent sources of AD.

Uncertainty assessment

The main concern in the uncertainty analyses relates to the uncertainty values used for EFs and AD. The 2006 IPCC Guidelines provide default uncertainty values for CH_4 and N_2O EFs and examples of uncertainty ranges for CO_2 and non-CO_2 EFs and AD. You should assess how the uncertainty estimates for EFs and AD have been selected or derived, the correctness of the method used, especially for error propagation methods, and how the results are reported in the NID in accordance with the MPGs.

To learn more, see sections 2.4.1 and 2.4.2 (vol. 2, chap. 2, pp.2.38 and 2.40, respectively) of the 2006 IPCC Guidelines and paragraphs 29 and 44 of the MPGs.

Remember that developing countries that need flexibility in the light of their capacities are encouraged, not required, to provide quantitative estimates of uncertainty as discussed in lesson 3 of the overview and cross-cutting course.

Quality assurance and quality control

Specific review steps for the information on QA/QC procedures for stationary combustion include the following:

- Has the Party reported on category-specific QC checks implemented and planned in the NID in accordance with paragraph 35 of the MPGs?
- Are AD and EF checks undertaken by the Party?
- For measurement-based tier 3 estimates, assess the information on QA/QC applied to these measurements;
- Explore the results of the comparison between the national estimates of CO_2 emissions from fuel combustion obtained using the sectoral approach with those obtained using the reference approach for those fuels that are exclusively used for stationary combustion in the Party (see box 3.5). Assess whether significant differences exist between the estimates of total CO_2 emissions from stationary combustion using the two approaches. In such cases try to identify the categories or subcategories that are

driving these differences and formulate questions to the Party with regard to the accuracy of the corresponding CO_2 emission estimates, as appropriate.

Box 3.5. Comparison of CO_2 estimates for specific fuels used under stationary combustion

Although the CO_2 emissions estimated using the top-down reference approach correspond to national totals that include both, stationary and mobile combustion, for many Parties certain fuels would most likely be used for stationary combustion only (for example, coal, other kerosene, peat, refinery gas, solid biomass). In these cases, the results of the reference approach can be used to compare the total CO_2 emission estimates from stationary combustion obtained using the sectoral approach.

Remember that developing countries that need flexibility in the light of their capacities are encouraged, not required, to implement and provide information on general inventory QC checks (para. 35 of the MPGs) as discussed in lesson 3 of the overview and cross-cutting course.

3.4. Walk-through example

You will work here in a five-step example of a review inspired by the submission of Party A and the previous TERR. Both information sources are the starting point but the flow of information, particularly that between the TERT and the Party, is entirely a construct. The example simulates working in a subsequent review cycle using the previous TERR as one of the information sources.
The example covers the following topics: (1) use of notation keys; (2) checking the status of previous TERR recommendations; (3) formulating questions; (4) assessing inconsistencies with the MPGs; and (5) drafting the TERR.

Background information

Although the following recommendation comes from the generalist of the previous TERT, as an energy expert you must assess the issues of your sector.

Previous recommendation

The TERT noted that Party A has made improvements in its use of notation keys; however, there are still some cells that are blank (e.g. CRT 1.C) and there are cases of incorrect use of notation keys or lack of explanatory information in the NID on the use of some notation keys as described in the sectoral part of this report. Thus, Party A uses notation key "NA" in a number of categories in all sectors and some of these activities do occur within the country and result in emissions (e.g. CH_4 and N_2O emissions from chemicals (manufacturing industries and construction)) and therefore should be estimated and reported or otherwise other notation keys such as "NE", "IE" should be used, as appropriate, to report these categories. In response to the questions raised by the TERT, Party A indicated that this issue will be addressed, and the TERT comments will be taken into account more strictly.

In addition, Party A has not provided in the NID detailed information or explanations on the assessment of completeness. In CRT 9, the Party reported an explanation on the use of notation key "IE" for three categories from the energy sector. However, apart from that, Party A has not provided in the CRTs or in the NID any information on the use and justification of use of notation keys "NE" and "IE".

The TERT recommends that the Party complete all cells and not leave blank cells in the CRTs and ensure the correct use of the notation keys (including "NA") in the CRTs in line with the MPGs, paragraph 31. The TERT further recommends that the Party provide justification on the use of notation keys, particularly the notation keys "NE" and "IE", in the NID and in CRT 9.

In this example, we concentrate on stationary combustion only. Access CRT 1, CRT 1.A.(a) and CRT 9 for the latest year of the submission of Party A needed for this example, available in the Supplementary Material in file https://unfccc.int/resource/tet/be/be3-01_en3_exmpl.xlsx.

1. Identify the use of notation keys in CRT 1.A(a) for stationary combustion

Organize your work by doing a small analysis of the previous recommendation taking into consideration the following:

- What elements are there?
  - Use of notation keys, particularly "NA", "NE" and "IE";
  - Assessment of completeness;
  - CRT 9.
- What were the issues?
  - Lack of explanatory information on the use of notation keys;
  - Detailed information on the assessment of completeness not provided in the NID;
  - Incomplete information in CRT 9 on the use of notation keys "NE" and "IE".
- What was the Party recommended to do?
  - Complete all cells without leaving blank cells in the CRT;
  - Ensure the correct use of the notation keys in the CRTs.

Provide justification on the use of notation keys, particularly "NE" and "IE", in the NID and in CRT 9.

Review of the use of notation keys in the Party's latest submission

Now that you have considered the issues identified by the previous TERT and the recommendations provided, you can start working with the materials for the review. Look for the use of notation keys "NO", "NA" and "IE" in CRT 1.A(a) (sheets 1, 2 and4). Table 3.1 shows a summary of the use of these notation keys. Note that we have not asked you to consider the use of notation keys "NE" and "C" (confidential) as the Party has not used these to report any stationary combustion activity or emission.

Table 3.1. Use of notation keys "NO", "NA" and "IE" for stationary combustion

Notation key	Fuel	Category: subcategory(ies)
NO	Peat	All stationary combustion categories
NO	Biomass	Waste incineration with energy recovery
NO	Fossil fuels	Waste incineration with energy recovery
NA	Biomass	Energy industries: petroleum refining; manufacture of solid fuels and other energy industries
NA	Other fossil fuels	Manufacturing industries and construction: non-ferrous metals; pulp, paper and print
NA	Other fossil fuels	Other sectors: agriculture/forestry/fishing
NA	Gaseous fuels	Other sectors: agriculture/forestry/fishing – off-road vehicles and other machinery
IE	Other fossil fuels	Energy industries

IE	Other fossil fuels	Manufacturing industries and construction
IE	Other fossil fuels	Other sectors: residential; agriculture/forestry/fishing
IE	Gasoline	Other sectors: agriculture/forestry/fishing – off-road vehicles and other machinery
IE	Diesel oil	Other sectors: agriculture/forestry/fishing – off-road vehicles and other machinery
IE	LPG	Other sectors: agriculture/forestry/fishing – off-road vehicles and other machinery
IE	All fuels	Other sectors: agriculture/forestry/fishing – fishing

2. Check the status of previous recommendations and look for inconsistencies with the MPGs

From the inspection of the sectoral background data CRT 1.A(a), you identified that the Party is using notation keys "NO", "NA" and "IE" for certain fuels in certain stationary combustion categories and subcategories. However, the use of these notation keys does not imply that the Party has not addressed previous recommendations adequately. To assess whether the previous recommendation has been resolved or to possibly identify new issue(s), you need to refine your analysis, noting that further information is required.

Preliminary findings by the reviewer

A summary indicating the use of each notation key and the additional information that you would consider in the NID, the CRTs and possibly elsewhere to refine your assessment is shown below.

Notation key "NO"

- The use of three fuels is reported as "NO": peat under all stationary combustion categories, biomass and fossil fuels for incineration with energy recovery.
- The NID should be consulted to obtain more information in this regard. It would also be advisable to consult the LULUCF and waste experts of the TERT because more information on peat and waste incineration, respectively, may be discussed in these sectors.
- Although expert reviewers undertake the review of the information provided in the Party's NID and CRT submission on a bona fide basis, it is useful to check alternative information sources (International Energy Agency and United Nations energy statistics and/or Internet search), especially for categories reported as "NO".

Notation key "NA"

- The use of biomass, other fossil fuels and gaseous fuels is reported as "NA".
- According to paragraph 31 of the MPGs, the use of notation key "NA" for AD and GHG emissions in CRT 1.A(s) indicates that the activity occurs within the Party but does not result in GHG emissions. The use of "NA" for stationary combustion seems rather inappropriate. It seems unlikely that any combustion which occurs would not emit GHGs.
- The NID should be consulted to check whether the Party provides its interpretation of this notation key and explains its use.

Notation key "IE"

- The use of other fossil fuels under energy industries, manufacturing industries and construction, residential and agriculture/forestry/fishing is reported as "IE". The use of other

fuels is only reported under commercial/institutional. In addition, liquid fuels under off-road vehicles and all fuels under fishing are reported as "IE".

- CRT 9 and the NID should be consulted for an explanation of where the use of the above-mentioned fuels was allocated.
- For other fossil fuels, it should be checked whether the Party provides information in the documentation box in CRT 1.A(a) (sheet 4) on which fuels are included and also a reference to the NID where this is discussed.

3. Formulate questions to the Party

Consult CRT 9 and assume (for the purpose of this example) that the NID does not provide the necessary information to address the findings listed in step 2. In addition, assume that you found that the United Nations energy statistics report no consumption of peat in Party A in 1990–2004 and after 2008 up to the present; however, some use of peat is reported for 2005–2007.
Based on the analysis of the available information, decide for each notation key whether some of your findings may need recommendations. However, you would probably need to ask the Party for clarification or further information before you can reach a conclusion.
Formulate appropriate questions to the Party, include a title indicating category – type of fuel – GHG and a brief description of your finding (e.g. use of notation key "NO").

Preliminary questions to the Party

1.A Fuel combustion – peat – CO_2, CH_4, N_2O – use of notation key "NO"

Party A reports the use of peat as "NO" for all categories under stationary combustion for the entire time series. The TERT noted that the United Nations energy statistics report that peat has been used in the country in 2005, 2006 and 2007. The TERT would appreciate it if Party A clarified whether peat was used for energy purposes in 2005–2007.

1.A Fuel combustion – biomass, other fossil fuels and gaseous fuels – CO_2, CH_4, N_2O – use of notation key "NA"

CRT 1.A(a) reports the use and associated GHG emissions of biomass, other fossil fuels and gaseous fuels for several stationary combustion categories using notation key "NA". The TERT would appreciate it if Party A could clarify why the combustion of the mentioned fuels under the subcategories reported as "NA" does not result in GHG emissions.

1.A Fuel combustion – all fuels – CO_2, CH_4, N_2O – use of notation key "IE"

Party A uses notation key "IE" for the following fuels and categories:

- Other fossil fuels under (i) energy industries category, (ii) manufacturing industries and construction category and (iii) residential and agriculture/forestry/fishing subcategories of other sectors;
- Liquid fuels (gasoline, diesel oil and LPG) under off-road vehicles;
- All fuels under fishing.

The TERT notes that Party A does not provide information on which fuels are included under other fossil fuels in the documentation box of CRT 1.A(a). In addition, the TERT notes that the information about the use of notation key "IE" provided by the Party in CRT 9 reports only for subcategory 1.A.1.a electricity and heat production that "according to the Agency of Statistics of the Party A since 2009, other fuels in the Fuel-Energy Balance are included, but not separately monitored due to the codes lack of entering into a common software package".

The TERT would appreciate it if Party A indicated (i) which fuels are included under the denomination "other fossil fuels", (ii) the allocation of the use and associated GHG emissions for all fuels and subcategories reported as "IE" and (iii) how it was ensured that omission or double counting of emissions have not occurred.

4. Inconsistencies with the MPGs

It is likely that the questions and answers dialogue would continue with further questions by the TERT and clarifications by the Party. For the purpose of this example, we assume that the Party's answers allow the TERT to decide if each finding leads to a recommendation or if it can be closed. The Party's answers are summarized below.

- 1.A Fuel combustion – peat – CO_2, CH_4, N_2O – use of notation key "NO"
  - Peat use was confirmed for electricity and heat production in 2005, 2006 and 2007.
- 1.A Fuel combustion – biomass, other fossil fuels and gaseous fuels – CO_2, CH_4, N_2O – use of notation key "NA"
  - Biomass – petroleum refining; manufacture of solid fuels and other energy industries: small amounts of biomass fuels were combusted under these categories. Emissions were considered insignificant.
  - Other fossil fuels – non-ferrous metals; pulp, paper and print; agriculture/forestry/fishing: total use of other fossil fuels accounts for only 0.002 per cent of the total fuel use under stationary combustion. The use of this fuel for all stationary combustion categories is included under commercial/institutional (the Party did not provide information on the fuels included under other fossil fuels).
  - Gaseous fuels – agriculture/forestry/fishing – off-road vehicles and other machinery: this use does not occur in the country.
- 1.A Fuel combustion – all fuels – CO_2, CH_4, N_2O – use of notation key "IE"
  - Other fossil fuels – manufacturing industries and construction; agriculture/forestry/fishing: see answer on use other fossil fuels above.
  - Gasoline, diesel oil, LPG – agriculture/forestry/fishing – off-road vehicles and other machinery: the three fuels are included under liquid fuels.
  - All fuels – agriculture/forestry/fishing – included under subcategory 1.A.4.c.i stationary.

Based on the answers provided above, recommendations are needed on completeness for peat and biomass, on accuracy and transparency for other fossil fuels; and on transparency for gaseous fuels, liquid fuels use in off-road vehicles under machinery – other sectors and use of all types of fuels under fishing.

Recommendation by the reviewer on the use of biomass

Write your recommendation on biomass, taking into account the following: (i) what is the finding identified?; (ii) why is it a problem?; (iii) describe any explanation provided by the Party during the review, including challenges identified by the Party to estimate emissions consistent with the MPGs; (iv) what ideal situation would solve the problem?; and (v) what is the recommendation by the TERT?

- What is the inconsistency identified?
  - The Party reported as "NA" the use and associated GHG emissions of biomass under petroleum refining and manufacture of solid fuels and other energy industries. During the

review, the Party indicated that relatively small amounts of biomass are used but the associated GHG emissions were considered negligible. However, the Party did not provide justifications for exclusion in terms of the likely level of CH_4 and N_2O emissions as indicated in paragraph 32 of the MPGs.

- Why is it a problem?
  - Although the emissions may seem small, the inventory is not complete. In addition, notation key "NE" should have been used as the activity and the emissions occurred.
- What ideal situation would solve the problem?
  - The Party either estimating and reporting the GHG emissions or reporting them as "NE".
- What is the recommendation by the TERT?
  - Estimate and report the GHG emissions from biomass use under petroleum refining and manufacture of solid fuels and other energy industries, include the CH_4 and N_2O emissions in the sectoral and national totals and report the CO_2 emissions as a memo item. If the Party considers that the emissions are insignificant, it should provide adequate justification in line with the MPGs.

5. Provide input to the generalist and draft recommendation in the technical expert review report

You should provide inputs to the TERR from the work done so far:

- Inform the generalist of your TERT to conclude on the assessment of issues associated with the use of notation keys for stationary combustion and the rationale for the status of implementation of the recommendation included in the previous TERR;
- Draft corresponding new specific recommendations to be included in the TERR.

Information for the generalist

Draft your conclusions on the status of implementation of the previous recommendation on the use of notations keys for stationary combustion (whether the Party has resolved this issue or not) and your rationale for it. This is to be provided to the generalist of the TERT.

The Party has not resolved this issue.

The Party used notation key "NA" for activities which occur (use of biomass under petroleum refining and manufacture of solid fuels and other energy industries) and for activities that do not occur (gaseous fuels in off-road vehicles and other machinery under agriculture/forestry/fishing). The Party used notation key "NO" for an activity that occurred (use of peat for electricity and heat production for 2005–2007). The Party used notation key "IE" without providing information in CRT 9 and the NID for the use of other fossil fuels for many stationary combustion categories and for the use of liquid fuels in off-road vehicles and other machinery under agriculture/forestry/fishing.

Recommendation by the technical expert review team

Draft your recommendation on the estimation of GHG emissions from the use of biomass in the TERR. The file with the template for your inputs contains instructions on how to draft your new finding in the TERR and a table format for your drafting on the finding and recommendation. The template to input your recommendation on the identified issue on biomass is available in the Supplementary Materials at https://unfccc.int/resource/tet/be/be3-02_en_terr_template.docx. An example is shown below.

Finding classification	*Description of the finding with recommendation*	*Classify by type*
1.A.1 energy industries – biomass CO_2, CH_4, N_2O	AD and associated GHG emissions of biomass under subcategories 1.A.1.b petroleum refining and 1.A.1.c manufacture of solid fuels and other energy industries are reported using notation key "NA". According to paragraph 31(c) of the MPGs, notation key "NA" denotes activities under a given source/sink category that occur within the Party but do not result in emissions or removals of a specific gas. The TERT notes that the use of notation key "NA" for reporting emissions from biomass implies that the combustion of biomass occurs under the cited subcategories and therefore it is expected that this combustion would result in GHG emissions. During the review, the Party indicated that relatively small amounts of biomass are used but the associated GHG emissions were considered negligible. However, the Party did not provide justifications for exclusion in terms of the likely level of emissions as indicated in paragraph 32 of the MPGs. The TERT recommends that Party A estimate and report the GHG emissions from biomass use under subcategories 1.A.1.b petroleum refining and 1.A.1.c manufacture of solid fuels and other energy industries, include the CH_4 and N_2O emissions in the sectoral and national totals and report the CO_2 emissions as a memo item. If the Party considers that the emissions are insignificant, the TERT recommends that the Party report AD and GHG gas emissions using notation key "NE" and provide adequate justification in the NID for exclusion of these GHG emissions in line with paragraph 32 of the MPGs.	Completeness

Comments on the example for stationary combustion

The in-depth review of the energy-related issues arising from a seemingly general comment from the previous TERR of Party A allowed you to go through nearly all stationary combustion categories and assess the use of some relatively less-used fuels.

Note that the inconsistencies identified in the example were largely related to the fact that the CRT of Party A were used as a starting point for the review and that the case was constructed assuming that the NID did not contain any information on the issues referred to in the previous recommendation and on the basis of a few answers by the Party to your preliminary questions.

Throughout this example you have done all that is expected to be done in an actual review with regard to the analysis of the implementation of previous recommendations, including information for the generalist of the TERT.

4. Practical exercises

You will work with exercises in the following areas:

- Exercise 1: Energy industries – gaseous fuels – CO_2 emission factors;
- Exercise 2: Energy industries and manufacturing industries and construction – all fuels – use of plant-specific data;
- Exercise 3: Non-energy use of fuels – solid fuels;
- Exercise 4: Energy industries – liquid fuels – CO_2 emission factors;
- Exercise 5: Food processing, beverages and tobacco – biomass – CH_4 emission factors.

4.1. Exercise 1. Energy industries – gaseous fuels – CO_2 emission factors

The value reported in CRT 1.A(a) (sheet 1) of the CO_2 IEF for gaseous fuels in energy industries for the entire time series (54.9 t/TJ) was below the IPCC default value (56.1 t/TJ) and close to the lower end of the 95 per cent confidence interval range of values (54.3 t/TJ). In principle, this value may be possible

as it is within the 95 per cent confidence interval range of values. However, as a reviewer you should be interested to know the reasons for this relatively low value.
In response to your first preliminary question requesting the Party to explain the reasons underlying this relatively low CO_2 IEF, the Party referred to the changes in the use of coke oven and blast furnace gas and lignite. In response to a follow-up question, the Party explained that coke oven and blast furnace gas are reported as solid, not gaseous, fuels.
Do you think that the Party satisfactorily addressed the questions by the TERT?

A. Yes
B. No

4.2. Exercise 2. Energy industries and manufacturing industries and construction – all fuels – use of plant-specific data

Starting from 2005, Party A used plant-specific data from the EU ETS to report the majority of CO_2 emissions from energy industries and manufacturing industries and construction, which are key categories.
From the EU ETS reporting framework, you learn that depending on the plant capacity, the emission estimates can be performed using methods equivalent to tier 1, 2 or 3 of the 2006 IPCC Guidelines. Therefore, the use of data from the EU ETS that are based on tier 1 for key categories is not in line with the generalized decision tree for stationary combustion of the 2006 IPCC Guidelines. Your preliminary question concerned whether the plant-specific data used for the inventory were based on higher-tier methods only (i.e. data from tier 1 methods, if any, were excluded).
In response to your question, the Party provided, as an example, part of a monitoring plan and explained that it would be difficult to provide specific information on the methodologies, EFs, NCVs and oxidation factors of the plants under the EU ETS in the NID as these data can be different for each plant (each plant has its own emissions trading permit and a monitoring plan, as required by the EU ETS). The Party also explained that the monitoring plan is confidential.
In spite of confidentiality, you consider that:

A. The Party should include all the information reported under the EU ETS in an annex to its NID
B. The national inventory arrangements should ensure that the inventory compiler has access to the relevant information reported under the EU ETS
C. The Party should ensure that the emissions and associated parameters from the EU ETS have been estimated in line with good practice of the 2006 IPCC Guidelines (methods equivalent to tier 2 or tier 3 for key categories)
D. B and C

4.3. Exercise 3. Non-energy use of fuels – solid fuels

In the previous review report it was recommended that the Party report GHG emissions from the combustion of solid fuels in subcategory 1.A.2.b non-ferrous metals in the energy sector separately from the emissions from the part of solid fuels used as reducing agents or anodes reported in the IPPU sector. The TERT notes that the Party continues to report all GHG emissions (combustion and process) together under the energy sector, which is not in accordance with the 2006 IPCC Guidelines. The current NID indicates that the AD used to estimate these emissions are in line with the information provided by the General Energy Statistics Office and therefore the approach adopted ensures the complete accounting of GHG emissions and avoids double counting.

In your review, you would:

A. Reiterate the previous recommendation with no further inquiries
B. Identify in which metal production process(es) the solid fuels of concern are being used as reducing agents of anodes

4.4. Exercise 4. Energy industries – liquid fuels – CO_2 emission factors

The CO_2 IEF for liquid fuels reported for subcategory 1.A.1.a public electricity and heat production dropped from 73.4 CO_2 t/TJ in 1990 to 57.9 t/TJ from 2011 onward. The values of the CO_2 IEFs in the latest years are particularly low in the range 57.9–59.2 CO_2 t/TJ compared with the IPCC default values for the most common liquid fuels, such as 63.1 t/TJ (LPG), 74.1 t/TJ (gas oil) and 77.4 t/TJ (residual fuel oil).
In your preparation before the review week, what indicators/facts would you check before drafting your question(s) to the Party? List at least three in your notes and then compare them with the likely required indicators/facts to be checked listed in the answer key.

4.5. Exercise 5. Food processing, beverages and tobacco – biomass – CH_4 emission factors

The NID reports that CH_4 emissions from biomass use in subcategory 1.A.2.e food processing, beverages and tobacco were estimated using a tier 1 method with default EFs for the different types of biomass fuels used for 1990–1997, 2006–2007 and from 2010 onward. Emissions were reported as "NO" for 1998–2005. For 2008–2009, a hybrid method was applied with country-specific EFs for some of the biomass fuels and default EFs for the rest. The TERT notes that (i) the Party reported that a tier 2 approach was used for certain biomass fuels only for 2008–2009 and then apparently reverted to a tier 1 method and (ii) the CH_4 IEF for 2008 (7.31 kg/TJ) is the lowest reported value in the time series, and considerably lower than the values reported for other years (20.39–30.00 kg/TJ).
Although the reasons for using country-specific EFs for only two years of the time series must be asked by the reviewer in the preliminary questions to the Party, this exercise focuses on the low CH_4 IEF for 2008. In response to a question raised by the TERT during the review, the Party indicated that data from the emissions trading scheme indicated a large amount of biodiesel for 2008, with a CH_4 EF lower by an order of magnitude than the EF of solid biomass. You consider that:
A. The Party is overestimating the CH_4 emissions from biomass use in food processing, beverages and tobacco for 1990–1997, 2006–2007 and 2010 onward
B. The Party is underestimating the CH_4 emissions from biomass use in food processing, beverages and tobacco for 2008 and possibly 2009
C. There is a lack of consistency in the methods and CH_4 EFs applied

4.6. Answer key

1. Exercise 1

The correct answer is B. The answer provided by the Party was irrelevant as it alluded to solid fuels, whose emissions are not reported under gaseous fuels. Considering that gaseous fuels involved almost exclusively natural gas, the TERT should further investigate this issue, in particular regarding carbon content, NCV and AD of the natural gas used to estimate these emissions.

2. Exercise 2

The correct answer is D. Parties are not obliged to report confidential information in the NID; however, its national inventory arrangement must ensure that the inventory compiler has access to all information necessary to evaluate the accuracy of the data used to estimate the emissions reported in the GHG inventory. The inventory compiler must know the choice of methods, AD and EFs and other physical properties of fuels that were used to estimate the emissions of each plant whose reported emissions under the EU ETS were incorporated into the national inventory. Without violating confidentiality agreements, the NID should include relevant information covering the above-mentioned items. In addition, the NID should explain how the consistency of the time series is ensured when using different data sources for different periods.

3. Exercise 3

The correct answer is B. In estimating emissions for this subcategory, there is a risk of double counting or omission of emissions in either the IPPU or the energy sector. Although the Party tried to avoid this difficulty, the CO_2 emissions from solid fuels used as reducing agents or anodes in the non-ferrous metals industry must be reported under the IPPU sector to enhance transparency and comparability between reporting Parties' GHG inventories. However, keep in mind that the guidance on completeness for the estimation and reporting of emissions from metal production in the 2006 IPCC Guidelines indicates that since the primary goal of carbon sources (coal, coke, natural gas, etc.) used as a reductant is to produce metals, the emissions are considered to be industrial process emissions and should be reported as such.

Therefore, you need to fully understand the reasons why the previous TERT recommended reporting the emissions separately between the IPPU sector (use of solid fuels as a reductant) and the energy sector (use of solid fuels for energy). With the information provided you do not know if the current allocation under subcategory 1.A.2.b non-ferrous metals includes more than one metal production process. If only metal production is involved it is likely that it would be aluminium production because of the mention of the use of solid fuels as anodes. In such a case, it is likely that two distinct solid fuels would be used, one for the carbon anodes and another for combustion, possibly for electricity production because primary aluminium production utilizes large amounts of electricity. Therefore, you need to first consult the IPPU chapter in the NID to identify the non-ferrous production metals in the country and formulate preliminary questions to the Party before making a final decision.

4. Exercise 4

1. Liquid fuels used by the Party: consult the NID and the series of energy balances, if available, to identify the liquid fuels used by Party A under subcategory 1.A.1.a public electricity and heat production. If this information is not available, request it from the Party in your preliminary questions before the review week.

2. Comparison of the CO_2 IEFs values with the reference EFs in the 2006 IPCC Guidelines: consider the IPCC default CO_2 EFs (t/TJ) and their 95 per cent confidence interval range for the liquid fuels most likely used under public electricity and heat production. Inspect the table below.

Fuel	Default value	Lower	Upper
Gas oil	74.1	72.6	74.8
Residual fuel oil	77.1	75.5	78.8
Liquefied petroleum gas	63.1	61.6	65.6
Refinery gas	57.6	48.2	69.0

Considering the values reported in the table above, only an increasing use of refinery gas in the fuel mix under this subcategory would explain both the decreasing trend and the relatively low level in CO_2 IEFs.

3. Information in the NID on the CO_2 EFs used by the Party for these fuels: assess the reported information. If it is not enough for your assessment, ask the Party for further information. If there are significant differences between the values of CO_2 EFs reported by the Party and those included in the 2006 IPCC Guidelines, draft a question regarding this issue in your set of preliminary questions.
4. AD reported in CRT 1.A.(a) (sheet 1): if the CO_2 EFs of the liquid fuels used by the Party are in line with the IPCC defaults, an alternative cause for the low IEFs is that the AD reported in CRT 1.A.(a) for subcategory 1.A.1.a are higher than those used to estimate the emissions. Check the reporting of AD and ask the Party for clarification, if necessary.
Depending on the Party's answers to your preliminary questions, further questions may be needed, a sound explanation may be provided by the Party or you may identify inconsistencies that would lead to a recommendation, most likely on accuracy. Nevertheless, if the Party provides a sound explanation, a recommendation may be needed regarding transparency on the underlying reasons explaining the low IEFs.

5. Exercise 5

The correct answer is C. There is an obvious lack of consistency in the methods and EFs applied. The selection of CH_4 EFs may also trigger an accuracy issue that is worth investigating; however, with the information available it is not possible to make a definite assessment. The reviewer should ask the Party for further clarification regarding the type of biomass fuels used throughout the period and the selection of CH_4 EFs. The TERT should also ask the Party for the reasons for reporting "NO" for CH_4 emissions for 1998–2005 and confirm that these emissions did not occur and were not reported elsewhere.
In addition, the TERT should ask for the reasons for using country-specific EFs only for two years and investigate if the use of the fuel(s) for which country-specific EFs were chosen or developed occurred only in those specific two years. If not, the reviewer should ask for the reasons for applying this country-specific EF for only a fragment of the time series.

5. Self-check quiz

This quiz is offered so that you can test your skills as a reviewer of stationary combustion. It has nine questions, which were inspired by past submissions by different Parties. You will be able to assess a variety of situations, which include:

- Use of tier 1 approach to estimate emissions for a key category;
- Linkages between the energy sector and the IPPU sector regarding the use of fuels in industrial processes for both energy use and non-energy use;
- Choice and development of CO_2 and non-CO_2 country-specific EFs;
- Combustion of non-conventional fuels (waste);
- Combustion of crude oil for energy use;
- The use of implied EFs as indicators of possible problems;
- Changes in the fuel mix of certain categories across the time series and their effect on the pattern of CO_2 and CH_4 emission trends;

- Abrupt changes in emissions for certain years in the emission time series and the need for recalculations in one or more categories or subcategories.

The examples presented constitute a small sample of the issues you might face in a review. Nevertheless, the walk-through example (section 3.4), the practical exercises (topic 4) and this quiz show you a wide range of cases that would help to strengthen your skills as an expert reviewer of stationary combustion emission estimates.

1. For ammonia production, the amount of natural gas used as feedstock was accounted under the IPPU sector in an inventory, while the amount of natural gas combusted was accounted under the energy sector. This is:
   A. In line with the 2006 IPCC Guidelines
   B. Not in line with the 2006 IPCC Guidelines

2. A Party applied the tier 2 method to estimate CO_2 emissions for several stationary combustion categories. However, the country-specific EFs used are not presented or clearly explained in the NID, which cites the energy balance and plant-specific information as the data sources. The EFs are not sufficiently elaborated to enable a comparison with the IPCC default EFs. In your TERR, you would recommend that the Party:
   A. Include information on the data sources and methodologies used for the calculation of the country-specific EFs
   B. Switch back to tier 1 IPCC default EFs
   C. Compare the country-specific EFs with the IPCC default EFs
   D. A and C

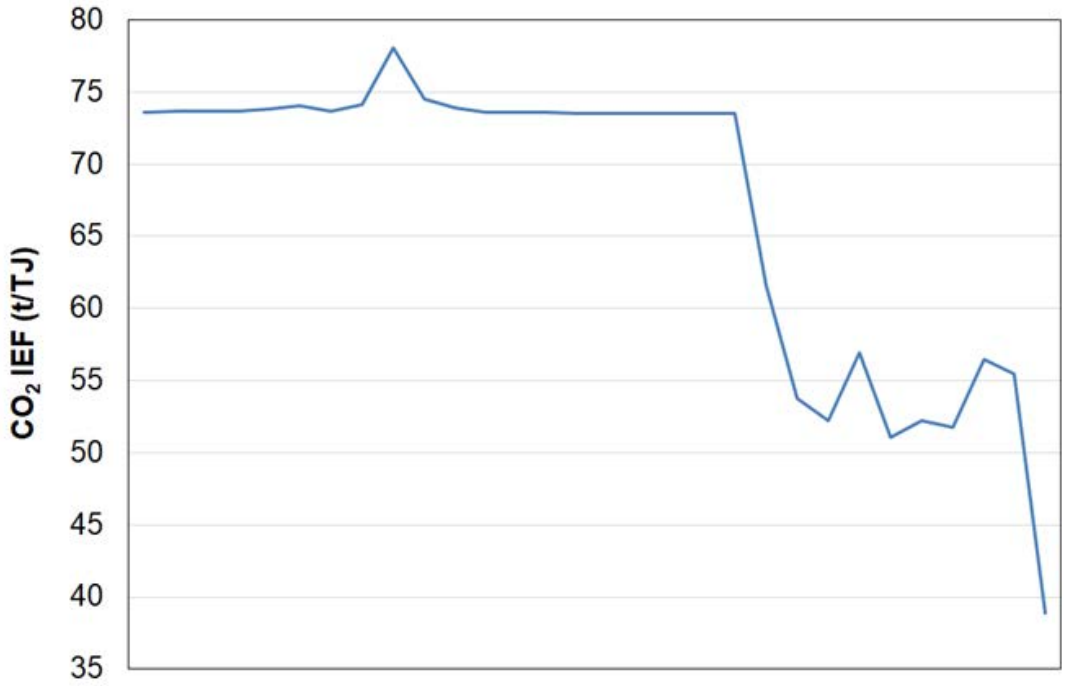
3. The NID of a Party indicates that (1) cement plants may use waste as fuel; (2) this waste includes plastics, used tyres, waste oils, industrial wastewater sludge and biomass; and (3) the use of this waste for energy is considered under the energy sector. However, these emissions were reported in the CRT as “NO”. During the review, the Party confirmed the use of waste as fuel in cement plants to the TERT and explained that it was not possible to identify the amount of waste used as fuel in the energy balance, which is its source for AD, and that it was therefore unable to estimate these emissions. You as a reviewer concluded that since the use of waste as fuel in cement plants did occur, the Party must have reported the corresponding emissions as “NE” for other fossil fuels and biomass under subcategory 1.A.2.f non-metallic minerals.
   True
   False

4. A Party indicated in the NID that it reported emission estimates for crude oil combustion under subcategory 1.A.1.b petroleum refining. As burning crude oil is not usually done at refineries, you asked the Party to clarify whether crude oil was combusted at these facilities. In its response, the Party explained that crude oil was actually burned to support activities for oil and natural gas extraction and the reason for reporting these emissions under petroleum refining was that this is the only subcategory covering the oil industry under 1.A.1 energy industries. The reporting by the Party is:
   A. Correct; emissions from crude oil combustion should always be allocated under petroleum refining

B. Incorrect; these emissions should be reallocated to manufacture of solid fuels and other energy industries
C. Incorrect; combustion of crude oil is not to be expected and emissions should be reported as "NA"

5. In your review, you identified that the CO_2 IEFs for liquid fuels used under subcategory 1.A.1.a public electricity and heat production are in the range of 38.9–78.1 t/TJ across the time series, as depicted in figure 4.1. You also noted that the IPCC default CO_2 EFs for liquid fuels commonly used for electricity and heat production are between 57.6 t/TJ (refinery gas) and 77.4 t/TJ (residual fuel oil). Considering the information above for this category:
   A. You would conclude that the estimation of CO_2 emissions across the time series is not correct
   B. You would conclude that the time series for the selected CO_2 EFs is not consistent
   C. You would investigate the pattern of the different liquid fuels used across the time series

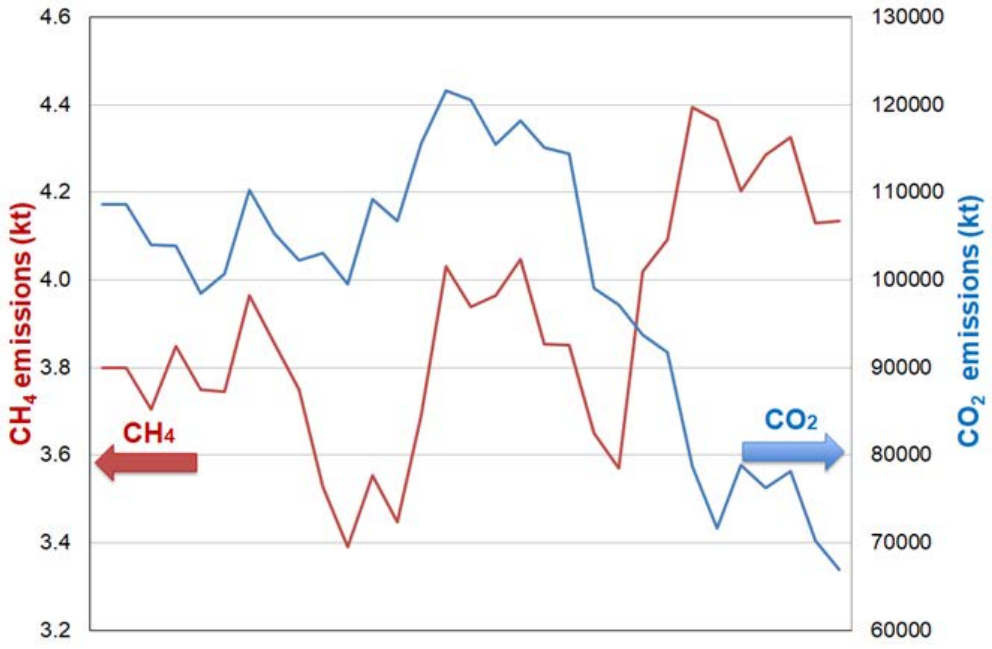
P. Figure 4.1. Time series of CO_2 implied emission factor (t/TJ)



6. Figure 4.2 depicts the time series of CO_2 and CH_4 emissions from the combustion of all fuels used for electricity and heat production of a reporting Party and accounted in its national totals. Note that the left axis is for CH_4 and the right axis for CO_2. In the latest years, CO_2 emissions decreased while CH_4 emissions increased. You consider that this behaviour may be due to:
   A. Changes in the mix of fuels burned across the time series

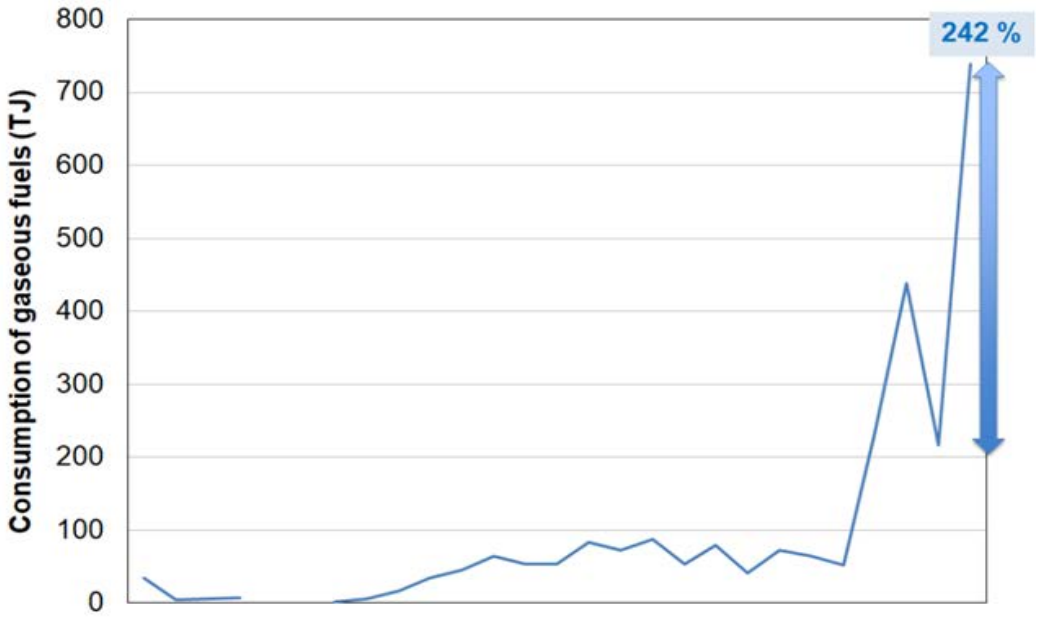
B. Possible errors in the calculations and/or in the selection of EFs, because it is expected that CO_2 and CH_4 emissions exhibit a high degree of correlation

Q. Figure 4.2. Time series of CO_2 and CH_4 emission estimates



7. You noted that gaseous fuels consumption (TJ) under subcategory 1.A.4.b residential increased by 242 per cent in the last two years of the time series (see figure 4.3). The NID indicates that this increase was due to changes in the report by companies to the National Statistics Office. During the review, the Party explained that the change relates to a company that until the last year of the time series had reported natural gas consumption under district heating. The company reported natural gas separately only for the last year and this amount was allocated under 1.A.4.b. For the previous years, the company kept reporting fuel consumption under district heating. For this consistency issue, you would recommend that the Party update AD and recalculate CO_2, CH_4 and N_2O emissions for the entire time series for:
   A. Residential
   B. Public electricity and heat production
   C. A and B

R. Figure 4.3. Time series of consumption of gaseous fuels under residential



8. In the previous TERR it was recommended that the Party estimate CH_4 emissions from biomass combustion under subcategory 1.A.4.a (commercial/institutional) using a tier 2 approach, because this category was identified as key. The Party provided in the NID a summary of a study conducted by a national research institute to determine national EFs. The study concluded that CH_4 measurements to determine appropriate EFs would take several years, and therefore a tier 1 approach was used by the Party in its current submission. In your review, you would consider that the reporting by the Party is:
    A. Not in accordance with the 2006 IPCC Guidelines and the MPGs
    B. In accordance with the 2006 IPCC Guidelines and the MPGs

9. A Party estimated CH_4 and N_2O emissions from stationary combustion plants under categories 1.A.1 energy industries and 1.A.2 manufacturing industries and construction using country-specific tier 2 EFs. These EFs were derived calculating weighted averages based on the measured emissions and the corresponding fuel consumption. The NID indicates that the plant-specific data were collected by stack tests from emissions sources representative of the main technologies used across the country from 1991 to 2000. These country-specific EFs were applied to estimate the emission across the entire time series until the last submission in 2022. It is worth noting that the NID does not contain information on the applicability of these EFs to the national circumstances for 2001–2022. In your review you would consider that:
    A. The Party's time series is consistent since the same country-specific CH_4 and N_2O EFs have been applied
    B. You identified a finding related to comparability and this would lead to a recommendation to improve comparability

C. You identified a finding related to accuracy and this would lead to a recommendation on accuracy

5.2. Answer key

1. **The correct answer is B**. The 2006 IPCC Guidelines indicate that combustion emissions from fuels used as feedstock for an IPPU process, as well as a source of heat for the process, are to be allocated to the category in which the process occurs, in this case category 2.B.1 ammonia production under the IPPU sector.

To learn more, see sections 1.2 and 1.3.2 (vol. 2, chap. 1, p.1.5 and vol. 3, chap.1, p.1.13, respectively) of the 2006 IPCC Guidelines

2. **The correct answer is D**. When a tier 2 method is used, the data and/or parameters selected must be transparently explained in the NID. It is good practice to compare any country-specific EFs with the IPCC default values. If the Party has made the effort to develop country-specific EFs and use a tier 2 method, moving to a tier 1 method is not consistent with good practice.

To learn more, see sections 2.3.1.2 and 2.3.2.2 (vol. 2, chap. 2, pp.2.12 and 2.24, respectively) of the 2006 IPCC Guidelines and paragraphs 24 and 39 of the MPGs.

3. **The correct answer is ´True´**. As long as waste is used as fuel in cement plants, reporting of these emissions as "NE" under subcategory 1.A.2.f non-metallic minerals is the least that the Party can do. However, this would be the first step regarding this issue for the Party, as it needs to investigate and collect appropriate AD, estimate the emissions, differentiating them by fossil and biogenic origin, and report them accordingly in CRT. Note that waste as fuel has been increasingly used in cement kilns worldwide.

4. **The correct answer is B**. If the Party identified the use of crude oil for combustion in oil and natural gas extraction activities, the correct allocation of the related emissions is under subcategory 1.A.1.c.ii oil and gas extraction under manufacture of solid fuels and other energy industries. Table 2.1 of the 2006 IPCC Guidelines (vol. 2, chap 2, p.2.7) indicates that the category other energy industries includes, among others, the emissions from own-energy use for oil and gas extraction and the processing and upgrading of natural gas.

5. **The correct answer is C**. Although the time series of CO_2 IEFs is unusual, it cannot be concluded without further analysis that the estimation is not correct or that the time series is not consistent. It is nevertheless worth mentioning that the drop of CO_2 IEFs from about 75 t/TJ to about or below 55 t/TJ deserves special attention by the reviewer, particularly considering that the IPCC default CO_2 EF for natural gas is 56.1 t/TJ. The CO_2 IEF for the latest year (below 40 t/TJ) should draw your attention, as well as those values that clearly are below the IPCC range of values for liquid fuels. The first feature to investigate for the reviewer concerns the liquid fuels used in different years and their corresponding CO_2 EFs. This would be the starting point for the assessment and a number of questions to the Party would probably be needed.

6. **The correct answer is A**. Different shares of fuels across the time series may lead to substantial differences in the trend of emissions of CO_2 and non-CO_2 gases, particularly because the dependence of emissions is different for both types of GHG. In addition, if biomass replaces fossil fuels across the time series this would lead to a decrease in CO_2 emissions that are reported in the national totals and a possible increase in CH_4 emissions, depending on the type of biomass; for example the IPCC default CH_4 EF for solid biomass is one order of magnitude higher than those for liquid, solid or gaseous fossil fuels. Although it is possible that some mistakes may have been made in the calculations, on the basis of the discussion above, the time series of CO_2 and CH_4 emissions should not necessarily exhibit a high degree of correlation.
   Even when the consideration of changes in the fuel mix used across the time series is plausible, in your review, you should check that the Party discussed this behaviour of the CO_2 and CH_4 emission time series in the NID. If not, you should ask the Party to provide explanations. Although it is not expected that CO_2 and CH_4 be correlated, it may also happen that the Party made mistakes in its calculations, and it would be advisable to check the methods, AD and EFs used by the Party to estimate these emissions.

7. **The correct answer is C**. Consumption of gaseous fuels formerly reported as for district heating must be reallocated from 1.A.1.a public electricity and heat production (the subcategory under which the emissions supposedly coming from district heating were reported) to 1.A.4.b residential, where it belongs, and therefore the emissions from both categories must be recalculated for the complete time series. You should also ask the Party to explain the behaviour of the emissions in the two years before the latest year in the time series, where there was a significant increase followed by a decrease, before the 242 per cent increase occurred.

8. **The correct answer is A**. Although the Party has provided an explanation about the difficulty in developing country-specific CH_4 EFs, it did not provide a clear indication as to why it was unable to implement a tier 2 approach. The Party has not indicated why it has not investigated the availability of regional CH_4 EFs and the possible application of them to the national circumstances, as suggested in the previous TERR based on the good practice provided in section 2.3.2.2 of the 2006 IPCC Guidelines (vol. 2, chap. 2, p.2.24). You should also consider paragraph 23 of the MPGs. In addition, if you are reviewing a developing country Party, you may explore with the Party whether it identified any possible capacity-building needs to assist in improving emission estimates.

9. **The correct answer is C**. Since the measured data used to derive the country-specific EFs date back to 1991–2000, some or possibly all CH_4 and N_2O EFs may not be applicable to the technologies in use in the latter years of the inventory time series. Although the 2006 IPPC Guidelines do not require continuous measurement of emissions, accurate estimation may require regularly updating the country-specific EFs, particularly for CH_4 and N_2O because of their dependency on technology and utilization practices. Note, however, that the effort made by the Party to develop country-specific EFs must be taken into account by the reviewer and using default EFs after 2000 instead of the country-specific EFs would not be good practice, as discussed in question 2 above. In your review, you should ask the Party about the effort implied in updating the EFs for the new technologies incorporated since 2001 and provide a

recommendation that would be helpful to the Party. It is possible that only a small number of new technologies need to be sampled and/or the use of reference or regional EFs may be selected as representative of the new technologies. Consequently, a set of updated weighted average EFs may be developed that would better represent the mix of technologies for the latter years of the time series.

6. Key points to remember

The main topics to consider during the review of emission estimates from stationary combustion categories were covered in this lesson. The only GHG-emitting activity in this large and important category is combustion within a mostly fixed apparatus (although some mobile sources, such as off-road vehicles and other machinery, are included under several stationary combustion categories). This dominant feature gives common characteristics to both the emitting process and the review of the corresponding GHG emission estimates.

Information that is common or similar to all stationary combustion categories includes:

- AD (fuel consumption or fuel sales to the market);
- Physical properties of fuels (NCV and carbon content).

This seemingly small amount of information is key for the review of the estimates in the energy sector since it is the basis for the estimation of CO_2 emissions, which constitute the largest contributor to the total emissions in stationary combustion.

There are also numerous details to consider, such as:

- Linkages with other inventory sectors and the avoidance of omission or double counting of emissions;
- Background information supporting country-specific or plant-specific data;
- The use of fuels for both energy use and non-energy use in industrial processes;
- Fuels that are used in relatively smaller quantities such as other fossil fuels and biomass;
- The use of notation keys and its implications.

Annex 3.1. Characteristics of CO_2 and non-CO_2 emissions from stationary combustion

CO_2 emissions

CO_2 emissions result from the oxidation of carbon in fuels during combustion. In perfect combustion conditions, the total carbon content of fuels would be converted to CO_2. However, in real life combustion processes are not perfect and result in small amounts of partially oxidized and unoxidized carbon. Incomplete oxidation occurs as a result of inefficiencies in the combustion process. The carbon flow for a typical combustion process can be described as follows:

- Most carbon is emitted as CO_2 immediately. A small fraction of the carbon in the fuel escapes without being immediately oxidized to CO_2 during combustion. Most of this fraction is emitted as carbonaceous non-CO_2 gases such as CH_4, CO and NMVOCs. However, for solid fuels, in particular low coal grades such as lignite, a portion of carbon is unburned and could be fixed in boiler slag and in fly ash (see third bullet below);
- At tier 1, the carbon in these gases is integrated into the overall calculation of CO_2 emissions. The assumption for inventory purposes is that the carbon contained in partially oxidized combustion gases (i.e. CH_4, CO and NMVOCs) is fully oxidized and implies that CO_2 emission estimates are independent of combustion technology;
- The remaining part of the fuel carbon is unburned (i.e. unoxidized) and remains as soot and ash. In general, this fraction of the fuel carbon is assumed to remain stored indefinitely (i.e. not emitted in gaseous form). The oxidation factor indicates the percentage of carbon that is actually oxidized when combustion occurs;
- At tier 2 or 3, the amount of carbon in CH_4, CO and NMVOCs can be accounted for if the CO_2 emissions are estimated for the amount of carbon fully oxidized.

Non-CO_2 emissions

Owing to incomplete combustion of hydrocarbons in fuel, small proportions of carbon are released as CH_4, CO or NMVOCs, all of which eventually oxidize to CO_2 in the atmosphere. Combustion processes also result in emissions of N_2O and NO_X.

Unlike CO_2, emissions of CH_4, N_2O, NO_X, CO and NMVOCs are strongly dependent on technology and operating practices. Accurate estimation of these emissions requires detailed technology-based process information and knowledge of several interrelated factors. These include combustion conditions, type, size and vintage of the combustion technology, maintenance, operational practices, emission controls and fuel characteristics. To take into account these characteristics, estimation methods should be applied at a detailed activity/technology level. In this regard, the total amount of a given fuel used in each combustion category needs to be disaggregated according to the technology and practices that produce different emission levels for the same amount of fuel.

CH_4 emissions

CH_4 is produced in small quantities from fuel combustion as a result of incomplete combustion of hydrocarbons. CH_4 emissions are usually an indication of inefficiency in the combustion process. The production of CH_4 is dependent on the temperature and the amount of oxygen available in the boiler/kiln/stove. In large efficient combustion facilities and industrial applications, the CH_4 emission rate is very low. In smaller combustion sources, emission rates are often higher, particularly when

smouldering occurs. The highest rates of CH_4 emissions from fuel combustion occur in residential applications (small stoves and open burning).

N_2O emissions

N_2O is produced directly from fuel combustion. It has been determined that, in general, lower combustion temperatures cause higher N_2O emissions. Solid and liquid fuels contain nitrogen bound to their molecular structure (fuel nitrogen) and can be oxidized into N_2O under relatively low temperature conditions. The mechanisms of N_2O chemistry seem to be relatively well understood, but experimental data are limited.

In addition, some N_2O may occur in the atmosphere, originating from the atmospheric deposition of NO_X, some of it arising from combustion. The 2006 IPCC Guidelines provide guidance on estimating these indirect N_2O emissions (vol. 1, chap. 7, section 7.3.1).

Annex 3.2. Guidance on completeness for the estimation and reporting of emissions from metal production in the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*

In the review of the estimation and reporting of emissions from fuels that can be used as a reductant and for energy purpose in the metal industry, you must be familiar with the guidance in section "Avoiding double counting activity data with other sectors" of the 2006 IPCC Guidelines (vol. 2, chap. 2.3.3.3, p.2.32) more precisely on the following paragraph (p.2.33):

"IPPU, AFOLU – Use of carbon as reducing agent in metal production
The greenhouse gas emissions originating from the use of coal, coke, natural gas, prebaked anodes and coal electrodes as reducing agents in the commercial production of metals from ores should be accounted for in the IPPU sector. Wood chips and charcoal may also be used in some of the processes. In this case, the resulting emissions are counted in the AFOLU sector. By-product fuels (coke oven gas and blast furnace gas) are produced in some of these processes. These fuels may be sold or used within the plant. They may or may not be included in the national energy balance. Care should consequently be taken not to double count emissions."

If a particular fuel has not been used as a reductant in metal production, that is if it has been used only for energy purpose, the associated GHG emissions must be allocated to subcategories 1.A.2.a (iron and steel) or 1.A.2.b (non-ferrous metals), depending on the particular metal considered.
However, when a fuel is used as a reductant, the specific guidance on completeness in the IPPU volume of the 2006 IPCC Guidelines (vol. 3, chap. 4) must be followed. It can be summarized as follows: since the primary goal of carbon sources (coal, coke, natural gas, etc.) used as reductants is to produce metals, the emissions are considered to be industrial process emissions and should be reported as such. In these cases, you must consider the particular metal production for which the fuel is used as a reductant (iron and steel, ferroalloys, lead or zinc). Note that the same chapter of the 2006 IPCC Guidelines also provides guidance to estimate process emissions from primary aluminium production but in this case the input of carbon to the process is in the carbon anodes and from magnesium production, for which the carbon input is in the carbonates, so in these cases fuel use for energy would be clearly differentiated from the carbon inputs to process.
Consulting with the IPPU expert reviewer of the TERT as well as reading the description of the estimation of emissions from metal production in the IPPU chapter of the NID is advisable to check that GHG emissions have not been double counted or part of them, especially those from combustion, omitted.
The carbon flows (inputs, recycles and outputs) in iron and steel production, especially in integrated steel mills, are rather complex and you must be familiar with the guidance in section 4.2 (iron and steel and metallurgical coke production) of the 2006 IPPC Guidelines (vol. 3, chap. 4).
For the production of ferroalloys, lead and zinc, sections 4.3, 4.6 and 4.7 of the 2006 IPPC Guidelines, respectively, provide methods to estimate the emissions from the carbon in the fuels used for reducing purposes. You must identify whether any fuel used as a reductant has also been combusted for energy purpose. In that case, you need to check how these emissions have been estimated and reported. In principle, all the emissions should have been reported under the IPPU sector. However, it is necessary to take into account that fuels used as reductant might be reflected differently in the national energy balances and therefore potential omissions could occur.

Lesson 4. Mobile combustion

1. Introduction

In this lesson we address the review of emission estimates from mobile combustion.

1.1. Learning objectives

At the end of this lesson you should be able to:

- Understand the key tasks to be undertaken to review a Party's reporting for mobile combustion;
- Identify whether a Party's reporting for mobile combustion is consistent with the requirements in the MPGs;
- Draft key review recommendations to Parties for mobile combustion emission estimates for the TERR.

1.2. Expected time needed to complete lesson 4

- For readers with experience in compilation of energy sector GHG inventories: 60–90 minutes

For readers with less experience in compilation of energy sector GHG inventories: 100–170 minutes

2. Category overview and methodological information

2.1. Mobile combustion categories

Mobile combustion is organized in five subcategories:

- Subcategory 1.A.3.a: domestic aviation including all passenger and cargo flights (commercial, private, agriculture, etc.) departing and arriving in the same country. Excludes military aviation;
- Subcategory 1.A.3.b: road transportation by cars, light- and heavy-duty trucks, buses, motorcycles, etc;
- Subcategory 1.A.3.c: railways comprising passenger and freight traffic;
- Subcategory 1.A.3.d: domestic navigation comprising vessels of all flags departing and arriving in the same country. Excludes military navigation;
- Subcategory 1.A.3.e: other transportation covering all remaining transport activities.

- Military transport not engaged in multilateral operations (such as those from fuel delivered to the country's military and fuel delivered within that country but used by the militaries of other countries) is reported under subcategory 1.A.5.b other (not specified – mobile).
- GHG emissions from international transport activities are reported separately under international bunkers and excluded from the national totals.

Emissions from certain transport modes (off-road vehicles on farmland or in forests, and inland, coastal and deep-sea fishing) are reported under the category 1.A.4 other sectors. All remaining aviation and marine emissions not specified elsewhere, as well as other emissions from mobile sources not included elsewhere, are reported under the category 1.A.5 other. However, 1.A.4 other sectors and 1.A.5 other are both combustion categories under stationary combustion.

To learn more about the complete list and definitions of mobile combustion subcategories, see table 3.1.1 of the 2006 IPCC Guidelines (vol. 2, chap. 3, pp.3.8–3.10).

2.2. Estimation methods

As for stationary combustion, the only GHG-emitting activity for transport is fuel combustion within an apparatus, which confers common features to both the emitting process and the review of CO_2 emissions because they are almost exclusively dependent of the amount of fuel consumed and its carbon content. However, because of the considerable differences among transportation modes and the broad range of technologies per transportation mode, there are significant differences in the estimation methods, especially for non-CO_2 gases. In addition to fuel and technology, the distance travelled and the manner in which this distance is covered constitute key considerations for detailed estimates.

For all mobile combustion subcategories and GHG gases, the 2006 IPCC Guidelines provide estimation methods according to a two-tiered approach. Tier 3 methods are also provided for some transportation modes, particularly for CH_4 and N_2O. The main features of each tier can be roughly summarized as:

- **Tier 1**: fuel consumption with default EFs;
- **Tier 2**: for all subcategories except civil aviation:
  - CO_2: fuel consumption with country-specific EFs;
  - Non-CO_2: fuel consumption disaggregated by technology or engine type and technology-specific and/or country-specific EFs;
  - Civil aviation also includes how travelled distance is covered (LTO and cruise);
- **Tier 3**: model-based approach.

Descriptions of tier 2 methodological approaches are provided for all transportation modes. However, under aviation, the tier 2 method is only applicable for jet fuel use in jet aircraft engines.

Although applicable, the distance-travelled tier 3 approach for road transportation and the locomotive-specific tier 3 approach for railways are not necessary to estimate CO_2 emissions. A tier 3 approach is not provided for waterborne navigation in the 2006 IPCC Guidelines.

2.3. CO_2 and non-CO_2 emissions

CO_2: As discussed in section 2.2 above and in lesson 2, CO_2 emission estimates depend almost entirely on the type of fuel and its carbon content. CO_2 emissions from several fuels are usually identified as key

categories under the level or trend assessment or both. Examples include gasoline and diesel oil in road transportation, jet kerosene in domestic aviation and diesel oil in domestic navigation. Whether CO_2 emissions from each fuel in each transport subcategory are identified as key category depends on the relative importance and variability of the transportation activities within the economic infrastructure of the country. In your review you would follow a similar assessment path to that followed in lesson 2 to assess CO_2 emission estimates from stationary combustion.

Non-CO_2: CH_4 and N_2O emissions are strongly dependent on the technologies employed in the different transportation modes, More specifically, they depend on the characteristics of the country´s fleets (road vehicle, aircraft or vessel) and on many parameters such as vehicle characteristics, including age and emission control technology, fuel specifications, and ambient and operating conditions (e.g. cold start, hot running, urban or rural driving for road vehicles, idle, taxi, cruise, LTO for aircrafts). CH_4 is mostly associated with the cold start of the vehicles or the use of natural gas. CH_4 and N_2O emissions from aircraft engines are higher at idle and taxi conditions and decrease at higher thrust levels. For road vehicles, the rate of N_2O generation can be increased by exhaust controls (e.g. catalytic converters or the injection of urea in selective catalytic reduction). Therefore, N_2O emissions from road transportation are often identified as key category, particularly under the trend assessment. If non-CO_2 emissions from a certain fuel and transport subcategory are identified as key category or if the Party has used a higher-tier approach to estimate these emissions, you should ensure that enough time is allocated to review these emissions, particularly if a tier 3 approach has been selected.

2.4. Decision trees

Although the generalized decision tree in figure 1.2 of the 2006 IPCC Guidelines (vol. 2, chap. 1, p.1.9) applies to all subcategories in mobile combustion, some of these subcategories have certain particularities that are reflected in specific decision trees in the 2006 IPCC Guidelines (vol.2, chap. 3) as summarized below.

Note that decision trees in chapter 3 of volume 2 of the 2006 IPCC Guidelines are provided for the following:

- Civil aviation (figure 3.6.1);
- Road transportation (figures 3.2.1, 3.2.2 and 3.2.3);
- Railways (figures 3.4.1 and 3.4.2);
- Waterborne navigation (figure 3.5.1);
- Figure 3.3.1 is a specific decision tree for off-road vehicles that are reported under other transportation (1.A.3.ii) and also under stationary combustion subcategories under manufacturing industries and construction (1.A.2) and other sectors (1.A.4.c).

2.5. Activity data

Tier 1 approach: Fuel consumption statistics by fuel type and transportation mode are usually sufficient to estimate emissions. Fuels such as motor gasoline, aviation gasoline and jet kerosene are almost exclusively used for transportation purposes. You must take note if these fuels are used for alternative purposes and verify such reporting. Disaggregating the use of diesel/gas oil and heavy fuel oil (used in navigation) between stationary and mobile combustion uses may be difficult. In your review you may

need to pay particular attention to how the Party handled this split. For aviation and navigation, separation of AD between domestic and international components is needed since the GHG emissions from the last component are estimated and reported under international bunkers and are not part of the national totals.

Tier 2 approach: similar AD to those for the tier 1 approach are required, for which the degree and type of disaggregation is determined by the GHG (CO_2 or non-CO_2). For aviation, the tier 2 method requires the number of LTO cycles, preferably by aircraft type. For aviation gasoline, only a tier 1 method has been provided in the 2006 IPCC Guidelines because the numbers of LTOs are generally not available for the aircrafts using this fuel.

Tier 3 approaches: fuel consumption statistics disaggregated by technology type are needed. For road transportation kilometres travelled are used. Flight movement data are used for aviation. For model-based approaches for which the amount of fuel combusted is not the main AD, it is crucial that the fuel consumption estimated by the model be reconciled with national fuel statistics or verified by independent sources, as indicated in the generalized decision tree for estimating emissions from fuel combustion of the 2006 IPCC Guidelines (vol. 2, chap. 1, figure 1.2, p.1.9). For tier 3 approaches, verification is essential in estimating, reporting and reviewing emissions.

2.6. Emission factors

Tier 1 default CO_2 EFs for fuels used in mobile combustion are provided in chapter 1 and repeated in chapter 3 of volume 2 of the 2006 IPCC Guidelines, organized by transportation modes. Although CH_4 and N_2O emissions are strongly dependent on transportation mode, fuel use, technology and operating and maintenance practices, the 2006 IPCC Guidelines provide tier 1 default CH_4 and N_2O EFs for all mobile combustion categories to estimate non-CO_2 emissions using only fuel consumption data at the subcategory level.
For road transportation and civil aviation, technology-specific EFs are also provided in the 2006 IPCC Guidelines. These include kilometre-based CH_4 and N_2O EFs for gasoline, diesel and alternative fuels used by road vehicles and CO_2, CH_4 and N_2O LTO EFs for typical aircraft using jet kerosene.
Note that in the case of biofuels (e.g. biodiesel, biogasoline or gasohol), the national AD for transport fuels would likely represent the blend of a fossil fuel and biofuel. However, CO_2 EFs must differentiate between fossil and biogenic origin, so Parties would have to adjust their AD to take this into account. In addition, the CH_4 and N_2O EFs should be based on the total amount of fuel without differentiating between fossil and biogenic.

Note that:
Tier 1 default EFs in chapter 3 of volume 2 of the 2006 IPCC Guidelines are reported as follows:

- CO_2 in tables 3.2.1 (road transportation); 3.4.1 (railways); 3.5.2 (waterborne navigation); 3.6.4 (civil aviation);
- Non-CO_2 in tables 3.2.2 (road transportation); 3.4.1 (railways); 3.5.3 (waterborne navigation); 3.6.5 (civil aviation).
  - Distance travelled non-CO_2 EFs for road transportation for gasoline and diesel are provided in tables 3.2.3 (United States) and 3.2.5 (Europe) and for alternative fuels in table 3.2.4.
  - For aviation LTO EFs for typical aircraft using jet kerosene are provided in table 3.6.9.

2.7. Main features by transport subcategory

1.A.3.a domestic aviation

Emissions from all civil and commercial uses of aircraft, including scheduled air transport and general aviation (e.g. agricultural aircraft, private jets and helicopters) are estimated and reported under this subcategory. These emissions depend on the amount and type of fuel used, the type of aircraft, the number of operations, the length of the flight and the type and efficiency of the engine. For higher-tier methods, aircraft operations are divided into two main phases: (i) LTO cycle and (ii) cruise. Fuel consumption must be differentiated between domestic and international aviation.

To learn more about the split between domestic and international aviation, see section 3.6.1.3 of the 2006 IPCC Guidelines (vol. 2, chap. 3, p.3.65).

The availability of AD largely determines the tier that can be applied to estimate emissions for this subcategory.

Availability of activity data	Approach
1: Only aviation fuel consumption	Tier 1
2: AD as 1 above + LTO data for individual aircraft type using jet fuel*	Tier 2
3: AD as 2 above + origin and destination by aircraft type	Tier 3A
4: AD as 3 above + full trajectory of each flight	Tier 3B
* LTO data are generally not available for aviation gasoline and only a tier 1 method is provided to estimate the emissions from this fuel in the 2006 IPCC Guidelines.	

To learn more about the methods to estimate GHG emissions from domestic aviation, see section 3.6.1 of the 2006 IPCC Guidelines (vol. 2, chap. 3, pp.3.57–3.64).

Completeness: the considerations made to estimate the split between domestic and international fuel consumption must be clearly specified to facilitate the assessment of completeness. When LTO data are used to estimate emissions:

- Completeness of the LTO statistics is crucial;
- The fuel-derived consumption must be consistent with fuel statistics at the national level;

- Non-scheduled activities and the use of aviation gasoline are not covered by this method and an alternative approach must be used.

Although emissions from military aviation are not allocated under domestic aviation, completeness may be an issue where military data are confidential.
Guidance on emissions estimation for military aviation is provided in chapter 3 of the 2006 IPCC Guidelines, but the corresponding emissions are reported under subcategory other – mobile (1.A.5.b) and not under mobile combustion (1.A.3).

To learn more about military aviation, see section 3.6.1.4 (vol. 2, chap. 3, pp.3.66–3.68) of the 2006 IPCC Guidelines.

1.A.3.b road transportation

Two methods are available to estimate emissions from road transportation: the fuel-based approach (tier 1 and tier 2) and the distance-travelled or VKT approach (tier 3).
Considering the almost exclusive dependence of the CO_2 emissions on carbon content of the fuel and the technology dependence of non-CO_2 emissions, the 2006 IPCC Guidelines indicate that CO_2 emissions are best estimated using a fuel-based approach, while the VKT approach is appropriate for non-CO_2 emissions.
Emissions are attributed to the country where the fuel is sold (i.e. loaded into the vehicle). Depending on the tier and the GHG (CO_2 or non-CO_2) concerned, different disaggregation levels of AD into vehicle type and emission control technology would be required to estimate emissions using the fuel-based approach. Exercise 2 below (section 4. Practical exercises) illustrates a case for road transportation where a significant amount of fuel loaded to vehicles in one country is consumed in other countries.

	Data	CO_2	Non-CO_2
Tier 1	AD	Amount of fuel consumed (as represented by fuel sold) by fuel type at the national level	
	EF	Default	Default
Tier 2	AD	Same as in tier 1	Amount of fuel consumed (as represented by fuel sold) by fuel type at the national level, disaggregated by vehicle type and emission control technology
	EF	Country-specific	Country-specific technology based

For a VKT approach, the vehicle fleet of the country is organized according to fuel type, vehicle type, emission control technology and operating and environmental conditions. For each combination of these parameters, the VKT approach requires country-specific data on distance travelled (km), average fuel consumption (l/km), EFs under thermally stabilized operating conditions (mg/km) and during cold start (mg/start or mg/km). This information constitutes a large data set. Many Parties report, in an annex to the NID, a summary, the entire set or provide a link to the data set used to estimate emissions. In your review, you are not supposed to make an in-depth assessment of all values in the data set but you must check that the NID reports the descriptions, assumptions, references and sources of information used to estimate the emissions in line with paragraph 39 of the MPGs.

Tier 3 emission models include components to estimate variables such as VKT-driven and speed-dependent EFs and capabilities to manage the considerable amount of data. When a VKT approach is used, you must check how the Party assessed whether fuel-derived consumption was consistent with fuel statistics at the national level. If this is not discussed in the NID you should ask for explanations and provide a recommendation in the TERR if necessary.

The 2006 IPCC Guidelines highlight the relevance of validating estimates of fuel consumption based on distance travelled by including it as a first step in the decision tree to estimate emissions from road transportation (vol. 2, chap. 3, figure 3.2.1, p.3.11).

To learn more about checks on AD selection to avoid omissions or double counting of emissions, see section 3.2.1.3 (vol. 2, chap. 3, pp.3.25–3.28) of the 2006 IPCC Guidelines.

1.A.3.c railways

The IPCC tier 1 and tier 2 approaches to estimate emissions from railways are fuel-based. The disaggregation of AD depends on the tier used and whether CO_2 or non-CO_2 emissions are being estimated.

	Data	CO_2	Non-CO_2
Tier 1	AD	Amount of fuel consumed by fuel type at the national level	
	EF	Default	Default
Tier 2	AD	Same as in tier 1	Amount of fuel consumed at the locomotive category level
	EF	Country-specific	Country-specific for locomotive type, if available

The tier 3 approach requires locomotive-specific information. Implementing a tier 3 approach is only worthwhile for non-CO_2 emissions although it is likely that they would not be identified as key categories. The disaggregated fuel consumption data used or estimated in a tier 3 approach must be consistent with the national fuel statistics used to estimate CO_2 emissions.

Some risks of omitting or double counting emissions concern fuels other than diesel oil that may be used in diesel locomotives for traction purposes and for railway carriage heating. There are potential overlaps with other fuel combustion categories where it is impossible to separate fuel used for locomotives and for stationary and off-road sources occurring in railways activities (e.g. at railway stations).

1.A.3.d domestic navigation

The 2006 IPCC Guidelines provide two-tier approaches to estimate CO_2, CH_4 and N_2O emissions from domestic navigation. They are fuel-based and the required AD and EFs for each tier are summarized in the decision tree shown in figure 3.5 of the 2006 IPCC Guidelines (vol. 2, chap. 3, p.3.43).

The considerations made to estimate the split between domestic and international activities must be clearly specified in the NID to facilitate the assessment of completeness. This could be the most important focus in your review of this subcategory: checking if the criteria used by the Party for defining international and domestic navigation are in line with the 2006 IPCC Guidelines, more specifically those criteria set out in table 3.5.4 (vol. 2, chap. 3, p.3.51). You also need to consider paragraph 53 of the MPGs in this regard.

Some misallocation of navigation emissions to another subcategory/subcategories may occur (e.g. for small watercraft powered by gasoline engines); this type of misallocation will not affect completeness of the total national CO_2 emissions inventory, but it will affect accuracy of the total non-CO_2 emissions inventory, because non-CO_2 EFs differ by technologies used between subcategories.

Fugitive emissions from transport of fossil fuels in ships should be estimated and reported under fugitive emissions from fuels.

Although military navigation is not allocated under domestic navigation, completeness may be an issue where military data are confidential.

3. Review approach

Similar to lesson 3, from the three main steps of the review approach (Prepare – Assess – Draft) this topic focuses on the assessment step. Drafting is covered in the walk-through examples and exercises.

The reporting and review of estimates of GHG emissions from fuel combustion have some common features. However, for mobile combustion there are fewer common aspects than for stationary

combustion, given the particularities of the different transport modes. CO_2 emissions based on fuel consumption and default or country-specific EFs constitute the main common feature, but even for these emissions there are particularities for each transport mode that need to be considered. The review of country-specific CO_2 and non-CO_2 EFs has similar aspects to that for stationary combustion and these are not repeated here.

3.1. Main review topics across categories

The connections of mobile combustion with other categories in the energy sector and other inventory sectors occur through (i) the use of specific fuels and (ii) combustion and other processes occurring in different transport modes. They were addressed in lesson 2. Nevertheless, it is worth considering the emissions associated with the use of lubricants and urea-based selective catalytic converters. The general criterion is that emissions from combustion are allocated in the corresponding transport category and non-combustion emissions are allocated in IPPU. Therefore, the following emissions are reported under the IPPU sector: CO_2 from non-energy use of lubricants under 2.D.1 and CO_2 from urea use in catalytic converters under 2.D.3.

Keep in mind the connections of transport with other energy categories and other inventory categories discussed in lesson 2.

3.2. Category-specific considerations

1.A.3.a domestic aviation

Activity data

- The split between domestic and international fuel consumption should be in accordance with the criteria in table 3.6.6 of the 2006 IPCC Guidelines (vol. 2, chap. 3, p.3.65). If the split is not in line with IPCC good practice, you should assess what effort must be done by the Party to apply the IPCC criteria (see also para. 53 of the MPGs).
  - Remember that journeys between two airports in the national territory are domestic even if the country has overseas territories and the journeys are between the mainland and an overseas territory.
- Estimated emissions correspond to the total amount of gasoline and jet kerosene used for aviation in the country. Note that for tier 2 emission estimates the allocation between LTO and cruise will not be complete if the LTO statistics are not complete. Check that fuel consumption estimates have been reconciled with national statistics in line with IPCC good practice.
- Aviation fuels used in applications other than aviation (engine and airframe testing) have been excluded.

Verify that the following activities were not included under domestic aviation

- Military aviation reported under subcategory 1.A.5.b other – mobile.
- Stationary combustion at airports, reported under subcategory 1.A.4.a commercial/institutional.

- Fuel use for ground transport at airports, reported under subcategory 1.A.3.e other transportation.

1.A.3.b road transportation

Activity data checks

- Ensure that the inventory includes all fuels used. The use of certain fuels (e.g. LPG, CNG, biofuels and recovered gas from the waste sector) may have been disregarded, especially when the fuel has been recently incorporated and its share in total fuel use by road vehicles is very low as compared with those of gasoline and diesel oil.
- Consider inclusion of all fuels used for road transportation that were sold in the territory of the Party. This is particularly relevant where cross-border transfers take place in vehicle tanks.
- Consider possible alternative uses of fuels sold for road transportation (e.g. for stationary boilers, recreational vehicles and boats) if fuel sales are used as AD.
- Consider disaggregation between on-road use and off-road use.

Treatment of biofuels and blended fuels

- If the Party reports use of biofuels, check if it has assessed the biofuel origin so as to identify and separate fossil from biogenic feedstocks. Inspect possible fossil origin of fuels such as methanol and ethanol (biodiesel made from fossil fuel derived methanol and animal feedstocks is an example of biofuel with a fossil component).
- Verify that double counting with the waste sector has been avoided:
  - If recovered gas (from landfills, biological treatment or wastewater treatment plants) is used as transport fuel;
  - If wastes (such as waste cooking oil) are used to produce biofuels.

Verification

- If the VKT approach is used, check if the estimated fuel use from the VKT data has been compared and reconciled with fuel statistics and the results of the comparison are reported.
  - Find out if the Party has carried out QC activities by comparing CO_2 estimates using VKT and fuel statistics data. Assess the conclusions of such a comparison.
- If the Party has used EFs from an emission model (such as COPERT; MOVES, PHEM) to estimate GHG emissions from road transport, verify that the Party transparently documented how the EFs applied are appropriate to its national circumstances. This might be rather difficult, but you as a reviewer can verify that the Party transparently documented how the parameters affecting the CH_4 and N_2O emissions have been determined.

Correct allocation (industrial processes and product use sector versus road transport subcategory)

- Check that emissions from lubricants when they are combusted in two-stroke engines are allocated under road transportation and when they are not combusted (used mainly to reduce friction and wear on moving parts in engines) are allocated under the IPPU sector.

- If a urea-based catalyst is used, check that the corresponding CO_2 emissions have been allocated to the IPPU sector. Although the 2006 IPCC Guidelines indicate that these emissions should be reported under energy (vol. 3, chap.3, box 3.2, p.3.16), the CRTs indicate that they should be reported under category 2.D.3 of the IPPU sector (footnote 13 in CRT table 1.A(a), sheet 4).

Note that where there is inconsistent guidance between the 2006 IPCC Guidelines and the MPGs (including CRTs), the guidance in the MPGs is to be followed.

1.A.3.c railways

Activity data checks

Check that the following activities and their emissions were not included under subcategory 1.A.3.c railways, ensuring than no double counting or omission of emissions occurred:

- Stationary combustion by railway companies (e.g. at railway stations) and railway power stations (reported under subcategory 1.A.4.a commercial/institutional);
- Fuels used for heating cars (reported under subcategory 1.A.4.a commercial/institutional);
- Lubricant use in diesel locomotives (reported in the IPPU sector under 2.D.1 lubricant use).

1.A.3.d domestic navigation

Activity data checks

- The split of domestic/international fuel consumption should be in accordance with table 3.5.4 of the 2006 IPCC Guidelines (vol. 3, chap.3, p.3.51).
  - Remember that journeys between two ports in the national territory are domestic even if the country has overseas territories and the journeys are between ports in the mainland and an overseas territory.
- Check that there is no omission or double counting of fuel consumption for some types of watercraft such as ferries, passenger vessels, recreational vessels, etc.
- Check that the following activities and their emissions were not included under domestic navigation:
  - Military navigation (to be reported under subcategory 1.A.5.b other – mobile).
  - Fishing vessels (to be reported under subcategory 1.A.4.c.iii agriculture/forestry/fishing – fishing.

1.A.3.e other transportation

Check that the following activities and their emissions were included under subcategory 1.A.3.e other transportation, ensuring that no double counting or omission of emissions occurred:

- Pipeline transport (1.A.3.e.i) and other (1.A.3.e.ii). The latter subcategory includes emissions from off-road vehicles and mobile machinery such as airport and port ground support equipment. It does not include off-road activities that have been included under different subcategories within the stationary combustion categories 1.A.2 manufacturing industries and construction or 1.A.4 other sectors.

3.3. Key points to consider when reviewing cross-cutting issues

Transparency

Where methods requiring disaggregated fuel consumption are used, the NID should indicate how this information has been obtained and how it has been reconciled with national totals.

Although archiving all information used to estimate and report emissions is a mandatory function of the national inventory arrangements as established by paragraph 19(c) of the MPGs, keeping a complete record of all input data and facilitating access to the reviewers is particular important for the review of tier 3 models. Although you are not expected to undertake an in-depth investigation of the enormous amount of values for the parameters used in a tier 3 mobile combustion model, you may need to look for certain input data to better understand how the model was implemented and run. Key checks on the outputs of tier 3 models include:

- The representativeness of national circumstances if the default model's parameters were used;
- The total amount of fuel used as calculated from associated AD (e.g. VKT and fuel economy) and the validation step against fuel statistics.

Overall, emissions from aviation and navigation activities are reported in several categories and subcategories, including domestic, international, military (under subcategories 1.A.5.b other – mobile and 1.A.4.c.iii fishing (for navigation). All issues associated with the allocation of these emissions should be transparently reported in the NID.

Some AD confidentiality issues may involve:

- The use of fuel by the military;
- Where only one or two companies operate domestic transport in a given country, including fuel suppliers;
- The composition of some additives used in road transportation.

Time-series consistency:

- Changes in efficiency in fuel use would affect GHG emission levels but they would not greatly affect CO_2 IEFs. If you note atypical variations of the CO_2 IEFs across the time series (for example, large variability, the existence of outliers, inconsistent values for the same fuel used by different road vehicle types, e.g. significantly different CO_2 IEFs for diesel oil used by passenger cars, light-duty vehicles and heavy-duty vehicles) you should investigate the reasons for this behaviour. If you have findings on accuracy and/or consistency, you must provide the corresponding recommendation(s).
- Changes in the composition of the country's fleet and/or the introduction of air pollution measures would have a greater impact on non-CO_2 emissions. Higher-tier methods (VKT for road transportation, tier 2 or tier 3B for civil aviation) are, in principle, suitable for reflecting these changes. In your review, you must look for the explanations provided by the Party in the NID about the underlying reasons for such variability. Note that IEFs are useful indicators of changing patterns, possible problems, etc.; however, Parties are not obliged to explain the variability associated with each IEF in the emissions inventory but the NID must contain enough information to explain relevant changing patterns in emissions across the time series. If this information is missing, ask the Party for an explanation and provide a recommendation in the TERR if necessary.

Uncertainty assessment

The main concern relates to the uncertainty values for EFs and AD. The 2006 IPCC Guidelines provide default uncertainty values for CH_4 and N_2O EFs and examples of uncertainty ranges for CO_2 EFs, non-CO_2 EFs and AD. You should assess how the uncertainty estimates for EFs and AD have been selected or derived and whether results are reported in the NID in accordance with the MPGs.

To learn more see sections 3.6.1.7 (civil aviation), 3.2.2 (road transportation), 3.4.1.6 (railways) and 3.5.1.7 (waterborne navigation) of the 2006 IPCC Guidelines (vol. 2, chap. 3) and paragraphs 29 and 44 of the MPGs.

Remember that developing countries that need flexibility in the light of their capacities are encouraged, not required, to provide quantitative estimates of uncertainty. They are also encouraged to provide a qualitative assessment of uncertainty for key categories (para. 29 of the MPGs).

Quality assurance and quality control

Specific components of QA/QC procedures for mobile combustion include:

- Comparison of emission estimates using different approaches:
  - A comparison of CO_2 emission estimates between the sectoral approach and those from the IPCC reference approach should be reported by the Party and reviewed by the TERT. Although the reference approach is a top-down method that does not distinguish the categories or subcategories under which the different fuels are used, some fuels such as motor gasoline, jet kerosene and aviation gasoline are almost exclusively used by mobile combustion sources. You should assess whether significant differences exist between the estimates of total CO_2 emissions from both approaches for those fuels used almost exclusively for mobile combustion. In such cases try to identify the categories or subcategories that are driving these differences and formulate questions to the Party with regard to the verification and the accuracy of the corresponding CO_2 emission estimates. This comparison is only partial as it is not possible to check all fuels used for mobile activities, especially diesel oil, and it may not always be adequate because in some cases fuels have alternative uses in stationary combustion or in transport subcategories other than the subcategory where a particular fuel is supposed exclusively used;
  - If higher-tier approaches have been used to estimate emissions compare the results obtained with those from lower-tier approaches.

Remember that developing countries that need flexibility in the light of their capacities are encouraged, not required, to implement and provide information on general inventory QC checks (para. 35 of the MPGs).

3.4. Walk-through examples

You will work in five examples covering the following mobile combustion subcategories:

1. Domestic aviation;
2. Road transportation;

3. Use of biomass fuels under road transportation and railways;
4. Domestic navigation;
5. Other transportation.

The examples cover topics such as: (1) Use of notation keys; (2) Checking the status of previous recommendations; (3) Formulating questions; (4) Translating findings into issues; and (5) Drafting TERR.

1. Domestic aviation – aviation gasoline – all gases

For aviation gasoline, Party A has reported AD and CO_2, CH_4 and N_2O emissions as "IE" in CRT 1.A(a) (sheet 3) for most of the years in the time series. For those years for which emissions were reported separately under road transportation and domestic aviation, the Party used the corresponding tier 1 IPCC default EFs to estimate GHG emissions for both fuels under the corresponding subcategory.
In response to a question raised by the TERT during the review, Party A responded that for all years for which no separate data were available, aviation gasoline consumption in domestic aviation is reported together with gasoline use in road transportation. In its answer to a follow-up question, the Party clarified that when aviation gasoline was reported together with motor gasoline, the default EFs for the latter fuel were used to estimate the emissions.
The review topic is that such reporting:
1. Reduces the comparability of the inventory;
2. Affects the accuracy of the CO_2 emission estimates;
3. Affects the accuracy of the non-CO_2 emission estimates;
4. Is not time-series consistent.

Reviewer considerations

Comparability is reduced because the emissions are not allocated in line with the agreed reporting format defined by the CRTs. The reporting of these emissions under road transportation in certain years and under domestic aviation in others affects the time-series consistency of both subcategories. Since CO_2 depends on the AD and the carbon content of the fuel, considering that there is a slight difference in the carbon content of motor gasoline and aviation gasoline it is likely that the reporting would slightly affect the accuracy of the CO_2 emission estimates. However, non-CO_2 emissions are technology dependent and, consequently, the tier 1 IPCC default EFs for road transportation and civil aviation exhibit significant differences. CH_4 EFs for road transportation are in the range of 3.8–33 kg/TJ, while the CH_4 EF for civil aviation is 0.5 kg/TJ. N_2O EFs for road transportation are in the range of 3.2–8.0 kg/TJ, while the N_2O EF for civil aviation is 2 kg/TJ. Therefore, misallocating aviation gasoline consumption between these two subcategories involves accuracy issues, in particular for non-CO_2 emission estimates.

2. Road transportation – liquid fuels – CO_2

The NID of a Party indicates that CO_2 emissions for road transportation, which has been identified as key category, have been estimated using:

- A fuel-based approach with tier 1 IPCC default EFs for gasoline and diesel oil;
- The COPERT IV model (a VKT approach) for LPG and CNG.

2.1 Identifying possible inconsistencies with the 2006 IPCC Guidelines

With this brief information, you may identify at least two inconsistencies with the 2006 IPCC Guidelines. They are summarized below, indicating (1) the inconsistency identified; and (2) the corresponding rationale.

Inconsistency 1

1. For gasoline and diesel oil, the Party used a tier 1 approach to estimate CO_2 emissions for a key category.
2. The estimation is not in line with the 2006 IPCC Guidelines, which indicate the use of higher-tier approaches to estimate emissions from a key category. However, remember that paragraph 23 of the MPGs addresses those cases in which a Party has been unable to adopt a higher-tier method for a key category and indicates that a tier 1 approach may be used provided that the reasons for a methodological choice not in line with the 2006 IPCC Guidelines is clearly documented in the NID.

Inconsistency 2

1. For LPG and CNG to estimate CO_2 emissions, the Party uses a VKT approach, while the 2006 IPCC Guidelines indicate that CO_2 emissions from road transportation are best calculated on the basis of the amount and type of fuel combusted and its carbon content.
2. In principle this should not necessarily be an inconsistency; however, as the Party used a VKT approach it is important that the total fuel consumption calculated by the model be reconciled with the fuel consumption reported in the national statistics. The Party may have used a VKT approach because it may have been impossible to obtain disaggregated consumption of LPG and CNG to estimate emissions using the fuel-based approach. Note that evaluating fuel use balance (i.e. the difference in fuel use between the estimates based on the VKT approach and that reported in the national statistics) may pose difficulties if disaggregation between stationary and mobile fuel use has not been attained.

Note that currently some models such as COPERT V allow for automatic balancing of the model fuel consumption with the statistical fuel consumption (which is an input to the model).

2.2 Formulate questions to the Party

In both cases you need to find out the underlying circumstances that led the Party to estimate CO_2 emissions from road transportation in the manner described earlier. Before the review week you will need to draft preliminary questions to the Party on these two findings. Note that your questions should not provide indications or recommendations. The facts triggering your questions must be clearly described. Consider the examples below.

Question 1

The NID indicates that a fuel-based approach has been used to estimate CO_2 emissions from gasoline and diesel oil under road transportation using IPCC default EFs. The TERT would appreciate it if the Party indicated the difficulties faced in using country-specific CO_2 EFs to estimate these emissions.

Question 2

The TERT notes that a VKT approach has been used to estimate CO_2 emissions from LPG and CNG under road transportation, and would appreciate it if the Party indicated why this has been the preferred approach instead of using a fuel-based approach with country-specific CO_2 EFs. In addition, the TERT would like to know how the fuel consumption estimated with VKT compares with that reported by national statistics and whether it has been reconciled for preparing the emission estimates.

Note that the TERT would need to check whether LPG and CNG used for road transportation are de-facto reported as a subset of total LPG and CNG consumption in the national statistics in preparation of this specific question.

3. Use of biomass in road transportation and railways

Consider the report on biomass fuels under road transportation and railways provided in CRT 1.A(a) (sheet 3) and the summary report on methods and EFs used (CRT Summary 3) submitted by Party C. The CRTs needed for this example are available in the Supplementary Materials at https://unfccc.int/resource/tet/be/be4-01_en4_exmpl.xlsx.

Note that (1) for the purpose of this exercise, only the information for the energy sector is provided in CRT Summary 3 and (2) the NID did not include any information on the type of biomass used in these transport subcategories.

3.1. Findings

Possible inconsistencies found through the analysis of the information provided are listed below.

- Emissions of CH_4 and N_2O are reported with numerical values, while those of CO_2 as "NO".
- CRT Summary 3 indicates the use of tier 1 default EFs for the entire transport category.
- For road transportation the IEFs reported in CRT 1.A(a) (sheet 3) are the same for CH_4 and N_2O and equal to 30 kg/TJ. The only tier 1 IPCC default EFs for biomass fuels are for ethanol, which are in the range of 18–260 kg/TJ (CH_4) and 41 kg/TJ (N_2O).
- For railways the IEFs reported in CRT 1.A(a) (sheet 3) are 30 kg/TJ (CH_4) and 4 kg/TJ (N_2O). The 2006 IPCC Guidelines do not provide tier 1 default EFs for any biomass fuel.

3.2. Inconsistencies with the 2006 IPCC Guidelines and/or the MPGs

During the review the Party was asked to provide information on the use of biomass fuels for transport. The Party responded that, according to data from the energy balance, wood/wood waste is consumed in the transportation and communication sector as fuel for stationary combustion in institutional buildings.

In this regard, note that the tier 1 IPCC default EFs for biomass under stationary combustion in the commercial/institutional category are as follows:

- Solid biomass: CH_4 (300 kg/TJ) and N_2O (4 kg/TJ); charcoal: CH_4 (200 kg/TJ) and N_2O (1 kg/TJ);
- Liquid biofuels: CH_4 (10 kg/TJ) and N_2O (0.6 kg/TJ);
- Gas biomass: CH_4 (5 kg/TJ) and N_2O (0.1 kg/TJ).

Considering the findings, the Party's response and the information provided above, a summary of the inconsistencies identified is presented as follows:

Use of notation key "NO" for CO_2 emissions from biomass in CRT 1.A(a) (sheet 3)

Although CO_2 emissions from biomass are not to be included in the energy and national totals and are reported as a memo item, they must be reported in sectoral background CRT 1.A(a). In addition, note that reporting "NO" for all vehicle and fuel types under road transportation is not correct; probably notation key "IE" should have been used instead.

Report on use of wood/wood waste under category 1.A.3 transport

The use of wood/wood waste is not expected under mobile combustion. According to the answer by the Party, the CO_2 emissions from biomass must be reported under 1.A.4.a commercial/institutional, as they constitute emissions from stationary combustion activities.

CH_4 and N_2O EFs for wood/waste combustion under commercial/institutional

If wood/wood waste is the only type of biomass used as fuel and the Party uses tier 1 IPCC default EFs, then the CH_4 and N_2O IEFs should coincide with the IPCC default EFs. If other types of biomass are used as fuels, then the IEFs would be a weighted average of the corresponding default EFs. In any case, it

would be impossible to have an IEF for N_2O equal to 30 kg/TJ (reported for road transportation) as all IPCC default N_2O EFs for biomass fuels are less than or equal to 4 kg/TJ.

3.3 Drafting an assessment and recommendation to the Party in the technical expert review report

An example of the corresponding paragraph in the TERR is provided below.

Finding classification	*Description of the finding with recommendation*	*Classify by type*
1.A.3 transport Biomass – CO_2, CH_4, N_2O	Party C reported CH_4 and N_2O emission estimates from biomass in road transportation and railways. CO_2 emissions were reported as "NO". The TERT also noted that in CRT 1.A(a) the reported CH_4 and N_2O IEFs from biomass in road transportation are both 30.00 kg/TJ, while for railways the IEFs are 30.00 kg/TJ and 4.00 kg/TJ, respectively. The NID did not include any information on the type of biomass used in these transport subcategories. In response to a question raised by the TERT during the review, Party C stated that, according to data from the energy balance, "wood/wood waste" is consumed in the "transportation and communication" sector as fuel for stationary combustion in institutional buildings. The TERT recommends that Party C improve the accuracy and comparability of the reporting in its next GHG inventory submission by: reallocating CH_4 and N_2O emissions from biomass in road transportation and railways to subcategory 1.A.4.a commercial/institutional; applying the correct CH_4 and N_2O EFs for wood/wood waste in its calculations; and estimating and reporting CO_2 emissions from biomass use in the corresponding categories, as well as using the correct notation key for CH_4 and N_2O emissions from biomass in road transportation and railways, if this type of fuel is not used in these categories.	Accuracy

4. Domestic navigation – other fossil fuels – N_2O

Party D reported GHG emissions for other fossil fuels (LNG) under domestic navigation as "NO" for 1990–2014. From 2015 onward, the Party has estimated and reported CO_2 and CH_4 emissions for LNG but has reported N_2O emissions as "NE". The NID does not indicate why N_2O emissions were not estimated.

From the physical standpoint, if the activity occurs, all relevant GHG emissions also occur. If the Party has not estimated N_2O emissions, in accordance with paragraph 30 of the MPGs the Party should have explained in the NID why these emissions were not estimated.

Part of your assessment as reviewer is checking whether the 2006 IPCC Guidelines provide an estimation methodology and default EFs for non-CO_2 gases for waterborne navigation in table 3.5.3 of the 2006 IPCC guidelines (vol. 2, chap. 3, p.3.50).

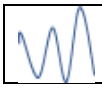
4.1 Drafting a preliminary question to the Party

This finding may lead to a completeness issue as the Party has not estimated emissions for which the 2006 IPCC Guidelines provide a methodology and default EFs. In the following preliminary question, the Party is asked about the reasons for not having estimated N_2O emissions for LNG use.

The TERT notes that from 2015 onward, the Party has estimated and reported CO_2 and CH_4 emissions for LNG (other fossil fuels) under domestic navigation but has reported N_2O emissions as "NE". For 1990–2014 the Party reported all GHG emissions for LNG under domestic navigation as "NO". The TERT further notes that the 2006 IPCC Guidelines provide tier 1 default EFs for N_2O emissions for waterborne navigation (vol. 2, chap. 3, table 3.5.3, p.3.50). The NID does not indicate why N_2O emissions were not estimated. The TERT would appreciate it if Party D indicated why it was unable to estimate these emissions.

4.2 N_2O emissions from liquefied natural gas combustion under domestic navigation considered insignificant

In its response, the Party considered that the likely level of N_2O emissions from LNG used for domestic navigation was equal to 0.0003 kt CO_2 eq. The Party estimated this value using the LNG consumption for the latest reported inventory year (5 TJ, the same AD used to estimate CO_2 and CH_4 emissions) and the tier 1 default N_2O EF (2 kg/TJ): 5 TJ x 2 kg/TJ x 298 = 0.0003 kt CO_2 eq. The Party noted that this value was well below 25 kt CO_2 eq (0.05 per cent of national total without LULUCF, as reported in CRT Summary 2) and 500 kt CO_2 eq, which are the insignificance thresholds in paragraph 32 of the MPGs. The Party therefore claimed that the reporting of these emissions as "NE" was in line with the MPGs.



Flexibility: although not needed for this case, the threshold for developing country Parties that need flexibility in regard to this provision would be 50 kt CO_2 equivalent.

After having assessed the Party's response, the TERR should consider that the use of notation key "NE" is not in line with paragraph 32 of the MPGs because the insignificance criteria apply to the category and all its gases and cannot be applied only to one gas in isolation. In this case AD are available and insignificance cannot be claimed for N_2O only. Alternatively, the Party may have originally decided to claim insignificance for the entire subcategory and all three gases (reporting all of them as "NE"). However, as the Party has already estimated and reported CO_2 and CH_4 emissions for this subcategory, it cannot report these emissions as "NE" as paragraph 33 of the MPGs clearly indicates that once emissions have been estimated for a category, the Party shall report these emissions as they continue to occur.

It is also worth noting that the estimation of these emissions does not require a disproportionate amount of effort as the AD are available and the IPCC default EF may be used. Therefore, the TERT must identify a completeness issue and recommend that the Party estimate and report N_2O emissions for the use of LNG under domestic navigation using the available AD and the tier 1 IPCC default N_2O EF.

5. Pipeline transport – gaseous fuels – CO_2, CH_4 and N_2O emissions

Party E reported emissions for subcategory 1.A.3.e.i pipeline transport as "IE"; however, no information is reported in CRT 9 on the allocation of emissions from this activity. Party E is an important natural gas producer and from a quick inspection of CRT 1.A(b) presenting information for the reference approach you note that in the latest inventory year Party E produced more than 100,000 million m^3 of natural gas and exported about 95 per cent of its production to neighbouring countries.

Before the review week you draft a clarifying question to the Party. An example is provided below.

5.1 Preliminary question

The TERT notes that emissions for subcategory 1.A.3.e.i pipeline transport have been reported as "IE" but the Party did not provide any information on the allocation of emissions from this activity. The TERT would appreciate it if the Party indicated the allocation of these emissions (category/subcategory) and the corresponding rationale for such decision.

5.2 Drafting an assessment and recommendation after receiving the Party's response

The Party indicated in its response that emissions from pipeline transport are reported under energy industries. It further explained that this is because electricity generation activities are undertaken in conjunction with natural gas transmission, making it difficult to properly attribute emissions.

Next, you need to assess the issue and provide a recommendation in the TERR. An example is given below.

5.3 Assessment of the issue and recommendation to the Party

Party E reported GHG emissions for subcategory 1.A.3.e.i pipeline transport using notation key "IE". However, no information was provided in the NID and in CRT 9 about the allocation of GHG emissions from this activity. During the review, Party E informed the TERT that emissions for subcategory 1.A.3.e.i pipeline transport are reported under category 1.A.1 energy industries and explained that this is because electricity generation is undertaken in conjunction with natural gas transmission, making it difficult to properly attribute emissions in the corresponding categories of CRT. The TERT considers that the current reporting is not fully in accordance with the MPGs.
The TERT recommends that Party E make the effort to estimate and report GHG emissions from pipeline transport separately from electricity generation and allocate them under subcategory 1.A.3.e.i (under 1.A.3.e other transportation). If this is not possible, the TERT recommends that the Party describe in the NID the reasons why it has determined that reporting GHG emissions for subcategory 1.A.3.e.i pipeline transport under category 1.A.1 is consistent with the MPGs and leads to accurate emission estimates and provide clear information on the allocation of these emissions in CRT 9.

4. Practical exercises

Exercises are provided for you below to practise your skills as an expert reviewer of emission estimates and related information for category 1.A.3 transport. You will work with exercises on the following topics:

- Exercise 1: Domestic aviation – domestic/international split;
- Exercise 2: Road transportation – activity data and CH_4 emission estimates;
- Exercise 3: Domestic navigation – activity data.

4.1. Exercise 1. Domestic aviation – domestic/international split

Party A has adopted the following criteria provided by its national civil aviation authority to define domestic and international flights:

- Domestic flight: both the initial point and the final point of the flight are domestic airports;
- International flight: either the initial point or the final point of the flight is an international airport.

For example, a flight that travels from airport A (within the country) to airport B (within the country) to airport C (outside the country) is categorized as international, as the final point is outside the country. The national civil aviation authority definitions are used to generate national statistics of international and domestic aircraft movements. Detailed AD provided by the national civil aviation authority include aircraft movements broken down by airport; aircraft type; and whether the flight is international or domestic. The Party is of the view that the consequence of the difference between national civil aviation authority and IPCC definitions on domestic or international flights will have little impact on national total emissions.
Based on the information above on the domestic/international split for aviation adopted by the Party, draft answers to the following four questions:

- What finding can you identify?

- Why is it inconsistent with the 2006 IPCC Guidelines and/or the MPGs?
- What ideal situation would avoid the occurrence of the inconsistency?
- What is the recommendation by the TERT?

4.2. Exercise 2. Road transportation – activity data and CH_4 emission estimates

Consider the following information provided in the NID by Party B describing the particular situation of the country's fuel sales of liquid fuels for road transportation:
Road transportation (with a high traffic volume by trucks and passenger vehicles) is the largest source of GHG emissions in Party B. The number of circulating passenger vehicles in the country has recently grown owing to an increasing high number of commuter journeys from and to neighbouring countries during working days. In comparison with international traffic, domestic traffic accounts for only 25 per cent of the total road fuels sold in the country. The fuel sales at filling stations provide the AD selected by the Party to estimate and report CO_2 emissions, although 75 per cent of these emissions cannot be assigned to the vehicles registered in the country and are actually emitted mostly abroad.

2.1 Choice of activity data

According to the description reported above, do you consider that Party B has selected the AD to estimate CO_2 emissions from road transportation in line with the 2006 IPCC Guidelines?
A. Yes
B. No

2.2 Estimates of CH_4 emissions from diesel light-duty trucks and heavy-duty trucks

The NID indicates that non-CO_2 emissions from road transportation are estimated using a km-based (VKT) model, which combines detailed calculation of the vehicle fleet composition and simulation of EFs on the vehicle level. The parameterization of the model is based on in-use measurements, which are updated regularly according to recent data on emission behaviour and vehicle technologies. All on-road categories of vehicles registered at the national level are covered.
Using an electronic review tool provided by the secretariat, you note that for Party B the CH_4 IEFs for diesel LDT and HDT (0.08 kg/TJ and 0.07 kg/TJ, respectively) are the lowest among reporting Parties in the latest reported year. You also note that for neighbouring countries, the CH_4 IEFs for diesel LDT are in the range of 0.12–0.22 kg/TJ and for diesel HDT in the range of 0.16–0.97 kg/TJ.
The NID indicates that since the major part of the fuel sold in the country goes out of the national territory and is "exported" in the tanks of the vehicles going to the neighbouring countries, the VKT model disaggregates the total fuel sold into that consumed within the national territory (domestic) and that consumed in the vehicles travelling out of the country (exported). According to the NID, (1) this calculation is made in several successive steps by subtracting the estimated domestic consumption of gasoline and diesel oil obtained with the VKT model (based on the national registered fleet) from the total amount of each fuel that was sold in the country as reported by the national energy statistics; (2) exported gasoline is allocated to passenger vehicles while diesel oil is allocated to both passenger vehicles and HDTs; (3) the distance (km) travelled by passenger cars and HDTs going out of the country is determined based on the estimated exported fuel amounts; (4) the emissions from domestic fuel use and exported fuel are calculated separately by the VKT model; and (5) it is assumed that the composition of the transborder fleet is identical to that of the domestic fleet.

During the review you note that supporting evidence to justify the assumption in point (5) above has not been provided in the NID.
Based on your findings and the description of the methodology in the NID, formulate a clarifying question to the Party.

2.3 Drafting an assessment and recommendation to the Party

The Party explained that the reason for the relatively low CH_4 IEFs for diesel LDT and HDT is that the national fleet is very modern and equipped with more efficient combustion and emission control systems than in most other countries.
Considering that the response by the Party addresses the emission levels of the local fleet, but not entirely those of vehicles not registered in the country, draft a paragraph for the TERR in the template available in Supplementary Materials in file https://unfccc.int/resource/tet/be/be4-02_en_terr_template.docx

4.3. Exercise 3. Domestic navigation – activity data

Party C describes in its NID that two information sources for the AD are used to estimate emissions from domestic navigation activities: (1) the aggregated figure at the national level for fuel used in shipping activities provided in the energy balance; and (2) detailed ship movements and technical information on ships (such as gross tonnage, ship type and speed) provided by the national seaport authority. Any vessel below a certain tonnage threshold is not considered in the AD method based on ship movement. The methodology takes into account the fuel used as well as the type of ship, the distance travelled and the average speed of the vessel. The estimated fuel consumption is used for top-down calibration.
In your preliminary assessment you identified that the country has navigable waterways and lakes.

3.1 Completeness of the activity data

The description in the NID ensures the completeness of fuel use under domestic navigation.
True
False

3.2 Drafting a preliminary question to the Party

Prepare a preliminary question to the Party and compare it with the suggested answer below.

3.3 Drafting an assessment and recommendation to the Party

In response to your question, the Party explained that the energy balance data on navigation are used to complete the fuel consumption estimates for domestic navigation. This takes into account small boats that are not covered in the data from the national seaport authority since the definition for domestic navigation used in the energy balance is in line with that of the 2006 IPCC Guidelines.
Based on the issue identified and the response by the Party, write the corresponding paragraph in the TERR using the file https://unfccc.int/resource/tet/be/be4-03_en_terr_template.docx

4.4. Answer key

1. Exercise 1

- What is the identified finding?

The categorization of domestic and international flights by the Party's national civil aviation authority that was used to estimate the split between domestic and international aviation is not completely in line with the 2006 IPCC Guidelines.

- Why means inconsistency with the 2006 IPCC Guidelines and/or the MPGs?

The definition used implies that if an international flight (between an airport belonging to the national territory and an airport in another country) has intermediate stop(s) in the national territory, the domestic leg(s) are considered international, which is not in line with the 2006 IPCC Guidelines. This implies that emissions from domestic aviation have been underestimated.

- What an ideal situation would avoid the occurrence of the inconsistency?

The Party estimating and reporting emissions from domestic aviation in line with the 2006 IPCC Guidelines.

- What is the recommendation by the TERT?

That Party A use detailed AD and information available from the national civil aviation authority on aircraft movements broken down by airport to disaggregate the data on domestic leg(s) of international flights and allocate the disaggregated domestic leg(s) AD under domestic aviation in line with the 2006 IPCC Guidelines.

2. Exercise 2

2.1 Choice of activity data

The correct answer is Yes. Note that although the Party estimates that only 25 per cent of road fuel sold is burned in the country, the GHG emission estimates account for all fuel sold in filling stations within its territory. This is line with section 3.2.1.3 of the 2006 IPCC Guidelines (vol. 2, chap. 3, p.3.25), which indicates that "emissions from road vehicles should be attributed to the country where the fuel is sold".

2.2 Estimates of CH_4 emissions from diesel light-duty trucks and heavy-duty trucks

The TERT noted that (1) the CH_4 IEF for diesel LDT (0.08 kg/TJ) and HDT(0.07 kg/TJ) are the lowest among reporting Parties in the latest reported year; and (2) the national GHG emissions from road transportation include those of vehicles from neighbouring countries, which reported higher CH_4 IEFs for diesel LDT and HDT. The TERT would appreciate it if Party B explained the underlying reasons for reporting these relatively low CH_4 IEFs.

2.3 Drafting an assessment and recommendation to the Party in the technical expert review report

An example of the corresponding paragraph in the TERR is provided below.

Finding classification	*Description of the finding with recommendation*	*Classify by type*
1.A.3.b road transportation – diesel oil CH_4	The CH_4 IEFs for diesel light-duty trucks (0.08 kg/TJ) and heavy-duty trucks (0.07 kg/TJ) are the lowest among reporting Parties (ranging from 0.08 to 8.04 kg/TJ for light-duty trucks and 0.07 to 12.35 kg/TJ for heavy-duty trucks). The NID indicates that (1) a distinct characteristic of traffic flow within the national territory is given by a high number of commuter journeys from and to neighbouring countries during working days with domestic traffic (i.e. that comprising the vehicles registered in Party B) accounting for only 25 per cent of the total road fuels sold in the country; (2) a km-based (VKT) model was used to estimate CH_4 and N_2O emissions; (3) the VKT	Accuracy

Finding classification	*Description of the finding with recommendation*	*Classify by type*
	model allows disaggregating the total fuel sold in the country into that consumed within the national territory (domestic) and that consumed in the passenger cars (running with diesel oil and gasoline) and the diesel HDTs travelling out of the country (exported); (4) the kilometres travelled by passenger cars and HDTs going out of the country is determined on the basis of the estimated exported fuel amounts; (5) the emissions from domestic fuel use and exported fuel are calculated separately by the VKT model; (6) all the emissions from the fuels sold in the country are allocated to the national totals; and (7) it is assumed that the composition of the transborder fleet is identical to that of the domestic fleet. During the review, the Party explained that the reason for the relatively low CH_4 IEFs is that the national fleet is very modern and thus equipped with more efficient combustion and emission control systems than in most other countries. The TERT considers that the composition of the transborder fleet may be somewhat different from the domestic fleet, in which case different CH_4 EFs would be applicable. The TERT recommends that the Party provide justification of the applicability of domestic fleet CH_4 EFs to the transborder fleet or adopt an alternative approach, such as where appropriate using more representative CH_4 EFs for the transborder fleet (especially diesel HDTs) for which fuel use and kilometres travelled has been estimated on the basis of the VKT model.	

3. Exercise 3

3.1 Completeness of the activity data

The correct answer is 'False'. Even when the description of the methodology indicates the availability of fuel used for navigation from the energy balance and provides detailed ship movements from national seaports and associated technical information on vessel characteristics, it is not clear how the vessels below the tonnage threshold (the value of this threshold is not reported) and/or for shipping in waterways and lakes have been taken into account.

3.2 Drafting a preliminary question to the Party

1.A.3.d domestic navigation – liquid fuels – activity data

The NID indicates the availability of fuel used for navigation from the energy balance and provides detailed ship movements from national seaports and associated technical information on vessel characteristics. However, from the description of data used it is not clear how shipping in vessels below the tonnage threshold, which is also not reported, and fuel used by vessels for navigation in navigable waterways and lakes of the country has been taken into account in the emission estimates. The TERT would appreciate it if Party C clarified how fuel consumption by the above-mentioned vessels has been taken into account and confirmed whether reported emission estimates for subcategory 1.A.3.d domestic navigation include emissions from these vessels.

3.3 Drafting an assessment and recommendation to the Party in the technical expert review report

An example of the corresponding paragraph in the TERR is provided below.

Finding classification	*Description of the finding with recommendation*	*Classify by type*
1.A.3.d domestic navigation – liquid fuels CO_2, CH_4, N_2O	AD for domestic navigation are based on ship movement with a tonnage threshold (i.e. any vessel below the threshold is not considered in the AD method based on ship movement). During the review, Party C explained that energy balance data on navigation are used to complete the fuel consumption estimates for domestic navigation. The TERT noted that this procedure is not well documented in the NID describing the methodology for this category. The TERT considers that this makes it difficult for it to assess whether there is an underestimation or overestimation of fuel consumption for this	Transparency

Finding classification	*Description of the finding with recommendation*	*Classify by type*
	category. In addition, Party C informed the TERT that the fuel consumption of vessels below the tonnage threshold and vessels used in navigable waterways and lakes of the country are included in the consumption of national navigation, but that it is not possible to disaggregate this consumption by tonnage. The TERT agrees that, on the basis of this information, there is no underestimation of emissions. The TERT recommends that Party C update its methodological description of domestic navigation in the NID to describe how information from the energy balance is considered in the methodology to quantify fuel consumption for domestic navigation and indicate the threshold used, as part of a complete and clear description of the method in the NID.	

5. Self-check quiz

This quiz is offered so that you can test your skills as a reviewer of mobile combustion. It has eight questions, which were inspired by past submissions by different Parties. You will be able to assess a variety of situations, which include:

- Domestic aviation:
  - Use of tier 1 to estimate CO_2 emissions from jet kerosene (a key category);
  - Use of jet kerosene by the police and in military aircraft on domestic operations allocated under international aviation.
- Road transportation:
  - Information reported in the NID on the use of a tier 3 model to estimate non-CO_2 emissions;
  - Estimation and reporting of CH_4 and N_2O emissions from blended fuels;
  - Estimation and reporting of CO_2 emissions from urea-based catalysts.
- Domestic navigation:
  - Identification of a small amount of bunker fuel that is used in international waterways;
  - Use of tier 1 and country-specific methods to estimate CH_4 emissions;
- Other transportation:
  - Use off-road vehicles and other machinery for construction and industry.

As in lesson 2, the examples selected for the quiz constitute a small sample of the situations that you would face in an actual review. Nevertheless, we trust that with the walk-through example (section 3.4), the practical exercises (topic 4) and this quiz you have been faced with a wide range of cases that would have helped to strengthen your skills as an expert reviewer of mobile combustion.

1. Party D uses the COPERT model to estimate non-CO_2 emissions from road transportation. The following text is the description provided in the Party's NID regarding the methodology used to estimate these emissions:

"CH_4 and N_2O emissions from road traffic are estimated using the COPERT model, whose new version is used for the first time. This change of version gives rise to significant recalculations of N_2O emissions owing to a revision in the COPERT model software between versions that affects primarily older pollution control technologies of gasoline passenger cars. This explains the relatively small revisions to the years preceding 1993 and the years after 2006 when the number of vehicles with old pollution control technologies in use is small or not occurring. However, because CH_4 and N_2O emissions are

considerably lower than CO_2 emissions, the impact on the total for road transportation is minor. The COPERT model estimates emissions of CH_4 and N_2O on the basis of distance travelled using a detailed bottom-up approach (tier 3) that accounts for such factors as fuel type, fuel consumption, engine capacity, driving speed and a range of applicable technological emission controls that may be applied on the basis of the age of the vehicle. Detailed information on vehicle population by type and VKT data is presented in annex E."
The information reported in tabular form in annex E to the NID for every year of the reported time series contains information on the number of vehicles per type, size and fuel use. The information presented in the NID on the application of the COPERT model to estimate non-CO_2 emissions from road transportation is transparent since the data sources, assumptions and methodologies used are clearly explained and facilitate the replication and assessment of the inventory by the reviewer.

True
False

2. Party E has reported the notation key "IE" for CH_4 and N_2O emissions from biomass use under subcategory 1.A.3.b road transportation in CRT 1.A(a) (sheet 3). The NID indicates that the emissions from the biogenic share in gasoline and diesel oil are included together with the fossil fuel shares in the CRTs. During the review, Party E explained that CH_4 and N_2O emissions were calculated by considering the mass of the biogenic share together with the mass of the fossil share in the fuels and then applying specific EFs provided by the COPERT model for fossil fuels to the total mass of fuels, owing to a lack of specific EFs for fuel mixtures. This allocation:
   A. Overestimates the non-CO_2 emissions from fossil fuels in road transportation
   B. Underestimates the non-CO_2 emissions from biomass in road transportation
   C. Reduces the comparability of the inventory
   D. A and C

3. The TERT noted that due to lack of AD, Party C cannot distinguish the small amount of bunker fuel that is used for transport in international waterways (such as rivers and lakes) from that used for domestic navigation. Therefore, all navigation on these waterways is treated as domestic. The approach of the Party leads to:
   A. A potential overestimation of emissions from domestic navigation
   B. A potential underestimation of emissions from domestic navigation

4. A Party assumed that all jet kerosene in the country was used in international aviation, as there was no domestic commercial air traffic in its relatively small territory. During the review, the TERT asked about the possible use of jet kerosene in domestic aircraft, such as helicopters and turboprop aircraft, as well as in military aircraft on domestic operations. The Party responded that, upon further investigation, there were available data on the use of jet kerosene by police and the military. The Party must:
   A. Continue to include all jet kerosene used in the Party under international aviation
   B. Exclude jet kerosene used by the military and police from international bunkers

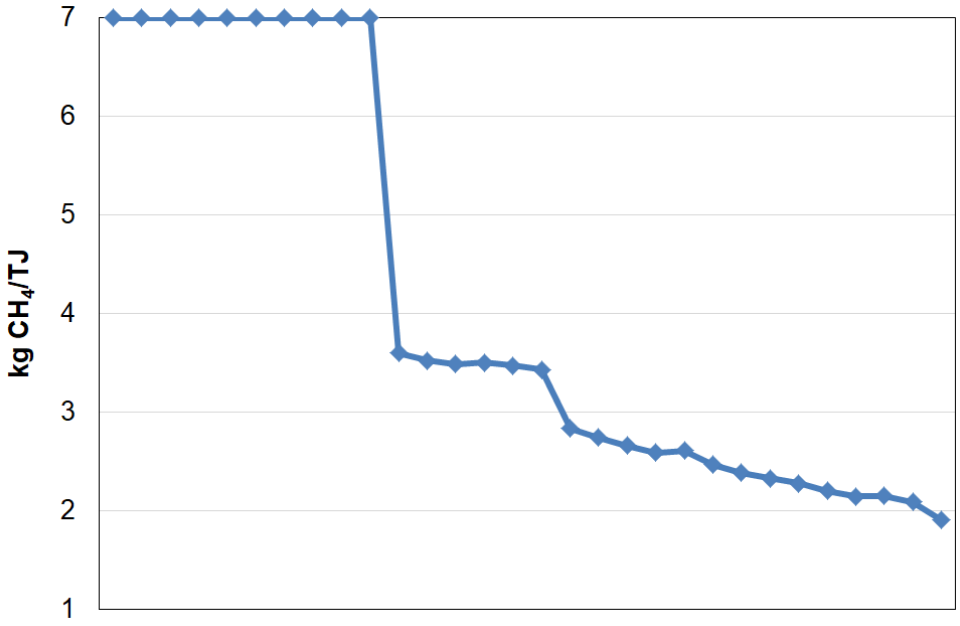
5. The Party reported emissions from machinery in construction and industry as off-road vehicles and other machinery under subcategory 1.A.3.e.ii other (under 1.A.3.e other transportation). You consider that these emissions are:
   A. In accordance with the 2006 IPCC Guidelines

B. Not in accordance with the 2006 IPCC Guidelines; they should have been allocated under category 1.A.2 manufacturing industries and construction
C. Not in accordance with the 2006 IPCC Guidelines; they should have been allocated under subcategory 1.A.5.b mobile

6. CO_2 emissions from urea-based catalysts were estimated using the COPERT model for diesel heavy-duty trucks. For the latest years of the time series they were reported under 1.A.3.e.ii other (under 1.A.3.e other transportation) and for 2010–2013 they were included under 1.A.3.b.iii heavy-duty trucks and buses (under 1.A.3.b road transportation). During the review, the Party clarified that "as calculated by the model, emissions from urea-based catalysts could not be separated from the total emissions of road transportation, and were therefore reported in the road transportation subcategory". The Party further explained that "the separation of emissions from fuel combustion and urea-based catalysts is part of the calibration of the model at the beginning of calculation and therefore it needs to be run again for every single year". You identified the following type of issues:
    A. Time-series consistency
    B. Comparability
    C. A and B

7. CO_2 emissions from jet kerosene were estimated using a tier 1 approach. CO_2 emissions from domestic aviation – liquid fuels were identified as a key category. You would recommend that the Party collect:
    A. Data on LTO by aircraft type to implement a tier 2 approach
    B. Data on origin and destination pairs by aircraft to implement an IPCC tier 3A approach
    C. Full flight movements with aircraft and engine data to implement an IPCC tier 3B approach
8. In the submission of Party A, the CH_4 IEF for gas/diesel oil under domestic navigation was 7.0 kg CH_4/TJ (equal to the tier 1 IPCC default EF) in the first 10 years of the time series and in the range of 1.9–4.0 kg CH_4/TJ, for the later years (figure 4.1). The NID reports only that the tier 1 IPCC default EF was used for the first 10 years of the time series and CH_4 EFs of volatile organic compounds from Party B were used to calculate marine transport emissions in the model applied by Party A for the later years. During the review, the Party clarified that CH_4 emissions for the later years were calculated as a fraction of volatile organic compound emissions using a model, which takes into account different classes of construction years and engines of the ships. The methodology is based on the emission registration and monitoring shipping protocol applied in its neighbouring country (Party B). Further explanations by Party A are: (1) EFs are expressed in g/kg fuel and it is not possible for the Party to express the EFs used in kg/TJ; and (2) CO_2 and N_2O emissions are calculated on the basis of the tier 1 IPCC default EFs. In your assessment, you noted that Party B uses the IPCC default CH_4 EF (7.0 kg/TJ) to estimate its CH_4 emissions from domestic navigation.

Figure 4.1. Time series of CH_4 implied emission factors for gas/diesel oil under domestic navigation



From the five inventory principles (TCCCA), you consider that there are issues regarding…

A. TCCCA
B. TCCCA except consistency
C. TCCCA except completeness
D. TCCCA except accuracy

5.2. Answer key

1. **The correct answer is 'False'**. The only input data reported in annex E to the NID indicates the number of vehicles per type, size and fuel use. There are other data used to run the model that have not been reported, most importantly the kilometres travelled per vehicle type and the fuel economy. Besides, there is no indication on how the information on fuel use from the energy balance has been treated and whether this fuel consumption was reconciled within the model.

2. **The correct answer is D**. The inclusion of CH_4 and N_2O emissions from the biogenic part into the emission totals for fossil fuels affects the comparability of the IEFs for these gases with those of other Parties. There may also be an accuracy issue as the emissions from the fuel blend is estimated using the emission properties of the fossil fuels. However, there is limited information thus far regarding non-CO_2 emissions from fuel blends used in road transportation. The allocation of the emissions from fossil fuels and biofuels under fossil fuels implies an overestimation of the emissions from fossil fuels and underestimation of the estimation from biofuels.

3. **The correct answer is A**. Since the small amount of fuel used for international navigation on waterways, such as rivers and lakes, cannot be disaggregated from the total amount of fuel used in navigation activities, all emissions are reported as domestic and included in the national GHG emission total, representing an overestimation of emissions.

4. **The correct answer is B**. The Party must exclude jet kerosene used by the military and police from international bunkers. The emissions from military use should also be excluded from domestic aviation and reported under subcategory 1.A.5.b mobile (aviation component). If part or all of this fuel was used for aviation in multilateral operations pursuant to the Charter of the United Nations, related emissions should be reported as a memo item (1.D.2 multilateral operations) and not included under either the international bunker or national totals.

5. **The correct answer is B**. The 2006 IPCC Guidelines (vol. 2, chap. 3, table 3.1.1, pp.3.8–3.10) indicate that emissions under subcategory 1.A.3.e other transportation include combustion emissions from transport activities other than civil aviation, road transportation, railways and waterborne navigation, including pipeline transport, ground activities in airports and harbours, and off-road activities not otherwise reported under 1.A.4.c agriculture or 1.A.2 manufacturing industries and construction. Table 2.1 (vol. 2, chap. 2 , pp.2.7–2.10) indicates that emissions arising from off-road and other mobile machinery in industry are to be reported under manufacturing industries and construction.

6. **The correct answer is C**. There are issues regarding (a) time-series consistency because of the different allocation between the earliest and latest years (both incorrect); and (b) comparability as these emissions must be reported under category 2.D.3 other (under 2.D non-energy products from fuels and solvent use).

7. **The correct answer is A**. Since this is a key category, the Party must move to a higher-tier approach. To be in line with the 2006 IPCC Guidelines, using a tier 2 approach would be enough (see decision tree, figure 3.6.1, vol. 2, chap. 3, p. 3.60). Using tier 3 approaches would also be in line with the decision tree; however, it is likely that the Party would need to make a considerable effort to collect the necessary AD and move from tier 1 to tier 3. Moving from tier 1 to tier 2 seems a more sensible approach.

8. **The correct answer is C**. Completeness seems not to be an issue because emissions from the three GHG were estimated. However, the reporting is not transparent because the Party did not provide enough documentation that would allow reproducing the results. There is inconsistency in the methodology applied to estimate CH_4 emissions between the first 10 years and the later years of the time series. Because of the low CH_4 IEFs in comparison with the IPCC default values the emissions may be underestimated and this is a possible issue of accuracy. In addition, note that different tiers were used for the estimation of CH_4 and those of CO_2 and N_2O for the later years. This is not necessarily a consistency issue because different tiers have been used, but there may be another concern relative to accuracy because the tier 1 approach used to estimate CO_2 and N_2O emissions is based on fuel consumption and therefore the NCV must be known; however, the Party claimed that it cannot express the CH_4 EF from the model (kg/kg fuel) in terms of kg/TJ. This is difficult to understand because the

NCV is the physical property for converting one into the other. Comparability seems affected because the Party´s CH_4 IEFs are very different from that of Party B, on which it is based.

6. Key points to remember

The main topics to consider in reviewing category 1.A.3 transport were covered in this lesson. As in stationary combustion, the only GHG-emitting activity in this category is combustion within an apparatus, which gives common characteristics to both the emitting process and the review, particularly for CO_2 emission estimates. Common information to transport subcategories includes physical properties of fuels (NCV and carbon content) and AD for tier 1 estimates (fuel consumption or fuel sales to the market). However, each transport mode (aviation, road transportation, railways, navigation and other transportation) has differentiating characteristics, which must be considered in the review. They include:

- Linkage with other energy categories and the avoidance of misallocation, omission or double counting of emissions, such as: energy industries (pipeline transport); manufacturing industries and construction (off-road mobile and other machinery used in industries); other sectors (stationary combustion at airports, ports, railway stations and railway power stations, off-road agriculture machinery and fishing vessels); and other (military aviation and navigation);
- Linkage with other inventory sectors: IPPU (urea use in catalysts, lubricants use); agriculture (on-road transportation of agricultural machinery, agricultural airplanes); LULUCF (transportation biofuels); and waste (use of recovered biogas as transportation fuel);
- Use of tier 3 methods for road transportation and domestic aviation;
- The domestic/international split for aviation and navigation;
- The use of biofuels (ethanol, biodiesel) and the possible fossil origin.

Lesson 5. Reference approach, including non-energy use and carbon excluded

1. Introduction

The reference approach is a top-down method to estimate CO_2 emissions from combustion. Three pieces of information are reported by Parties:

- The data used and the estimated CO_2 emissions;
- The comparison of estimates of CO_2 emissions from fuel combustion between the reference approach and the sectoral approach; and
- Background information on feedstocks, reductants and other non-energy use of fuels.

In this lesson we address the review of the CO_2 emissions from fuel combustion estimated using the reference approach and the comparison with the corresponding estimates from the sectoral approach.

1.1. Learning objectives

At the end of this lesson you should be able to:

- Understand the key tasks to be undertaken to review the comparison made by the Party of the CO_2 emissions from fuel combustion estimated using the sectoral approach with those obtained using the reference approach;
- Be able to draft recommendations to Parties for CO_2 emissions estimated using the reference approach and for the comparison of CO_2 emission estimates between the sectoral approach and the reference approach.

1.2. Expected time needed to complete lesson 5

- For readers with experience in compilation of energy sector GHG inventories: 30–45 minutes

For readers with less experience in compilation of energy sector GHG inventories: 60–80 minutes

2. Presentation of the reference approach and related issues

2.1. Verification of CO_2 emission estimates

In addition to the three-tiered bottom-up approaches to estimate emissions from fuel combustion, the 2006 IPCC Guidelines present an alternative method to estimate CO_2 emissions using a top-down

approach, known as the reference approach. This should be used by Parties only for verification purposes and as indicated in paragraph 36 of the MPGs:

> *"Each Party should* compare *the national estimates of CO_2 emissions from fuel combustion with those obtained using the reference approach, as contained in [the 2006 IPCC Guidelines], and report the results of this comparison in its national inventory report."*

The reference approach is used for verification of the CO_2 emission estimates, whereas the estimates performed using the sectoral approach are those included in the national totals.
The comparison of CO_2 emission estimates between the sectoral approach and the reference approach is reported by the Party in CRT 1.A(c).

2.2. Algorithm of the reference approach calculations

The reference approach is a top-down method, which basically uses the apparent consumption of each fuel as the AD and the corresponding carbon content as the EF:

- Apparent Consumption = Production + Imports – Exports – International Bunkers – Stock Change

Energy reviewers are expected to have a clear understanding of the algorithm of the reference approach.

To learn more about the algorithm of the reference approach, see the 2006 IPCC Guidelines (vol. 2, chap. 6.3, p.6.5).

2.3. Reporting in the common reporting tables

CRT 1.A(b) CO_2 from fuel combustion activities – reference approach (IPCC worksheet fuel combustion activities) provides the framework for reporting the corresponding calculations to estimate CO_2 emissions using the reference approach.
The calculations to estimate the amount of carbon excluded entered in column "Carbon stored (C excluded)" of CRT 1.A(b) are reported in CRT 1.A(d), which includes the reporting of CO_2 emissions from the use of fuels as feedstocks, reductants and other non-energy use of fuels that are excluded from the energy sector, together with an indication of under which category/categories these emissions have been reported.
CRT 1.A(c) shows the comparison between the CO_2 emissions from fuel combustion obtained using the reference approach and those using the sectoral approach.
In the case of discrepancies between these two approaches (of more than 5 per cent), it is expected that the Party investigate and document the reasons for such discrepancies in the NID. See footnote 6 to CRT 1.A(c).

To learn more about the reporting of the reference approach, see CRT 1.A(b), 1.A(c) and 1.A(d) available at https://unfccc.int/resource/tet/be/be5-01_en5_crt_ra.xlsx.

2.4. Main issues concerning the comparison of national CO_2 estimates

For review purposes it is key to assess discrepancies not only regarding CO_2 emissions but also the associated energy consumption. Sometimes, it is only one fuel type that drives the discrepancies between the two approaches. The 2006 IPCC Guidelines discuss the main issues concerning the comparison of national CO_2 estimates. Here, only a few specific issues are discussed taking into account that the purpose of the reference approach is to verify the national estimates of CO_2 emissions calculated using the sectoral approach.

To learn more about the comparison between the reference approach and the sectoral approach, see the 2006 IPCC Guidelines (vol. 2, chap. 6.8, pp.6.11–6.13).

Use of country-specific values for physical properties

Note that to avoid introducing unnecessary differences between the results of the national estimates of CO_2 emissions using the sectoral approach and those from the reference approach, for each inventory year the same physical properties (NCV and carbon content) should be used in both approaches. If these physical properties vary over time, this variability should be captured by both methods.

Excluded carbon and some features not taken into account in the reference approach

The amount of carbon that is not destined for combustion is excluded from the total carbon amount that is taken into account in the reference approach algorithm of calculation. This carbon excluded from combustion is either reported as emitted in another sector of the inventory (typically the IPPU sector) or is stored in some product and assumed as not emitted.

Three main types of carbonaceous products are considered in the calculation of excluded carbon, namely those used as:

- Feedstock (ethane, gas/diesel oil, kerosene, LPG; naphtha, natural gas, refinery gas, etc.);
- Reductant (coal and coal tar/pitch, coke oven coke and petroleum coke, natural gas, etc.);
- Non-energy products (bitumen, lubricants, paraffin waxes, white spirit, etc.).

The use of fuels as feedstock and/or reductants may generate subproducts that may be combusted for energy purposes. When these subproducts are exported from the IPPU sector to the energy sector, the associated emissions from combustion are estimated and reported under the energy sector. However, for simplicity this rule is not applied in the reference approach, which assumes complete exclusion of the carbon in:

- Feedstock;
- Fuel used as reductant (coke, coal and derived coal products, natural gas, etc.);
- Lubricants and paraffin waxes.

The effect of this complete exclusion of carbon may be reflected as a difference between the CO_2 estimates, depending on the uses for energy purposes of the possible subproducts from feedstock and reductants and of lubricants and waxes. In your review, keep this feature in mind when assessing the differences between the national estimates of CO_2 emissions and those from the reference approach.

CO_2 capture and storage

Since the reference approach does not include any feature to account for amounts of captured CO_2, the comparison with national totals should be done with CO_2 emissions before these amounts are subtracted from the CO_2 emissions produced.

3. Review approach

3.1. Main review topics

The energy expert should review whether energy estimates are reported using both the reference approach and the sectoral approach, and whether differences of more than 5 per cent are explained and documented.

Emission estimates

Consider the differences in CO_2 emission estimates obtained using the reference approach and the sectoral approach (CRT 1.A(c) and NID) for liquid fuels, solid fuels, gaseous fuels, other fossil fuels and peat.

- If significant differences and/or large time-series deviation exist for one or more particular types of fuel:
  - Check whether adequate explanations have been provided in the NID;
  - Check that the selection of the physical properties of fuels (NCVs and carbon contents) is consistent between the two approaches;
  - Investigate whether these differences may be indicative of potential overestimations or underestimations of national totals of CO_2 emissions.

If CO_2 is captured from large stationary combustion sources, check that the comparison with national totals was done with CO_2 emissions produced before subtracting the captured CO_2 amount.

Activity data

Consider the differences in fuel consumption estimates obtained when comparing the reference approach and the sectoral approach (CRT 1.A(c) and NID) for liquid fuels, solid fuels, gaseous fuels, other fossil fuels and peat.

- If significant differences and/or large time-series deviation exist for one or more particular types of fuel:
  - Check whether adequate explanations have been provided in the NID;
  - Verify that the amounts of fuels reported in CRT 1.B.1 (solid fuels) and 1.B.2 (oil, natural gas and other emissions from energy production) are in accordance with the fuel production values reported for reference approach in the CRT 1.A(b);
  - Assess whether these discrepancies are related to statistical differences in the national fuel statistics; if this is the case try to examine the reasons for these differences and their potential impact on the accuracy of the emission estimates from the sectoral approach;
  - Check whether inputs to fuel transformation (e.g. for coke ovens) have not been included in the AD to estimate CO_2 emissions from the reference approach;

- Check potential unrecorded consumption of fuels that may be associated with underestimation of emissions.

Feedstock and non-energy use of fuels

- Verify that the Party reported (i) the fuel quantity for non-energy use (NEU) (column E), (ii) the amount of carbon excluded (column G), (iii) the CO_2 emissions from the non-energy use (column I) and (iv) the categories under which the emissions from the non-energy use have been reported (column J) in CRT 1.A(d). Also, review the corresponding discussion in the NID.
- Verify, coordinating with the IPPU expert, whether all relevant emissions and related fuel use data have been included in the inventory and that no double counting has occurred.

3.2. Walk-through examples

You will work in three examples on the following:

- Statistical differences in the energy balance;
- Excluded carbon;
- Time series of differences between reference approach and sectoral approach CO_2 emission estimates.

The examples cover topics such as (1) differences in AD between the reference approach and the sectoral approach, (2) treatment of the non-energy use of fuels and (3) drafting recommendations.

1. Statistical differences in the energy balance

1.1 Impact on the CO_2 emission estimates

Following a recommendation from the previous review, Party A has included an annex to its NID explaining the differences in fuel consumption data between the reference approach and the sectoral approach.

During your review you note that the national energy balance, which was used as a source of AD for the sectoral approach and the reference approach, shows the following discrepancies: the apparent consumption of fuels reported in the reference approach is larger than the consumption reported in the sectoral approach by 21 per cent (solid fuels), 21 per cent (liquid fuels) and 5 per cent (gaseous fuels).

Review finding

The apparent consumption is larger than the sectoral consumption. It is possible that the AD for the sectoral approach are not complete, which in that case indicates that emissions may be underestimated. You should check whether the GHG emissions from fuel combustion activities included in the national totals estimated using the sectoral approach are underestimated.

1.2 Improvement of the inventory reporting

With respect to the differences of AD between the reference approach and the sectoral approach indicated above, the Party confirmed during the review that regarding the AD used for the sectoral approach, there are missing fuel consumption data from certain enterprises in the energy balance.

Recommendation on activity data selection for the sectoral approach

The TERT recommends that the Party ensure complete coverage of fuel consumption data used to estimate GHG emissions for the energy sector. It also recommends that the Party undertake gap-filling procedures to cover gaps in the information of fuel consumption data.

2. Excluded carbon

2.1 Non-energy use of fuels

Party B attributes the difference in CO_2 estimates between the reference approach and the sectoral approach to the amounts of fuel used as feedstock and for non-energy consumption, which are not accounted by the reference approach algorithm.

Review finding

You note that the statement by the Party is incorrect. The reference approach takes the amounts of fuel used as feedstock and for non-energy consumption explicitly into account in CRT 1.A(d) feedstocks, reductants and other non-energy use of fuels for the estimation and reporting of the amount of carbon excluded from the reference approach.

2.2 Energy and non-energy use of lubricants

Party D explained that all carbon in lubricants has been excluded from the calculations in the reference approach. This excluded amount is accounted for in the non-energy use of lubricants under category 2.D.1 non-energy products from fuels and solvent use – lubricant use of the IPPU sector, as well as the combustion of lubricants (e.g. mixed with gasoline in two-stroke motorcycles).

Review consideration

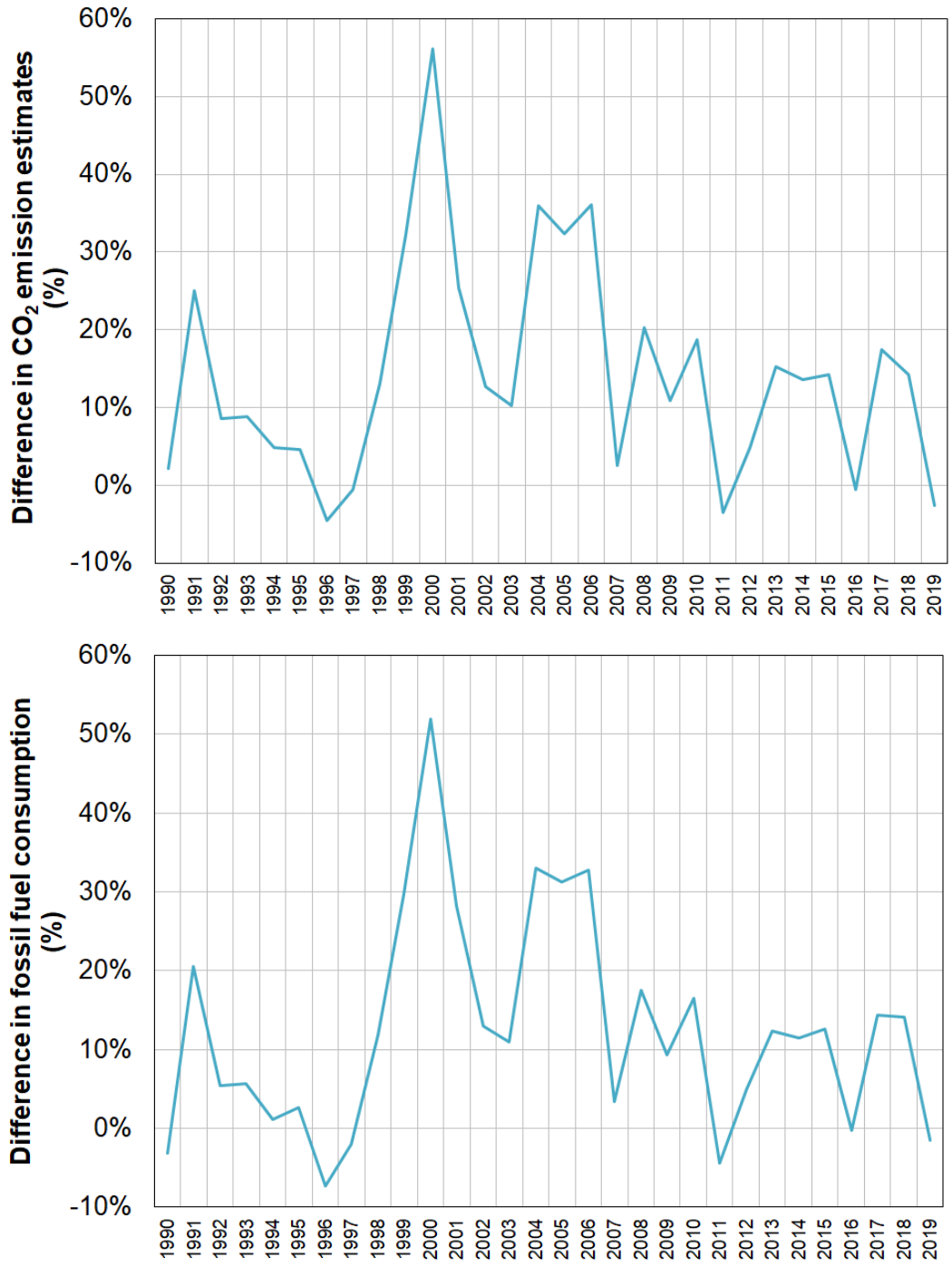
The accounting by the Party of the amount of carbon excluded from the use of lubricants in the reference approach is in line with the 2006 IPCC Guidelines and within the idea of simplification in the reference approach that all deliveries of lubricating oil should be excluded from the reference approach.

To learn more about the treatment of non-energy products use in the reference approach, see the 2006 IPCC Guidelines (vol. 2, chaps. 6.6.3 and 6.8, pp.6.9–6.10 and 6.11–6.13, respectively).

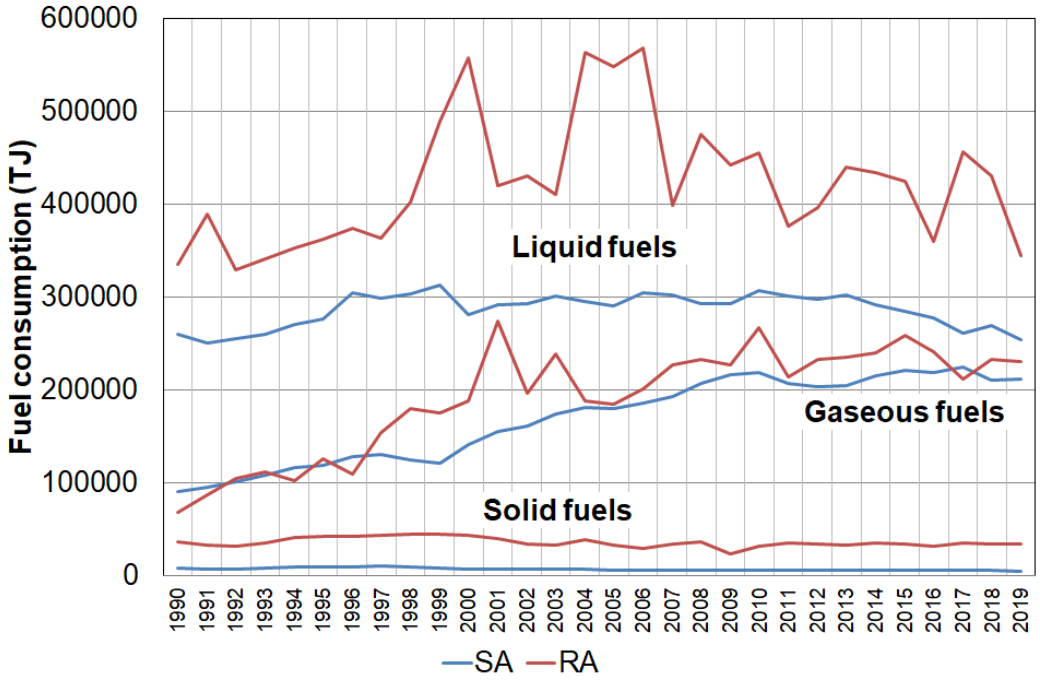
3. Time series of differences between reference approach and sectoral approach CO_2 emission estimates

The CO_2 estimates from the reference approach and the sectoral approach reported by Party A have exhibited large differences (up to 46–56 per cent) practically for all years across the time series (1990–2019). Inspect figures 5.1 and 5.2 and try to find out which type of fuel (liquid, gaseous or solid) is driving the large differences in CO_2 estimates between the reference approach and the sectoral approach.

S. Figure 5.1. Differences between the reference approach (RA) and the sectoral approach (SA) as reported in CRT 1.A(c) calculated as difference = 100 per cent x ((RA-SA)/SA).



T. Figure 5.2. Fuel consumption used to estimate emissions in the sectoral approach (SA) and the reference approach (RA).



Considerations by reviewer

Liquid fuels seem to be driving the differences; their consumption not only exhibit the highest levels but more significantly the largest differences between the sectoral approach and the reference approach across the time series (figure 5.2). In addition, the variability of the time series of liquid fuels is very similar to the variability of the differences in CO_2 estimates and total fossil fuel consumption across the time series.

4. Practical exercises

Exercises are provided below for you to practise your skills as an expert reviewer of reference approach CO_2 estimates.

You will work with exercises on the following topics:

1. Differences of CO_2 emission estimates between the reference approach and the sectoral approach;
2. Feedstock, reductant and other non-energy use of fuels.

4.1. Exercise 1. Differences of CO_2 estimates between the reference approach and the sectoral approach

1.1. Analysing the reporting by the Party in the common reporting tables

Consider the reference approach for the latest reported year of the submission by Party B. Analyse the reporting in CRT 1.A(b), 1.A(c) and 1.A(d), which is available in the Supplementary Materials at https://unfccc.int/resource/tet/be/be5-02_en5_excrs_1.xlsx. Make a list of your findings.

1.2 Follow-up of previous recommendations

Party B has been recommended in the past to investigate and explain in the NID and the CRTs the reasons for the observed difference between the reference approach and the sectoral approach. As we have observed, there are still significant differences in the CO_2 emissions estimates and fuel consumption reported for the reference approach and the sectoral approach. In addition, Party B has not provided any information in the documentation box of CRT 1.A(c) or in the NID.
In addressing the Party response to the previous recommendation, you would conclude that the issue:
A. Has been resolved by the Party
B. Is still being addressed by the Party
C. Has not been resolved by the Party

4.2. Exercise 2. Feedstock, reductant and other non-energy use of fuels

2.1 Assess the report by the Party in CRT 1.A(b) and CRT 1.A(d)

Consider the report of the reference approach by Party B in the CRT on feedstock, reductant and other non-energy use of fuels, which is available at https://unfccc.int/resource/tet/be/be5-03_en5_excrs_2.xlsx in Supplementary Materials.

Party B provided the following information in the NID regarding the reporting on feedstock and non-energy use of fuels (reported in CRT 1A(d)):
Description: consumption of bitumen, lubricants, coke, white spirit and paraffin wax used as feedstock is reported in CRT 1.A(d) for all years across the time series;
Methodological issues: carbon EFs from the 2006 IPCC Guidelines were used for all fuel types: bitumen (22 t/TJ), lubricants (20 t/TJ), coke (29.2 t/TJ), white spirit (20 t/TJ) and paraffin waxes (20 t/TJ).
Compare the report of excluded carbon in CRT 1.A(b) and in CRT 1.A(d) and make a list of your findings.

2.2 Drafting a preliminary question to the Party

Prepare a preliminary question to the Party.

2.3 Drafting a recommendation in the technical expert review report

During the review, the Party explained that feedstock emission data taken from particular IPPU subcategories were reported in CRT 1.A(b) and 1.A(d) in order to ensure consistency between the energy sector and the IPPU sector. In addition, the Party stated that in CRT 1.A(d) the EF values reported in the column “Carbon emission factor” are not the same as those shown in the 2006 IPCC Guidelines as they were calculated on a different basis. However, the Party did not provide information on how these EFs were calculated.

Based on your findings and the response by the Party, draft a recommendation for the TERR. Use the template provided at < https://unfccc.int/resource/tet/be/be5-04_en_terr_template.docx >.

4.3. Answer key

1. Exercise 1

1.1 Analysing the reporting by the Party in the common reporting tables

- Total CO_2 emissions estimated using the reference approach were negative; this is not possible.
- In the RA the reported negative CO_2 emissions were estimated for the use of liquid fuels and peat, while for solid and gaseous fuels the CO_2 emissions reported were positive.
- The difference in CO_2 emission estimates was –127.61 per cent.
- No information was provided in the documentation box of CRT 1.A(c).
- There is a difference of 100 per cent for energy consumption for each fuel type reported in CRT 1.A(c).
- The amount of crude oil reported for non-energy use (960,336.90 TJ) represents 98.6 per cent of the apparent consumption (974,126.70 TJ). Consequently, excluded carbon accounted for 98.6 per cent of the carbon content in the apparent consumption. In CRT 1.A(d) the Party reported that the non-energy use associated with this excluded carbon corresponds to lubricant use and paraffin wax use. This is likely to be a mistake as this use cannot be excluded from crude oil and in such an amount.

1.2 Follow-up of previous recommendations

The correct answer is C. Large differences between the reference approach and the sectoral approach estimates for both CO_2 emissions and fuel consumption still exist and no information on the matter has been provided by the Party. In fact there are serious mistakes in the reporting of the reference approach, which makes it unrealistic and not useful for verifying the CO_2 emissions estimated using the sectoral approach.

2. Exercise 2

2.1 Assess the report by the Party in CRT 1.A(b) and CRT 1.A(d)

The amounts of carbon stored/excluded for lubricants and other oil are different. The carbon EFs used for fuels reported in CRT 1.A(b) correspond to the IPCC default values in accordance with the information reported in the NID. However, the carbon EFs in CRT 1.A(d) are different from the IPCC default values. The Party does not provide an explanation of this discrepancy in the NID or in the documentation box of CRT 1.A(d). The values reported by the Party are summarized below.

	CRT 1.A(b)		CRT 1.A(d)	
	Carbon excluded (kt C)	Carbon EF (t C/TJ)	Carbon excluded (kt C)	Carbon EF (t C/TJ)
Bitumen	49.37	22.00	49.37	0.02
Lubricant	0.95	20.00	26.61	4.00
Other oil	NO	20.00	7.26	IE

2.2 Drafting a preliminary question to the Party

The TERT noted certain discrepancies in the reporting by the Party on amounts of carbon stored/excluded and EFs in the reference approach. Specifically, the amount of carbon stored/excluded reported in CRT 1.A(b) (50.32 kt C) is not equal to that reported in CRT 1.A(d) (83.24 kt C). The amounts reported for lubricants and other oil are different. The reporting of carbon excluded for lubricants is 0.95 kt C (CRT 1.A(b)) versus 26.61 kt C (CRT 1.A(d)). Notation key "NO" is used to report the carbon excluded for other oil in CRT 1.A(b) while 7.26 kt C is reported in CRT 1.A(d). The carbon EF for the fuels in CRT 1.A(b) correspond to the IPCC default values in accordance with the information reported in the NID. However, the carbon EFs reported in CRT 1.A(d) for bitumen, lubricants and other oil are different. The TERT would appreciate it if Party B clarified the reasons for these discrepancies.

2.3 Drafting a recommendation in the technical expert review report

Finding classification	*Description of the finding with recommendation*	*Classify by type*
Feedstocks, reductants and other non-energy use of fuels – all fuels CO_2	The TERT noted that the data on the reporting of excluded carbon for lubricants and other oil in CRT 1.A(b) (0.95 kt C and "NO", respectively) are different from those reported in CRT 1.A(d) and in the NID (26.61 kt C and 7.26 kt C, respectively). In addition, the carbon EFs reported in CRT 1.A(b) for bitumen (22.00 t C/TJ), lubricants (20.00 t C/TJ) and other oil (20.00 t C/TJ) correspond to the IPCC default values. However, in the latest reported year, the corresponding EFs in CRT 1.A(d) were for bitumen (0.02 t C/TJ), lubricants (4.00 t C/TJ) and other oil ("IE"). The NID states that carbon EFs from the 2006 IPCC Guidelines are used for all fuel types, but this is not consistent with CRT 1.A(d). During the review, Party B explained that feedstock emission data taken from particular IPPU subsectors were reported in CRT 1.A(b) and CRT 1.A(d) in order to ensure consistency between the energy sector and the IPPU sector. The Party also stated that in CRT 1.A(d) the values reported in the column "Carbon emission factor" are not the same as those shown in the 2006 IPCC Guidelines as they were calculated on a different basis, but did not provide further information on how these EFs were estimated. The TERT recommends that Party B revise the calculations of excluded carbon for the entire time series by applying correct/consistent EFs. In addition, the TERT recommends that Party B report the information regarding carbon excluded in a consistent way in CRT 1.A(b) and CRT 1.A(d) and include in the NID a clear description of methods, assumptions, AD and EFs used.	Inconsistency with the MPGs

5. Self-check quiz

1. What is a Party required to do with respect to the comparison of its national estimates of CO_2 emissions from fuel combustion under the sectoral approach and those obtained using the reference approach?
    A. Explain the differences if they exceed 5 per cent
    B. Report the results of the comparison in the NID
    C. A and B

2. In the reference approach, the main flows of carbon concerned in the calculation of excluded carbon include:
    A. Feedstock

B. CO_2 captured from energy sources or industrial processes
C. Reductant
D. Non-energy products
E. A, C and D

3. In CRT 1.A(b) for reporting the reference approach, under the column "Production", the Party reported:
   A. The raw amount of each primary fuel produced in the country
   B. The marketable amount of each secondary fuel produced in the country
   C. The marketable amount of each primary fuel produced in the country

4. In the CRTs for reporting the reference approach (CRT 1.A(b), CRT 1.A(c) and CRT 1.A(d)), peat and biomass are taken into account as follows:
   A. Peat and biomass are considered in all three tables
   B. Peat and biomass are reported in CRT 1.A(b)
   C. In CRT 1.A(c) (Comparison of CO_2 emissions from fuel combustion), peat is reported but biomass is not reported
   D. In CRT 1.A(d) (Feedstocks, reductants and other non-energy use of fuels), only peat is reported
   E. B and C

5. Coal production is reported in two CRTs: 1.A(b) (CO_2 from fuel combustion activities – reference approach) and 1.B.1 (solid fuels). In your review, you must check that the reported amounts of coal production in these two CRTs are identical.
   True
   False

6. Fuels consumed under international aviation and international navigation are not taken into account in the reference approach since the purpose of this approach is to verify the national CO_2 emission estimates.
   True
   False

5.1. Answer key

1. **The correct answer is C**. The MPGs indicate that "each Party should compare the national estimates of CO_2 emissions from fuel combustion with those obtained using the reference approach…and report the results of this comparison in its national inventory report". In addition, footnote 6 to CRT 1.A(c) indicates that "in the case of discrepancies between the approaches (of more than 5 per cent), investigate and document the reasons for such discrepancies." Note also the indications in the documentation box of CRT 1.A(b): "Parties should provide a detailed description on the fuel combustion sub-sector, including information relating to CO_2 from the reference approach, in the relevant section of chapter 3 ("Energy" (CRT sub-sector 1.A)) of the NID, if any additional information and/or further details are needed to explain the contents of this table."

2. **The correct answer is E**. The carbon in fossil fuels used as feedstock (e.g. ethane, gas/diesel oil, LPG, naphta, natural gas or refinery gas); reductant (e.g. coal, coke or natural gas) and for

non-energy purposes (e.g. bitumen, lubricants, paraffin waxes or white spirit) is subtracted to account for the carbon that is not combusted for energy purposes. CO_2 captured has no role in the reference approach as the comparison with the sectoral approach estimates is done against the CO_2 emission estimates before the amount of captured CO_2 is subtracted out (gross emissions).

3. **The correct answer is C**. Only the production of marketable primary fuels is included in the reference approach. The production (or manufacture) of secondary fuels is not taken into account in the calculations because the carbon in these fuels is already included in the carbon accounted for in the supply of primary fuels from which they were derived. With respect to raw amount of primary fuels, the 2006 IPCC Guidelines indicate the following: (i) production of natural gas is measured after purification and extraction of natural gas liquids (NGLs) and sulfur and extraction losses and quantities reinjected, vented or flared are not included; (ii) production of coal includes the quantities extracted or produced calculated after any operation for removal of inert matter; and (iii) production of oil includes marketable production and excludes volumes returned to formation.

4. **The correct answer is E**. Peat and biomass are included in the IPCC calculation algorithm and reported in CRT 1.A(b). Biomass is included only for information purposes. Biomass is not included in the comparison of CO_2 estimates (CRT 1.A(c)), because its emissions are not part of the national totals. Peat is included in this comparison table, because CO_2 emissions from peat are part of the national totals. Normally, peat is not used as feedstock, reductant or for non-energy purposes.

5. **The correct answer is 'False'**. As a reviewer of the energy sector, it is good practice that you check for consistency of reporting on coal production between the two tables, but the amounts will not necessarily be identical as, normally, production in the reference approach is that of saleable coal, while the amount produced to estimate fugitive emissions from coal refers to raw coal production.

6. **The correct answer is 'False'**. The consumption of international bunker fuels is explicitly taken into account in the reference approach. Consumption of international bunkers is subtracted out in the calculation of the apparent consumption of fuels to account only for CO_2 emissions that are part of the national totals.

6. Key points to remember

The main topics to review CO_2 emission estimates using the reference approach were covered in this lesson:

- The reference approach is a top-down method to estimate CO_2 emissions from fuel combustion based on the apparent consumption of fuels using data from the national energy balance.
- It is used to verify the CO_2 emissions from fuel combustion estimated using the sectoral approach.
- Estimates of CO_2 emissions using the reference approach should be reported in CRT 1.A(b), while the comparison of these CO_2 estimates with the national estimates of CO_2 calculated using the sectoral approach should be reported using CRT 1.A(c).
- The amount of carbon which does not lead to fuel combustion emissions (i.e. carbon in feedstocks, reductants and in non-energy use of fuels) is excluded from the reference approach estimates.
- Parties should compare their national estimates of CO_2 emissions from fuel combustion with those estimates obtained using the reference approach and report the results of this comparison in the NID.
- In the case of discrepancies between the approaches (of more than 5 per cent), it is expected that the Party investigate and document the reasons for such discrepancies and report them in the NID.
- The results of the reference approach and the comparison of CO_2 emission estimates obtained using the sectoral approach and those obtained using the reference approach are reviewed by the TERT.
- For review purposes it is key to assess discrepancies not only regarding CO_2 emissions but also the associated energy consumption.

Lesson 6. Fugitive emissions from fuels

1. Introduction

This lesson addresses the review of fugitive emissions from fuels.
Fugitive emissions cover all intentional or unintentional release of GHGs that occurs (i) during coal mining and handling and (ii) along the oil and natural gas systems. Coal mining comprises deep and surface mines, while the oil and natural gas systems are subdivided in the corresponding fuel supply chains.

1.1. Learning objectives

At the end of this lesson you should be able to:

- Understand the key tasks to be undertaken to review a Party's reporting of fugitive emission estimates;
- Identify whether a Party's reporting of fugitive emissions is consistent with the requirements in the MPGs;
- Draft key review recommendations to Parties for emission estimates for this category in the TERR.

1.2. Expected time needed to complete lesson 6

- For readers with experience in compilation of energy sector GHG inventories: 80–120 minutes

For readers with less experience in compilation of energy sector GHG inventories: 150–200 minutes

2. Category overview and methodological information

2.1. Categories under fugitive emissions from fuels

Fugitive emissions from fuels are divided into two main categories, one primarily concerned with coal and the other with oil and natural gas:

- Fugitive emissions from solid fuels (category 1.B.1);
- Fugitive emissions from oil and natural gas and other emissions from energy production (category 1.B.2).

For the complete list and definitions of the fugitive emissions categories given in the 2006 IPCC Guidelines, see volume 2, chapter 4:

- Solid fuels, table 4.1.1 (p.4.8);
- Oil and natural gas, table 4.1.2 (pp.4.33–4.35).

1.B.1 solid fuels

This category is organized in three subcategories:

- Subcategory 1.B.1.a coal mining and handling.

Emissions for this subcategory generally constitute the major source of fugitive emissions from solid fuels.

- Subcategory 1.B.1.b fuel transformation.

This subcategory covers fugitive emissions from (i) charcoal and biochar production; (ii) coke production; (iii) coal to liquid fuels transformation; and (iv) gas to liquid fuels transformation.

- Subcategory 1.B.1.c other.

This subcategory covers any other solid fuel related activities resulting in fugitive emissions, such as emissions from uncontrolled combustion in waste coal piles.

Note that:

- The 2006 IPCC Guidelines do not provide methods to estimate fugitive emissions from subcategories 1.B.1.b and 1.B.1.c, which are included in the CRTs. Therefore, these activities are not considered as mandatory for reporting under the MPGs;
- Some Parties may, in accordance with paragraph 28 of decision 5/CMA.3, choose to use on a voluntary basis the 2019 Refinement to the 2006 IPCC Guidelines to estimate some of these fugitive emissions. See box 6.1 for an overview of the coverage in the 2019 Refinement to the 2006 IPCC Guidelines with regard to the estimation of fugitive emissions from solid fuels.

Box 6.1. Fugitive emissions from solid fuels in the 2019 IPCC Refinement to the 2006 IPCC Guidelines

For fugitive emissions from solid fuels, the 2019 IPCC Refinement to the 2006 IPCC Guidelines offers guidance on:

- Fugitive emissions from mining, processing, storage and transportation of coal. New guidance has been included on fugitive CO_2 emissions from underground and surface mines and year-specific default input values for fugitive CH_4 emissions from abandoned underground mines were extended from 2016 to 2017–2050.
- Fugitive emissions from fuel transformation, for which a new section was added, includes methods for fugitive emissions from charcoal production, biochar production, coke production (including flaring) and gasification transformation processes (coal to liquids and gas to liquids).

1.B.1.a coal mining and handling

There are two main types of coal mines: underground and surface. The main emission sources under this subcategory are organized differentiating between underground and surface mines as follows:

- Mining activities: 1.B.1.a.i.1 underground mines; 1.B.1.a.ii.1 surface mines;
- Post-mining activities: 1.B.1.a.i.2 underground mines; 1.B.1.a.ii.2 surface mines.

For underground mines, two additional subcategories are included in the CRT 1.B.1:

- 1.B.1.a.i.3 abandoned underground mines;
- 1.B.1.a.i.4 flaring of drained methane or conversion of methane to CO_2.
- Other emissions such as those from the surrounding strata in the mine and reject piles, low temperature oxidation of coal exposed to air and/or uncontrolled combustion in waste coal piles are allocated to subcategories other: for underground mines under 1.B.1.a.i.5 other and for surface mines under 1.B.1.a.ii.3 other.

U. Figure 6.1. Underground and surface coal mines

1.B.2 oil, natural gas and other emissions from energy production

1.B.2.a oil and 1.B.2.b natural gas

Oil and natural gas systems include exploring, producing and upgrading, refining or processing, transporting, storage and marketing/distributing crude oil, natural gas and refined products. Often, there is joint extraction of oil and natural gas. Fugitive emissions arise from the release of CH_4 and formation CO_2 present in the oil and gas when leaving the reservoir, and may include N_2O emissions from oil exploration, production and refining, gas production and processing and LPG transport during non-productive combustion activities.

1.B.2.c venting and flaring

Venting (i.e. the controlled discharge of natural gas and other gaseous streams directly into the atmosphere) and flaring (i.e. the controlled burning of natural gas and other gaseous streams in an open flame) are common practices in the gas and petroleum industry. Small quantities of crude oil or oil/gas condensates are flared as common practice.

Venting and flaring constitute distinct fugitive emission sources. Although they occur in practically all segments of the oil and gas industry, they are assigned special categories by the 2006 IPCC Guidelines and in the CRTs. The CRTs include subcategory 1.B.2.c venting and flaring, which is subdivided into three subcategories: (i) oil; (ii) gas and (iii) combined.

Often vented and flared volumes are not differentiated. Vented volumes of raw (or formation) CO_2 extracted from the produced gas at gas processing plants may sometimes be not reported. More information on venting, flaring and other types of fugitive emissions is provided in box 6.2.

Box 6.2. Venting, flaring and other types of fugitive emissions

In venting, waste gas streams and process by-products are released directly into the atmosphere on either a continuous or intermittent basis and not burned. These typically CH_4-rich streams generally are composed of natural gas, water vapour and other gases, such as hydrocarbon vapours and CO_2.

Flaring is the controlled burning of natural gas and waste gas/vapour streams during routine operations. This burning occurs at the end of a flare stack, which releases into the atmosphere emissions that are composed mainly of CO_2 and water vapour, and also contain other combustion gases, particularly N_2O.

In addition to venting and flaring emissions, other types of primary fugitive emissions occur across the diverse activities of the gas and oil industry. These discharges include:

- fugitive equipment leaks;
- evaporation losses (i.e. from product storage and handling, particularly where flashing losses occur);
- accidental releases or equipment failures, which may include well blowouts, pipeline breaks, tanker accidents, tank explosions, gas migration to the surface around the outside of wells, surface casing vent blows and leakage from abandoned wells;
- fugitive discharges from maintenance and tie in events, such as well testing and pipeline pigging activities.

All gas and vapour releases that are not specifically typified as either vented or flaring are estimated and reported under the corresponding oil and gas industry activity (subcategories 1.B.2.a and 1.B.2.b, respectively).

To learn more about typical venting and flaring sources see the 2006 IPCC Guidelines (vol.2, chap.4, pp.4.35–4.36).

1.B.2.d other

Emissions from geothermal energy production and other energy production not included under categories 1.B.1 or 1.B.2 are reported under subcategory 1.B.2.d other. No methodology is provided in the 2006 IPCC Guidelines to estimate emissions for activities to be reported under this subcategory (for guidance on the review approach, see section 3.2 of this lesson (pp.134–135) below). Example 4 below (section 3.4 Walk-through examples) provides an example of the review of geothermal emission estimates, including a recommendation on transparency.

Key activities of the oil and gas industry

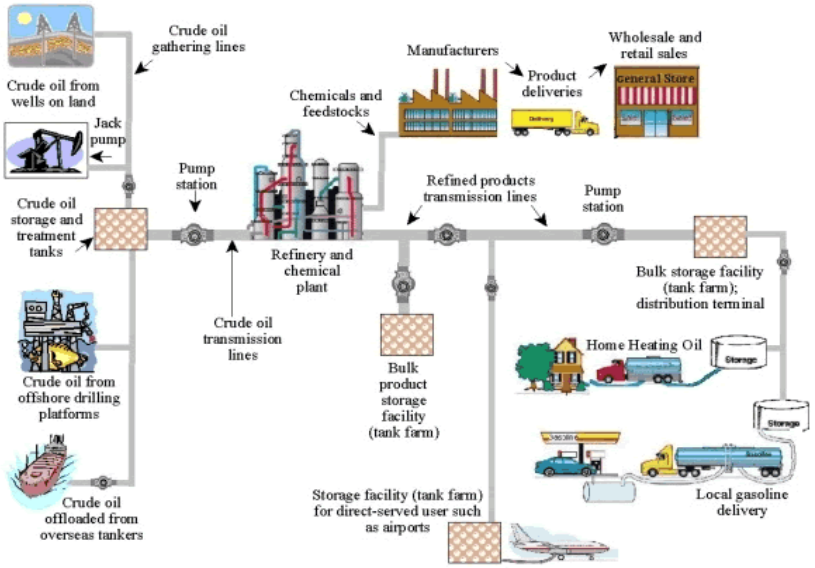
The oil and natural gas supply chains are composed of different activities, including:

- Exploration:
  - Oil exploration – subcategory 1.B.2.a.i;
  - Natural gas exploration – subcategory 1.B.2.b.i;
- Production, upgrading and gathering:
  - Oil production and upgrading – subcategory 1.B.2.a.ii;
  - Natural gas production and gathering – subcategory 1.B.2.b.ii;
- Transformation into final products:
  - Oil refining and storage – subcategory 1.B.2.a.iv;
  - Natural gas processing – subcategory 1.B.2.b.iii;
- Transportation of final products:
  - Oil transport – subcategory 1.B.2.a.iii;
  - Natural gas transmission and storage – subcategory 1.B.2.b.iv;

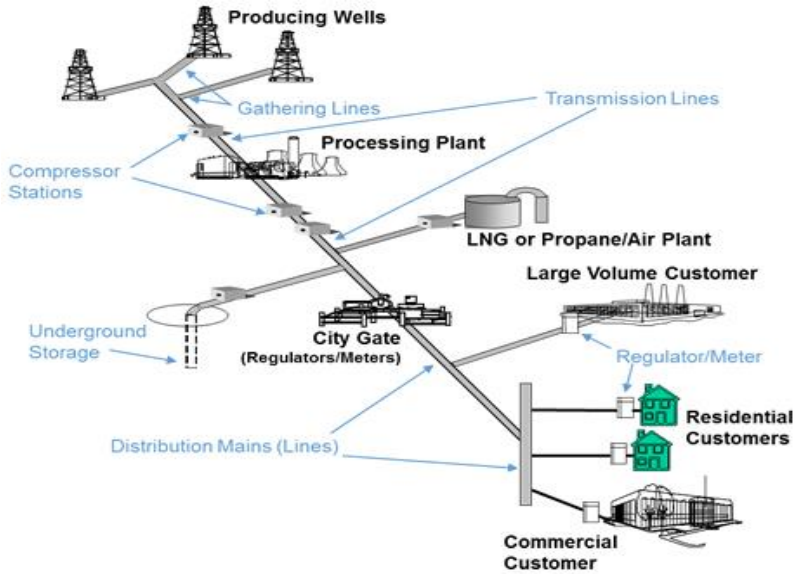
- Distribution:
  - Distribution of oil products – subcategory 1.B.2.a.v;
  - Distribution of natural gas – subcategory 1.B.2.b.v.

Oil and gas systems are potentially very complex and usually much more diverse than implied by the categories in the CRTs.

V. Figure 6.2. Activities of the oil industry



W. Figure 6.3. Activities of the natural gas industry

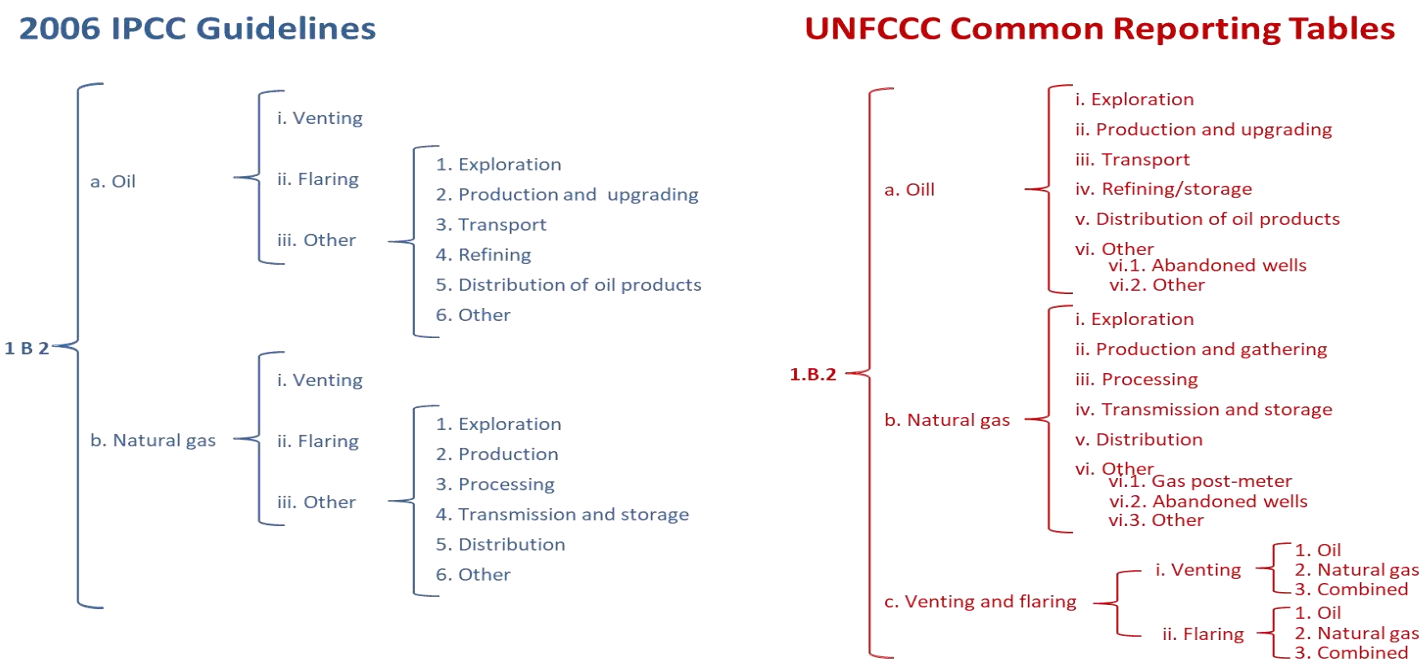


Organization of the oil and natural gas category in the 2006 IPCC Guidelines and in the common reporting tables

The CRTs address the same fugitive emissions subcategories as those of the 2006 IPCC Guidelines. However, they are organized in a different manner. In addition, the CRTs contain two drop-down lists with the following subcategories, which are not treated in the 2006 IPCC Guidelines and therefore these activities are not considered as mandatory for reporting under the MPGs:
Under 1.B.2.a oil: 1.B.2.a.vi.1 abandoned wells and 1.B.2.a.vi.2 other;
Under 1.B.2.b natural gas: 1.B.2.b.vi.1 gas post-meter, 1.B.2.b.vi.2 abandoned wells and 1.B.2.b.vi.3 other.

A graphical representation of the different structuring of the oil, gas, venting and flaring subcategories in the 2006 IPCC Guidelines and the MPGs is shown in figure 6.4. The IPCC definitions of the oil and natural gas categories are contained in table 4.2.1 of the 2006 IPCC Guidelines (vol. 2, chap.4, pp. 4.33–4.35). The organization in the CRTs reflect the structuring for the MPGs.

X. Figure 6.4. Graphical representation of the structuring of the oil and natural gas category in the 2006 IPCC Guidelines and in the UNFCCC common reporting tables



2.2. Estimation methods

1.B.1.a coal mining and handling

The 2006 IPCC Guidelines (vol. 2, chap. 4, section 4.1, pp.4.6–4.32) provide the estimation methods shown below. Key aspects are summarized in table 6.1.

Table 6.1. Estimation methods for coal mining and handling in the 2006 IPCC Guidelines

Subcategories	Underground mines (1.B.1.a.i)	Surface mines (1.B.1.a.ii)
1. Mining activities	Tier 1: raw coal production and default CH_4 EF	
	Tier 2: raw coal production and country or basin-specific CH_4 EF	
	Tier 3: direct measurements on a mine-specific basis	
2. Post-mining activities	Tier 1: raw coal production and default CH_4 EF	
	Tier 2: raw coal production and *in situ* gas content of coal or basin-specific CH_4 EF	
3. Abandoned underground mines	Tier 1: global average approach	
	Tier 2: country or basin-specific approach	
	Tier 3: mine-specific approach	
4. Flaring of drained methane or conversion of methane to CO_2	CH_4 and CO_2 emissions estimated on the basis of volume of flared methane and combustion efficiency	

CH_4 emissions: the 2006 IPCC Guidelines provide tier 1 and tier 2 methods for mining and post-mining activities for both underground and surface mines. A tier 3 method for mining activities in underground mines is also provided. Further, it is provided a three-tiered approach for abandoned underground mines. The main variables or parameters used for estimates of each approach are indicated in table 6.1.

CO_2 and CH_4 emissions: the 2006 IPCC Guidelines provide a general approach to estimate emissions from drained methane flared or catalytically oxidized and guidance to avoid omission or double counting of emissions.

When CH_4 from active or abandoned coal mines is recovered and utilized or converted to CO_2 through combustion with no energy recovery (flaring or catalytic oxidation), in your review you need to consider the estimation and reporting of the associated emissions.

- If recovered CH_4 is utilized as an energy source, check that the resulting emissions are reported according to its final end use under the corresponding combustion category.
- Where recovered CH_4 is fed into a gas distribution system and used together with natural gas, check that the fugitive emissions are dealt with under corresponding subcategories of 1.B.2.b natural gas.
- When recovered CH_4 is combusted without useful energy, as in flaring or catalytic oxidation, check that the associated CO_2 and CH_4 emissions are included under subcategory 1.B.1.a.i.4 flaring of drained methane or conversion of methane to CO_2.
- When tier 1 or tier 2 approaches have been used, check that the amount of recovered CH_4 used for energy purposes or flared/oxidized was subtracted from the total estimated emissions as the CH_4 EF include all CH_4 produced.

Note that decision trees in chapter 4 of volume 2 of the 2006 IPCC Guidelines are provided for:

- Underground coal mines (figure 4.1.1, p.4.11);
- Surface coal mines (figure 4.1.2, p.4.18);
- Abandoned underground coal mines (figure 4.1.3, p.4.22).

The 2006 IPCC Guidelines do not contain methodologies for subcategories other (1.B.1.a.i.5 and 1.B.1.a.ii.3) or for CO_2 emissions from mining and post-mining activities under both underground and surface mines, and from abandoned underground mines. Therefore, these fugitive emissions are not considered as mandatory for reporting under the MPGs.

Some Parties may, in accordance with paragraph 28 of decision 5/CMA.3, choose to use on a voluntary basis the 2019 Refinement to the 2006 IPCC Guidelines. See box 6.3 for an overview of the coverage in the 2019 Refinement to the 2006 IPCC Guidelines with regard to the estimation of fugitive CO_2 emissions.

Box 6.3. Fugitive CO_2 emissions from coal mining and handling in the 2019 IPCC Refinement to the 2006 IPCC Guidelines

The 2019 IPCC Refinement to the 2006 IPCC Guidelines provides methods to estimate fugitive CO_2 emissions from **mining activities** only. **Post-mining activities** are not covered.

For **underground mines**, a three-tiered approach is included. It is worth noting that the tier 1 approach uses CO_2 EFs that cover all fugitive emission sources including low temperature oxidation.

For **surface mines**, a two-tiered approach is included.

1.B.2.a oil, 1.B.2.b natural gas and 1.B.2.c venting and flaring

A three-tiered approach to estimate emissions from venting, flaring and fugitive emission sources from different segments of the oil and natural gas activities is provided in the 2006 IPCC Guidelines (vol. 2, chap. 4, section 4.2.2.2, pp.35–73).
In the same chapter, tier 1 default EFs for developed countries (table 4.2.4, pp.4.48–4.54) and for developing countries and countries with economies in transition (table 4.2.5, pp. 4.55–4.63) are provided for different emission sources (venting, flaring, fugitives) per industry segment.

Although the EFs for venting and flaring are disaggregated by oil and natural gas industry segment, the reporting of these emissions must be done under subcategory 1.B.2.c, differentiated according to oil, natural gas or combined. See box 6.4 for an example.

Box 6.4. Example of reporting emissions from different sources under oil production.

Consider the tier 1 EFs for oil production provided in table 4.2.4 of the 2006 IPCC Guidelines (vol. 2, chap. 4, p.4.50).

Category	Sub-category[e]	Emission source	IPCC Code	CH_4		CO_2[1]		NMVOC		N_2O		Units of measure
				Value	Uncertainty (% of value)	Value	Uncertainty (% of Value)	Value	Uncertainty (% of value)	Value	Uncertainty (% of value)	
Oil Production	Conventional Oil	Fugitives (Onshore)	1.B.2.a.iii.2	1.5E-06 to 3.6E-03	±100%	1.1E-07 to 2.6E-04	±100%	1.8E-06 to 4.5E-03	±100%	NA	NA	Gg per 10^3 m^3 conventional oil production
		Fugitives (Offshore)	1.B.2.a.iii.2	5.9E-07	±100%	4.3E-08	±100%	7.4E-07	±100%	NA	NA	Gg per 10^3 m^3 conventional oil production
		Venting	1.B.2.a.i	7.2E-04	±50%	9.5E-05	±50%	4.3E-04	±50%	NA	NA	Gg per 10^3 m^3 conventional oil production
		Flaring	1.B.2.a.ii	2.5E-05	±50%	4.1E-02	±50%	2.1E-05	±50%	6.4E-07	-10 to +1000%	Gg per 10^3 m^3 conventional oil production

These EFs are disaggregated according to the fugitive emission sources (onshore and offshore oil production), venting and flaring, being m^3 of conventional oil production the AD used.

The estimated fugitive emissions from oil production must be reported under subcategory production and upgrading (1.B.2.a.ii).

The corresponding emissions from venting arising from oil production must be reported under venting–oil (1.B.2.c.i.1) together with other emissions from venting occurring under other segments of the oil industry.

The corresponding emissions from flaring arising from oil production must be reported under flaring–oil (1.B.2.c.ii.1) together with other emissions from flaring occurring under other segments of the oil industry.

Additional information on estimation methods in the 2006 IPCC Guidelines is contained in box 6.5. Considerations on the review of the application of estimation methods for fugitive emissions from oil, natural gas, venting and flaring are presented in section 3 below.

Box 6.5. Further information on methods in the 2006 IPCC Guidelines

Oil and gas throughputs are the main AD for the tier 1 approach; the same AD is used for the standard tier 2 approach, which uses country-specific EFs instead of IPCC default EFs. An alternative tier 2 approach is provided in the 2006 IPCC Guidelines to estimate venting and flaring emissions from the production segment of oil system. It uses mass balance approach and country specific information on gas-to-oil ratios (GOR).

To learn more consult vol. 2, chap. 4, of the 2006 IPCC Guidelines, for: (1) guidance to collect AD for the tier 1 approach (table 4.2.7, pp.4.67–4.69); and (2) typical ranges of GOR for different types of production (table 4.2.3, p.4.44).

AD for a tier 3 approach includes system throughput, equipment and facility inventories (i.e. infrastructure data) and reported vented and flared volumes. Considerations during your review include completeness in regard to the coverage of the infrastructure data and the reported vented and flared volumes and the penetration of control technologies.

Note that an overview of the typical AD required for the different tier approaches is provided in table 4.2.6 of the 2006 IPCC Guidelines (vol. 2, chap. 4, p.4.66).

3. Review approach

3.1. Main review topics across categories

Similarly, to the previous lessons, from the three main steps of the review approach (Prepare – Assess – Draft) this topic focuses on the assessment step. Drafting is covered in the walk-through examples and exercises.
There are a number of simple checks of certain aggregated information reported in the CRTs to apply during your review that may help you to make preliminary findings that deserve further attention; these include:

- Relevance of the category: whether it is a key category;
- Estimation methods from CRT summary 3 to identify whether tier 1 methods have been used for key categories;
- Use of notation keys: they may be associated with completeness (especially "NE" and "IE"); if an activity is reported as "NO", this reporting should be checked against the energy balance.

The main review topics of each fugitive emissions category/subcategory are presented in the following sections.

3.2. Category-specific considerations

1.B.1.a coal mining and handling

Activities

- Mining activities: the first step is checking whether there is or there was coal production in the country. Quick check: look for data reported for the production of the different primary solid fuels (TJ) under the reference approach in CRT 1.A(b). If mining activities occur, check in the NID whether all applicable activities and sites have been included to estimate and report the corresponding emissions;
- Post-mining activities (processing, storage and transport): check whether the post-mining emissions include CH_4 emitted after coal has been mined, brought to the surface and subsequently processed, stored and transported;
- Check existence of abandoned underground mines;
- Check existence of CH_4 recovered and utilized for energy production or flared.

Methods

- If different methods have been used for the same type of individual activities, check whether these have been reported clearly (e.g. different tiers may have been used for different mines to suit the available AD).

Note that the 2006 IPCC Guidelines do not provide guidance to estimate emissions from abandoned surface mines and all types of CO_2 emissions except for those associated with flaring of drained methane or conversion of methane to CO_2. (1.B.1.a.i.4). Therefore, these activities are not considered as mandatory for reporting under the MPGs.

Activity data

- Check if the amount of fuel produced is based on the run-of-mine production or on the saleable production. If saleable coal is the AD, check if an estimate considering the fraction lost through washing has been made. Check if an appropriate explanation for this is provided in the documentation box of CRT 1.B.1;
- Check if the amount of fuel produced reported in CRT 1.B.1 is in accordance with (but not necessarily the same as) the production reported in CRT 1.A(b).

Emission factors

- Check that good practice has been used in selecting the EFs in line with the corresponding decision trees for underground mines, surface mines or abandoned underground mines. The quality and applicability of the EFs are important considerations.
- Check that the selected EFs are within the range of values provided in the 2006 IPCC Guidelines, or that significant departures from these are adequately explained. Significantly low IEFs reported in the CRT may be due to emission control measures such as mine degasification and vent gas treatment or recovery.

1.B.1.a.i underground mines

Activities

- Check if the mining emissions include all seam gas emissions vented to the atmosphere from coal mine ventilation air and degasification systems.
- If recovery/flaring of CH_4 occurs:
  - Check if the associated emissions from flaring are reported. This also includes CH_4 drained or ventilation gas converted to CO_2;
  - Identify how the recovered and utilized amounts have been (1) estimated (e.g. from mine operators, gas sales or specifications of the drainage system); and (2) allocated (e.g. stationary combustion or fugitive emissions from oil and natural gas).
- For each year of the inventory, check that each mine has been classified as either active or abandoned. Then:
- For abandoned underground mines:
  - Check that emissions have been estimated and reported;
  - Verify how historical data on the closing or decommissioning of the mine have been reported. Ideally, the Party would have a record of the date of closure and the method of sealing of each mine (or group of mines). This information may be not available for all mines, often depending on the number of years that have elapsed since the mines were closed. In this case, investigate how data gaps have been resolved;
  - Check from the NID the units of AD and EFs used by the Party and assess whether the emission estimates are correctly reflected in the CRT.

Methods

- Check that the stated method has in fact been applied; for example, extrapolation of tier 3 estimates for a few mines is basin-specific (tier 2) but not mine-specific (tier 3).
- For degasification systems, identify how the amount of drained CH_4 was estimated. If tier 3 methods are used, check if CH_4 recovered from degasification systems that is subsequently vented to the atmosphere was added to the total emissions released from the ventilation systems.

Activity data

- Check and confirm that assumptions used to bridge the gaps in AD are clearly stated.

Emission factors

- If tier 1 CH_4 EFs are used check and verify that they have been selected in accordance with the depth of the mine(s).

1.B.1.a.ii Surface mines

Methods

- If there are multiple coal basins and the estimates for mining and post-mining have been made using a tier 2 approach, assess whether AD and EFs have been disaggregated at the coal basin level.

Emission factors

- If tier 1 CH_4 EFs are used, verify that they have been selected with regard to the average overburden depth of the mine(s).

1.B.1.b fuel transformation

As indicated in section 2.2 above, the CRTs include four subcategories of fugitive emissions under fuel transformation:

- 1.B.1.b.i charcoal and biochar production;
- 1.B.1.b.ii coke production;
- 1.B.1.b.iii coal to liquids;
- 1.B.1.b.iv gas to liquids.

Keep in mind that the 2006 IPCC Guidelines do not provide guidance to estimate fugitive emissions from fuel transformation. Therefore, these activities are not considered as mandatory for reporting under the MPGs.

If the Party has estimated and reported emissions from any of these subcategories, check how the Party ensured that there is no double counting between this subcategory and other inventory categories or subcategories; for example, that the associated combustion emissions have been reported under the appropriate stationary combustion subcategory, most likely manufacture of solid fuels and other energy industries (1.A.1.c).

Note that some Parties may, in accordance with paragraph 28 of decision 5/CMA.3, choose to use on a voluntary basis the 2019 Refinement to the 2006 IPCC Guidelines to estimate some of these fugitive emissions.

1.B.2 oil, natural gas and other emissions from energy production

Activities

- Check that all applicable activities in all segments of the oil and natural gas industries have been addressed.
- Check how CO_2 from CO_2-rich streams is treated: (1) simply vented; (2) injected into a reservoir for EOR, EGR or ECBM or (3) captured for geological storage purposes. (See annex 6.1 for a discussion on CO_2-rich streams.)

Methods

- Confirm that an appropriate tier has been used in line with the corresponding decision tree provided in the 2006 IPCC Guidelines (vol. 2, chap. 4) for:
  - Natural gas system (figure 4.2.1, p. 4.38);
  - Oil production (figure 4.2.2, p. 4.39);
  - Crude oil transport, refining and upgrading (figure 4.2.3, p. 4.40).
- If estimates are based on measurements, check that the results are still applicable by considering whether the technologies and practices when the measurements were made are the same as or similar to those for which they were applied.
- If reported emissions are based on a compilation of estimates reported by individual oil and gas companies, check that there is no omission or double counting of emissions by examining whether the set of companies considered account for the total activity of the corresponding subcategory. If possible to perform, a comparison of the AD reported in CRT 1.B.2 with data from national statistics would be helpful for this purpose. In the case that facility-level data is used for the estimates and the facility population available is not the total national population, the reviewer should check the method used by the Party to scale up that data to the national level.
- If the alternative IPCC tier 2 method has been used, check (1) whether venting and flaring emissions are the dominant fugitive emissions; and (2) whether data on venting and flaring are available, and whether these have been used for comparison purposes, but the associated emissions have not been included in the estimates, avoiding double counting.
- For a tier 3 approach, check the type of and approach to the collection of data used. A list of key types of data required by a tier 3 method is provided in the 2006 IPCC Guidelines (vol. 2, chap. 4, p. 4.46).
- Where oil and gas projects involving CO_2 injection occur:
  - Identify the main purpose of each project (i.e. enhancing production or disposal/storage);

- Check that the emissions associated with the oil and gas portion of the project have been estimated using the appropriate tier method and reported under the appropriate subcategory;
- Where EFs are used to estimate emissions, check whether these have been periodically updated to reflect likely increasing CO_2 concentrations over time in the emitted natural gas and hydrocarbon vapours;
- If CO_2 for a capture and storage project has been collected at a gas processing facility or as a by-product of hydrogen production at refineries or heavy oil upgraders, check that:
  - The associated amounts of captured/stored and emitted CO_2 have been estimated using a tier 3 approach;
  - The amount captured has been reported under 1.B.2.a.4 refining/storage (hydrogen production) or under 1.B.2.b.3 processing (gas processing facility);
  - The resulting fugitive emissions from the CO_2 capture process have been reported under 1.B.2.c.i venting-oil (hydrogen production) or under 1.B.2.c.i venting-gas (gas processing facility).

• The 2006 IPCC Guidelines do not provide an explicit method to estimate emissions from subcategories 1.B.2.a.i oil – exploration and 1.B.2.b.i natural gas – exploration; however, they contain EFs that allow estimating GHG emissions from well testing and well drilling. See box 6.6 for more information on the availability of EFs for well testing and well drilling. If emissions are estimated using the tier 1 method, a Party may estimate emissions from flaring and venting using the EFs provided for well testing and possibly those for well drilling, reporting these emissions under the corresponding flaring subcategories (1.B.2.c.ii.1 flaring-oil and/or 1.B.2.c.ii.2 flaring-natural gas) and using notation key "IE" for subcategories 1.B.2.a.i oil – exploration and 1.B.2.b.i natural gas – exploration. In your review, check the reporting in CRT 1.B.2 and the information provided in the NID in regard to the estimation and reporting of these emissions.

Box 6.6. Availability of EFs for well testing and well drilling

Tables 4.2.4 and 4.2.5 of the 2006 IPCC Guidelines (vol. 2, chap. 4) include CO_2, CH_4 and N_2O tier 1 EFs for well testing, an activity that is normally performed to confirm the exploration hypothesis and to establish a first production forecast. So this activity can be assumed as exploration. These tables contain also tier 1 EFs for well drilling, an activity that takes place although not exclusively during exploration. These EFs refer to venting and flaring and not to fugitive emissions and the corresponding activity data is the amount of oil production. The reporting indication in the tables is that emissions are to be reported under IPCC subcategories 1.B.2.a.ii or 1.B.2.b.ii, which correspond respectively to **CRT subcategories 1.B.2.c.ii.1 flaring–oil and 1.B.2.c.ii.2 flaring–natural gas**.

Activity data

• Check that the AD (description and units) reported in CRT 1.B.2 is in accordance with the EFs used. The 2006 IPCC Guidelines provide guidance on the AD required for the tier 1 approach and the standard tier 2 approach (vol. 2, chap. 4, table 4.2.7, pp.4.67–4.69).

• Check the relevant energy categories or subcategories to ensure that relevant combustion emissions have been included under the corresponding fuel combustion activities (such as

1.A.1.b petroleum refining and 1.A.1.c.ii oil and gas extraction) and that the levels of these emissions seem consistent with the quantity of AD used to estimate fugitive emissions.

1.B.2.a oil

- Check whether the reported amount of oil production in CRT 1.B.2 is consistent with the reported production data in the reference approach (CRT 1.A(b)).
- If combined oil and natural gas production occurs in the Party, check whether the Party has indicated in the NID under which subcategory of 1.B.2.a oil or 1.B.2.b natural gas the emissions have been reported and how omission or double counting of emissions were avoided.
- Check whether the AD reported for oil transport are consistent with the AD for oil production. If not, check if the reason for the difference is described in the NID.

Note that CRT 1.B.2 contains a drop-down list that includes subcategory 1.B.2.a.vi.1 abandoned wells. The 2006 IPCC Guidelines do not provide methods to estimate these fugitive emissions. Therefore, this activity is not considered as mandatory for reporting under the MPGs.

1.B.2.b natural gas

- Check whether the amount of natural gas production reported in CRT 1.B.2 is consistent with the reported production data in the reference approach CRT 1.A(b).
- Check whether the AD reported for natural gas processing are consistent with the AD for natural gas production. If not, check if the reason for the difference is described in the NID.
- Check whether the AD for natural gas distribution are reasonably consistent with the reported total amount of natural gas used for fuel combustion activities and feedstock.

Note that CRT 1.B.2 contains a drop-down list that includes subcategories 1.B.2.b.vi.1 gas post-meter and 1.B.2.b.vi.2 abandoned wells. The 2006 IPCC Guidelines do not provide methods to estimate fugitive emissions from these two subcategories. Therefore, these activities are not considered as mandatory for reporting under the MPGs.

1.B.2.c venting and flaring

- Given the uncertainty in most venting and flaring systems, it is appropriate to assess the completeness and reasonableness of the estimates. Considering that:

  Total amount of natural gas and vapours vented or flared from oil systems

  ~ [Gross amount of associated gas production] – [Any volume sent into a gas gathering system] – [Reinjected] – [Utilized for fuel]

- The basic questions you should attempt to answer during your review are:
  - How much gas was produced in association with oil?
  - Is the reported amount of associated gas production reasonable?
  - Is the fraction of the associated gas production reported as vented or flared reasonable?
- Check whether the EFs are reported using the same units of measure and reference conditions as the AD, or whether appropriate conversion factors have been applied.

- If the tier 1 approach has been used, the information from the default EFs in tables 4.2.4 and 4.2.5 (vol. 2, chap. 4, pp.4.48–4.63) is useful to check whether all occurring activities for which venting and/or flaring are likely have been taken into account and whether the resulting emissions have been estimated and reported as part of the corresponding subcategory (venting or flaring). A table summarizing the information in tables 4.2.4 and 4.2.5 regarding venting and flaring is presented in box 6.7.

Box 6.7. Activities oil and natural gas for which the 2006 IPCC Guidelines provide default emission factors for venting and/or flaring in tables 4.2.4 and 4.25

	Venting	Flaring
Oil		
2006 IPCC Guidelines	1.B.2.a.i	1.B.2.a.ii
CRT	1.B.2.c.i.1	1.B.2.c.ii.1
Oil production		
• Conventional oil	x	x
• Heavy oil/Cold bitumen	x	x
• Thermal oil production	x	x
• Weighted total	x	x
Oil transport		
• Tanker trucks and rail cars	x	
• Loading of off-shore production on tanker ships	x	
Natural gas		
2006 IPCC Guidelines	1.B.2.b.i	1.B.2.b.ii
CRT	1.B.2.c.i.2	1.B.2.c.ii.2
Gas production		x
Gas processing		
• Sweet gas plants		x
• Sour gas plants	x (raw CO_2)	x
• Deep-cut extraction plants (straddle plants)		x
• Weighted total	x (raw CO_2)	x
Gas transmission and storage		
• Transmission	x	
Oil or natural gas	Flaring and venting	
2006 IPCC Guidelines	1.B.2.a.ii or 1.B.2.b.ii	
CRT	1.B.2.c.ii.1 or 1.B.2.c.ii.2	
• Well drilling	x	
• Well testing	x	
• Well servicing	x	

1.B.2.a, 1.B.2.b and 1.B.2.c: Review of estimates based on the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories

Some Parties may, in accordance with paragraph 28 of decision 5/CMA.3, choose to use on a voluntary basis the 2019 Refinement to the 2006 IPCC Guidelines to estimate some or all fugitive emissions from subcategories 1.B.2.a oil and 1.B.2.b natural gas. In this case, in your review you must be aware of how the methods for these subcategories have been covered in the 2019 Refinement to the 2006 IPCC Guidelines. See annex 6.2 for an overview of key aspects to be taken into account.

1.B.2.d other

- If the Party has reported the use of biogas under fuel combustion activities, check that fugitive emissions from biogas transmission/distribution have been estimated and reported. Note that

once biogas enters the transmission/distribution network it is indistinguishable from natural gas and emissions should be calculated accordingly.

- If geothermal energy use occurs in the Party and it is used for electricity or heat, the associated fugitive emissions (typically CO_2 and CH_4) may be estimated and consequently reported under subcategory 1.B.2.d other.

  The estimation method would necessarily be country-specific and most likely plant-specific as the physical properties of the geothermal fluid (vapour or liquid) and its GHG concentrations are site-dependent. Parties that estimate and report GHG emissions from geothermal energy normally consider its use in power plants, typically associated with the use of geothermal vapour at high temperatures. The use of geothermal liquids at relatively low temperatures is usually not taken into account in the GHG inventory. In your review check whether the information reported by the Party has transparently explained in the NID the method, data and/or parameters selected to estimate these emissions.

Note that the 2006 IPCC Guidelines do not provide methods to estimate fugitive emissions from geothermal energy. Therefore, this activity is not considered as mandatory for reporting under the MPGs.

3.3. Key points to consider when reviewing cross-cutting issues

Time-series consistency

- When a tier 3 method is used to estimate emissions for the first time and there are years for which plant-specific data or input data to run a specific model are not available, check that emissions have been estimated using splicing techniques to combine or join more than one method to form the complete time series, in line with good practice.
- For coal mining and handling, check:
  - If CH_4 emissions associated with coal seam degasification have been estimated and reported for the inventory year in which the emissions and recovery operations occur;
  - The transition from active to abandoned underground mines across the time series;
  - The emission estimates for new mines that have started production in new coalfields.
- For oil and natural gas, check:
  - If changes in such industry have been reflected in the estimation methods and emission estimates. Time series of IEFs may be useful to check these changes. Check that EFs for new technologies are used only for recent years, reflecting their penetration, while the appropriate EFs are used for previous years in which older technologies were in use;
  - Possible changes in facility ownership that may imply changes in time series data consistency, if data collection or emission estimates for some segments or facilities are performed by the operators and transferred to the inventory team.

Uncertainty assessment

- For tier 1 and tier 2 estimates, check that the uncertainty values and the corresponding uncertainty ranges selected for AD and EFs at the category level are consistent with the sectoral good practice guidance.
- For tier 3 emission estimates, verify that the uncertainty estimate corresponds to the inherent uncertainty of the method applied.
- Since there are wide ranges of possible AD, according to the tiers used, check that the uncertainty values for AD correspond to the different types of data used.

Remember that developing countries that need flexibility in the light of their capacities are encouraged, not required, to provide quantitative estimates of uncertainty. They are also encouraged to provide a qualitative assessment of uncertainty for key categories (para. 29 of the MPGs).

Quality assurance and quality control

- Evaluate the specific QA/QC measures that have been applied to ensure completeness and avoid any overestimation or underestimation and/or double counting.
- Check that these measures are properly documented.
- Consult sections 4.1.7 (pp.4.30–4.31) and 4.2.3 (pp.4.73–4.74), of the 2006 IPCC Guidelines (vol. 2, chap. 4), which provide clear guidance on how to review issues related to QA/QC.

Remember that developing countries that need flexibility in the light of their capacities are encouraged, not required, to implement and provide information on general inventory QC checks (para. 35 of the MPGs).

3.4. Walk-through examples

In this part of the course you will work in four examples covering cases for:

1. Coal mining and handling;
2. Oil;
3. Natural gas;
4. Geothermal energy.

The examples cover topics such as: (1) use of notation keys; (2) checking the status of previous recommendations; (3) formulating questions; (4) identifying inconsistencies with the MPGs; and (5) drafting the TERR.

1. 1.B.1.a.i.3 coal mining and handling – abandoned underground mines

1.1 Contrast the reporting by the Party with alternative information

Consider the CRT 1.B.1 reported by Party A (available in the Supplementary Materials at https://unfccc.int/resource/tet/be/be6-01_en6_exmpl_1.xlsx) and the information regarding emissions

from abandoned coal mines in the report on the coal industry of Party A, available from the *Global Methane Initiative* (see box 6.8).

> *"At least 20 underground coal mines in Party A have been abandoned since 1991. All are considered gassy and every abandoned mine is classified as a high hazard for coal and gas outbreaks."*

This information is based on a report published by the International Energy Agency in 2011.

Box 6.8. Global Methane Initiative

The Global Methane Initiative (GMI) is an information resource for 46 Partner Countries, more than 700 Project Network members and other stakeholders facilitating the exchange of information and technical resources on CH_4 mitigation in the areas of biogas, coal mines, oil and natural gas. For more information visit the GMI's website: https://www.globalmethane.org/.

Considerations by the reviewer

Assuming that the information reported by the Global Methane Initiative is accurate and reliable then the reviewer would make the following considerations:

Finding: the Party reported abandoned underground mines as "NO" in CRT 1.B.1, while an alternative and reliable information source reported that at least 20 underground coal mines in Party A have been abandoned since 1991 and all are considered gassy;

Inconsistency with the MPGs: if the activity occurs in the country, it cannot be reported as "NO". The only case for which emissions from abandoned underground mines are assumed to be zero is when the mines have been fully flooded. In this case it would be correct to use the notation key "NA" according to the MPGs. This seems to be a completeness issue in the Party's reporting;

Ideal situation: the Party estimating and reporting CH_4 emissions from abandoned underground coal mines, or providing documented evidence in the NID that abandoned underground mines in the country have been sealed and fully flooded or providing in the NID a demonstration of insignificance of emissions in accordance with paragraph 32 of the MPGs and reporting them as "NE".

Recommendation: collect the necessary data to estimate and report CH_4 emissions from abandoned underground mines or provide a documented demonstration either that abandoned underground mines in the country have been sealed and fully flooded or that emissions are insignificant in accordance with the MPGs.

1.2 Drafting your recommendation in the technical expert review report

These considerations can be translated into a recommendation in the TERR as indicated below.

Finding classification	*Description of the finding with recommendation*	*Classify by type*
1.B.1.a.i.3 abandoned underground mines – solid fuels CH_4	Party A reported CH_4 emission estimates from subcategory 1.B.1.a.i.3 abandoned underground mines as "NO" in in CRT 1.B.1. The TERT noted that, according to information published by the Global Methane Initiative based on a report by the International Energy Agency "…at least 20 underground coal mines in Party A have been abandoned since 1991. All are considered gassy and every abandoned mine is classified as a high hazard for coal and gas outbreaks." Considering that the Global Methane Initiative is a reliable source of information, the TERT is of the view that abandoned underground mines may be a source of CH_4 emissions, which have not been included in the national inventory. The TERT recommends that Party A collect the necessary data to estimate and report CH_4 emission estimates from abandoned underground coal mines using the methodological approach provided in the 2006 IPCC Guidelines (vol. 2, chap. 4, pp.4.20-4.28) or provide a documented demonstration in the NID either that abandoned underground mines in the country have been sealed and	Completeness

Finding classification	*Description of the finding with recommendation*	*Classify by type*
	fully flooded and report emissions as "NA" or that emissions from abandoned underground mines are insignificant in accordance with paragraph 32 of the MPGs and report them as "NE".	

2. 1.B.2.a.iii oil – transport

2.1 Identify findings

Party A has reported "NO" for oil transport AD and emissions in CRT 1.B.2; however, it reported AD and emission estimates for subcategories oil production and upgrading and oil refining/storage.

Assess if this reporting is consistent

Since oil is produced and refined in the country, it is expected that oil is transported. As the activity occurs, the correct notation key reported for this situation would be "NE". In principle the Party should estimate and report the associated emissions. If the Party provides background information showing that this activity does not generate any emissions, then the subcategory and the associated emissions may be reported as "NA".

2.2 Identifying inconsistencies with the MPGs

In response to a question raised by the TERT during the review regarding oil transport, Party A (a developing country) explained that the previous TERT advised the inventory team that the main source of emissions for this category occurs when crude oil is loaded onto tanker ships. Since this activity does not occur in the country it was reported as "NO". However, during the review week, the Party discussed this issue with the oil extraction company, which indicated that oil is transported to the refinery by tanker trucks and pipelines.

During the review you note that table 4.2.5 in the 2006 IPCC Guidelines (vol. 2, chap. 4, p.4.61) includes EFs to estimate emissions from oil transport by trucks in developing countries and in countries with economies in transition.

Chapter 4: Fugitive Emissions

TABLE 4.2.5(CONTINUED)
TIER 1 EMISSION FACTORS FOR FUGITIVE EMISSIONS (INCLUDING VENTING AND FLARING) FROM OIL AND GAS OPERATIONS IN DEVELOPING COUNTRIES AND COUNTRIES WITH ECONOMIES IN TRANSITION[a,b]

Category	Sub-category[c]	Emission source	IPCC Code	CH_4		CO_2[i]		NMVOC		N_2O		Units of measure
				Value	Uncertainty (% of value)	Value	Uncertainty (% of value)	Value	Uncertainty (% of Value)	Value	Uncertainty (% of value)	
Oil Upgrading	All	All	1.B.2.a.iii.2	ND	ND	ND	ND	ND	ND	ND	ND	Gg per 10^3 m^3 oil upgraded
Oil Transport	Pipelines	All	1.B.2.a.iii.3	5.4E-06	-50 to +200%	4.9E-07	-50 to +200%	5.4E-05	-50 to +200%	NA	NA	Gg per 10^3 m^3 oil transported by pipeline
	Tanker Trucks and Rail Cars	Venting	1.B.2.a.i	2.5E-05	-50 to +200%	2.3E-06	-50 to +200%	2.5E-04	-50 to +200%	NA	NA	Gg per 10^3 m^3 oil transported by Tanker Truck
	Loading of Off-shore Production on Tanker Ships	Venting	1.B.2.a.i	ND[h]	ND	ND[h]	ND	ND	ND	NA	NA	Gg per 10^3 m^3 oil transported by Tanker Truck
Oil Refining	All	All	1.B.2.a.iii.4	ND	ND	ND	ND	ND	ND	ND	ND	Gg per 10^3 m^3 oil refined.

Inconsistency identified

Since a method to estimate emissions from oil transport by tanker trucks is provided in the 2006 IPCC Guidelines, the Party should estimate these emissions. However, since the only emissions from oil transport for which EFs are reported in table 4.2.5 correspond to venting (not to leaks or other types of losses), the estimated emissions should be reported under subcategory 1.B.2.c.i.1 oil (under venting). For completeness, fugitive emissions for subcategory 1.B.2.a.iii transport (under oil) are to be reported as "IE", indicating that they are reported under venting in the corresponding CRT and the NID.

2.2 Drafting your recommendation in the technical expert review report

These considerations can be translated into a recommendation in the TERR as indicated below.

Finding classification	*Description of the finding with recommendation*	*Classify by type*
1.B.2.c.i.1. venting – oil – liquid fuels CO_2, CH_4	Party A has reported "NO" for oil transport in CRT 1.B.2. Since oil is produced and refined in Party A, it is expected that oil is transported. In response to a question raised by the TERT during the review regarding oil transport, Party A explained that the previous TERT advised it that the main source of emissions for this category occurs when crude oil is loaded onto tanker ships. Since this activity does not occur in the country it was reported as "NO". During the review week, Party A discussed this with the oil company, which informed it that oil is transported to the refinery by trucks and pipeline. The TERT notes that a methodology for estimating CO_2 and CH_4 venting emissions from oil transport by tanker trucks is available in the 2006 IPCC Guidelines. The TERT recommends that Party A estimate emissions from oil transport by trucks and report (i) the estimated emissions from oil transport by trucks under subcategory 1.B.2.c.i.1 venting – oil () and (ii) the emissions from oil transport by trucks under subcategory 1.B.2.a.iii oil – transport) as "IE".	Completeness

3. 1.B.2.c.i.2 gas – venting

Party A, a natural gas importer that does not produce this fuel, reported CH_4 emissions from venting under subcategory 1.B.2.c.i.2 gas – venting, while the notation key "NO" was used to report CO_2 emissions under this subcategory.

During the review, the Party clarified that the reported CH_4 emissions from venting activities were provided by the company responsible for transmission of natural gas, which is imported from the neighbouring country (Party B).

The Party claimed that reporting CO_2 emissions from venting under 1.B.2.c.i.2 was not correct because from its point of view, subcategory 1.B.2.c.i venting deals with CO_2 emissions related to the separation in processing facilities of the CO_2 contained in raw production natural gas, which is treated to meet specified quality standards set for pipeline transmission and distribution companies (pipeline levels of CO_2 should be below 2–3 per cent to avoid the formation of corrosion compounds). The Party further clarified that the treatment of the natural gas is performed by the vendor in Party B. In addition, Party A provided the TERT with the website of the natural gas transmission company, which reports that in the last 10 years the annual average CO_2 content in the imported natural gas was relatively low (0.0–1.6 per cent).

Review actions

Main considerations for the review are:

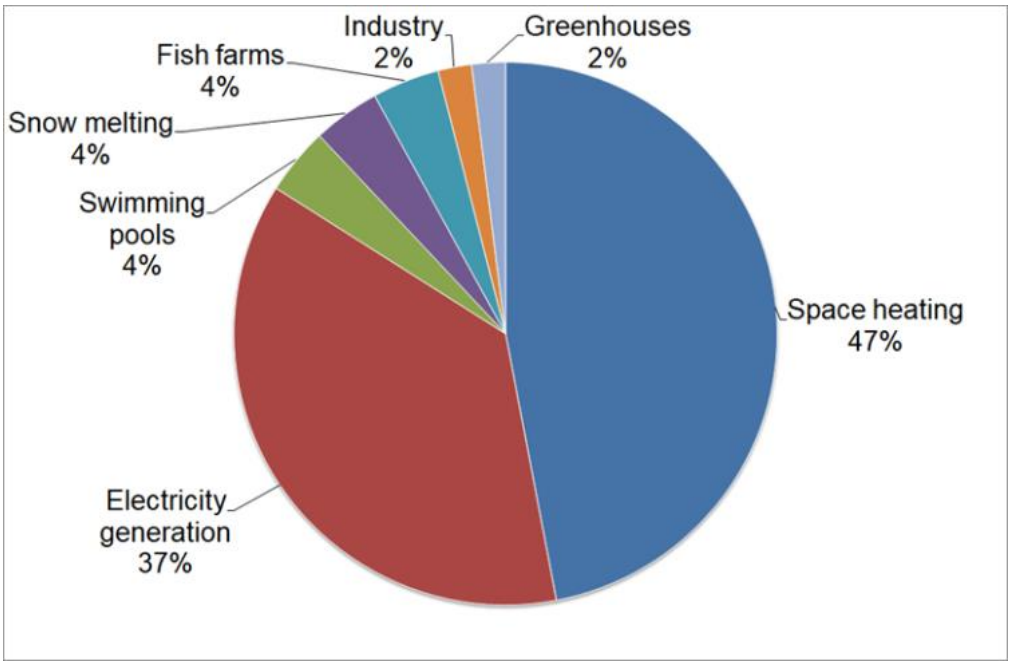
- According to the reporting by Party A, based on the information provided by the transmission company, venting from natural gas transmission occurs in the country;
- The information reported on the website of the transmission company indicates that CO_2 is present in the transmitted natural gas at average annual concentrations in the range of 0.00–1.6 per cent.

From these two points, you can conclude that since (i) natural gas venting occurs during transmission and (ii) this natural gas contains CO_2, then CO_2 emissions from this activity also occur. Therefore, reporting CO_2 emissions from venting as "NO" is not in line with the definitions of notation keys in paragraph 31 of the MPGs and Party A should have reported these emissions as "NE".
Additional remarks:

- Since plant-specific data are used to estimate these emissions, you should check whether the method and data selected are transparently explained in the NID, in line with paragraph 22 of the MPGs. In the course of the review, it would be worth asking the Party about the possibility of estimating and reporting these vented CO_2 emissions from transmission because, having the CO_2 content of the vented gas available, the Party would be able to estimate these emissions;
- The comment by Party A that subcategory 1.B.2.c.i venting deals with CO_2 emissions related to the separation in processing facilities is not entirely correct. The mentioned emissions are part of this subcategory as well as other activities, particularly transmission and storage for which the 2006 IPCC Guidelines include default CO_2 EFs.

4. 1.B.2.d other – fugitive emissions from geothermal energy

CO_2 emissions from geothermal energy were estimated and reported by Party B. The NID seems to indicate that emissions from geothermal energy use were estimated only for electricity generation activities. However, the report "Geothermal development and research in Party I" published by the Department of Energy indicates that a large share of geothermal energy is used in the country for other purposes, as summarized in the figure below extracted from the report.



Y. Figure 6.5. Use of geothermal energy in Party B.

Before the review week, you should clarify which activities use geothermal energy in the country, and whether emissions from these activities were estimated, and draft a preliminary question to the Party.

Preliminary question to the Party

The TERT notes that it seems that only GHG emissions from geothermal energy use for electricity generation have been estimated and reported by Party B. The TERT also notes that geothermal energy is used for other purposes in Party B, namely space heating, snow melting, fish farming, swimming pools, industry and greenhouses. These applications account for a large share of geothermal energy use in the Party. Has Party B assessed the potential emissions of GHGs (CO_2 and CH_4) from these other uses of geothermal energy?

Response by the Party

During the review, Party B indicated that geothermal power plants invariably use fluids from "high temperature" areas. These geothermal fluids are over 200 °C in the ground and are released as steam when they reach the surface. Geothermal facilities that produce only heat for other uses are invariably "low-temperature" district heating plants, where the geothermal fluid is less than 150 °C in the ground and much less steam is released. The experts of the national energy agency are of the view that GHG emissions are practically negligible, and they have not been estimated.

Technical expert review team actions and follow-up

As there is no methodology to estimate GHG emissions from geothermal energy in the 2006 IPCC Guidelines, the TERT cannot recommend the Party to estimate emissions from other uses of geothermal energy, but a recommendation on transparency of the information already reported by the Party should be included in the TERR.

4. Exercises

Exercises are provided below for you to practise your skills as an expert reviewer of category 1.B fugitive emissions from fuels.
You will work with exercises in the following topics:

- Exercise 1: Coal mining and handling – emissions from underground and surface mines;
- Exercise 2: Coal mining and handling – emissions from flaring of coalbed methane;
- Exercise 3: Oil and natural gas – emissions from venting and flaring;
- Exercise 4: Natural gas – emissions from transmission and storage, and distribution.

4.1. Exercise 1. Emissions from underground and surface mines

1.1 CH_4 emission factors

Party A reports in its NID that:

- Coal mining is carried out by surface mining and underground mining;
- Lignite, the main domestic coal, is mined by surface mining;
- Fugitive emissions from coal mining were estimated using the IPCC tier 1 method;
- CH_4 EFs were selected from the 2006 IPCC Guidelines bearing in mind that underground mines in the country have an average depth of less than 400 m, and surface mines for lignite have on average a depth of more than 25 m.

The NID indicates that CH_4 emissions from coal mining and handling have been identified as a key category and that no specific improvement are planned for this subcategory. No other specific information for this subcategory is reported in the NID. For further analysis, see CRT 1.B.1 for the most recent year in the Supplementary Materials at https://unfccc.int/resource/tet/be/be6-02_en6_exrcs_1.xlsx.
During your preparation for the review you should check whether the CH_4 EFs selected by the Party are those reported in the 2006 IPCC Guidelines. Table 6.2 summarizes the values (in m^3/t) reported for average CH_4 EFs from coal mining and handling; the conversion to mass units (kg/t) was done using the density of CH_4 at 20 °C and 1 atmosphere pressure (0.67 kg/m^3).

Table 6.2. Average CH_4 emission factors in coal mining and handling in the 2006 IPCC Guidelines

	Underground mines		Surface mines	
	(m^3/t)	(kg/t)	(m^3/t)	(kg/t)
Mining activities	18	12.06	1.2	0.804
Post-mining activities	2.5	1.675	0.1	0.067

After your assessment, you noted that CH_4 IEFs reported by the Party coincide with the average values of the IPCC CH_4 EFs, except for the EF from mining activities in surface mines. For this case, the Party has selected a value of 1.5 m^3/t (=1.005 kg/t/0.67 kg/m^3), which corresponds to that suggested by the *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*.
You consider that this approach of using three EFs from the 2006 IPCC Guidelines and one from the IPCC Good Practice Guidance is inconsistent. Furthermore, the Party reported in its NID the use of tier 1

CH_4 EFs from the 2006 IPCC Guidelines, and did not clarify or justify the use of an alternative value for a particular source taken from the IPCC Good Practice Guidance.
Then you draft a preliminary question to be sent to the Party before the review week. Compare it with the suggested under **Answer key**.

1.2. Estimation methods used for CH_4 emissions

In the answer to your question, Party A explains that the CH_4 EF of 1.005 kg/t used for mining activities in surface mines is a mistake remnant of previous submissions for which the Revised 1996 IPCC guidelines and the IPCC good practice guidance were used. The Party further indicates that this EF will be corrected in the next biennial transparency report (BTR) submission.
You consider that the answer by the Party is agreeable and look to another perhaps more relevant issue, which is whether the emission estimates by Party A are in accordance with the 2006 IPCC Guidelines and in line with the requirements of the MPGs. What do you think, are they in accordance or not?

1.3. Estimation method not in line with the 2006 IPCC Guidelines

Draft a preliminary question on the method used for the estimates to be sent to the Party before the review week.

4.2. Exercise 2. Emissions from flaring of coalbed methane

2.1. Emission allocation

Party C included emissions from flaring of coal bed methane with no energy recovery under subcategory 1.A.1.c manufacture of solid fuels and other energy industries.
Do you consider that the allocation of these emissions is in line with the MPGs and the 2006 IPCC Guidelines?
Hint: you may wish to consider the discussion on emissions from drained CH_4 in the 2006 IPCC Guidelines (vol.2, chap. 4, p.4.13).
A. Yes
B. No

2.2. Drafting a recommendation in the technical expert review report

Based on the issue identified, write the corresponding paragraph in the TERR using the template available at https://unfccc.int/resource/tet/be/be6-03_en_terr_template.docx.

4.3. Exercise 3. Oil and natural gas – use notation key "NE"

Party D (a developed country) reports the use of notation keys "NE" for CO_2, CH_4 and N_2O emissions from several subcategories in CRT 1.B.2. Use the extract of CRT 9, available in the Supplementary Materials at https://unfccc.int/resource/tet/be/be6-04_en6_exrcs_3.xlsx which contains only the reporting of the specific subcategories to be taken into account for this exercise.

3.1 1.B.2.a.v distribution of oil products – CO_2 and CH_4

What is your assessment of the reporting in CRT 9 on the use of notation key "NE" for CO_2 and CH_4 emissions from distribution of oil products?

3.2 1.B.2.a.iii oil – transport – CO_2

What is your assessment of the reporting in CRT 9 on the use of notation key "NE" for CO_2 emissions from oil transport? Note that Party D used a tier 1 method to estimate CH_4 emissions from oil transport.

3.3 1.B.2.c N_2O emissions from flaring

What is your assessment of the use of notation key "NE" for N_2O emissions from flaring? Note that the NID indicates that although N_2O emissions from flaring are currently not included, the Party is considering developing a country-specific methodology to estimate these emissions using available data sources for CH_4 and CO_2 emission estimates.

3.4 Drafting a recommendation in the technical expert review report

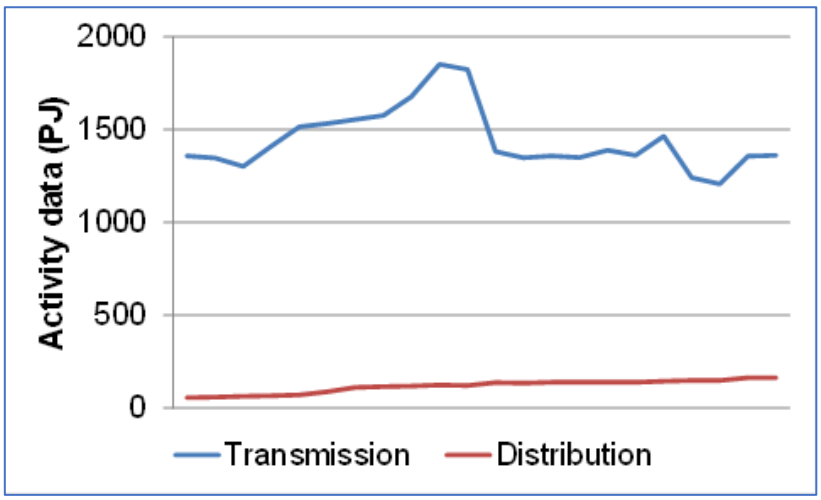
Considering your assessment for questions 3.1 to 3.3 above, draft a paragraph in the TERR indicating your findings regarding the reporting by the Party that is not in line with the 2006 IPCC Guidelines and/or the MPGs.

4.4. Exercise 4. Emissions from transmission and storage, and distribution

4.1. Significantly different amounts of natural gas being transmitted and distributed

CH_4 emissions from 1.B.2.b natural gas in Party B have been identified as a key category. During the review you note that Party B has reported AD for 1.B.2.b.iv transmission and storage of natural gas that are an order of magnitude higher than the figures provided for 1.B.2.b.v distribution (see figure 6.6).

Z. Figure 6.6. Transmission and distribution of natural gas in Party B



As there is no related information in the NID regarding this difference, draft a preliminary question on this finding.

4.2. Consumed versus in-transit natural gas

Party B indicated that the transmission system in the country not only supplies domestic consumption but is also used as a transit system to transmit natural gas to neighbouring countries. Hence, the amount of natural gas distributed is much lower than that transmitted, and although the country is not a significant natural gas producer, fugitive CH_4 emissions from transmission make 1.B.2.b natural gas a key category. Party B further indicated that it developed a tier 2 method to estimate fugitive emissions from natural gas (production/gathering, processing, transmission/storage, distribution and other leakage). Namely, the Party invested in developing country-specific EFs based on laboratory studies of the imported natural gas.
Draft a paragraph for the TERR, addressing the transparency issue and acknowledging the effort made by Party B to develop a tier 2 method. Use the template available at https://unfccc.int/resource/tet/be/be6-05_en_terr_template.docx.

4.5. Answer key

1. Exercise 1

1.1 CH_4 emission factors

The NID indicates that all CH_4 EFs used by the Party to estimate emissions from coal mining and handling from underground and surface mines were selected from the 2006 IPCC Guidelines. The TERT noted, however, that the CH_4 EF (1,005 kg/t) reported for mining activities in surface mines corresponds to that provided in the *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*. The TERT would appreciate it if the Party clarified why an EF value from the IPCC Good Practice Guidance was used in the calculations.

1.2. Estimation methods used for CH_4 emissions

The CH_4 emission estimates reported by the Party are not in line with the 2006 IPCC Guidelines and consequently with the MPGs. Decision trees for underground coal mines and surface coal mining

indicate the use of higher-tier methods (at least tier 2) to estimate these emissions for a key category (see figure 4.1.1, p.4.11, and figure 4.1.2, p.4.18, in vol. 2, chap. 4 of the 2006 IPCC Guidelines).

1.3. Estimation method not in line with the 2006 IPCC Guidelines

The TERT noted that Party A used a tier 1 method with default EFs to estimate CH_4 emissions from coal mining and handling, which has been identified as a key category. The TERT further noted that (i) this choice of method is not in accordance with the decision trees in the 2006 IPCC Guidelines (vol. 2, chap. 4, figure 4.1.1, p.4.11, and figure 4.1.2, p.4.18) and (ii) the NID does not indicate any specific improvement planned for this category. The TERT would appreciate it if Party A explained the difficulties encountered not allowing the use of higher-tier methods to estimate these emissions. The TERT would also appreciate it if Party A indicated its plans to implement a higher-tier approach to estimate these emissions.

2. Exercise 2

2.1. Emission allocation

The correct answer is B. The 2006 IPCC Guidelines indicate that when recovered CH_4 is simply combusted with no useful energy, as in flaring or catalytic oxidation to CO_2, the corresponding CO_2 emissions should be reported under GHG emissions from coal mining and handling activities. However, CRT 1.B.1 and therefore the MPGs include the reporting of these emissions under subcategory 1.B.1.a.i.4 flaring of drained methane or conversion of methane to CO_2.

2.2. Drafting a recommendation in the technical expert review report

Finding classification	*Description of the finding with recommendation*	*Classify by type*
1.B.1.a.i.4 flaring of drained methane or conversion of methane to CO_2 – solid fuels CO_2, CH_4	The Party has included flaring of coal bed methane with no energy recovery in subcategory 1.A.1.c (manufacture of solid fuels and other energy industries). However, according to the 2006 IPCC Guidelines (vol. 2, p.4.13), when recovered CH_4 is simply combusted with no useful energy, as in flaring or catalytic oxidation to CO_2, the corresponding CO_2 emissions should be reported under the GHG emissions from coal mining and handling activities. However, CRT 1.B.1 and therefore the MPGs include the reporting of these emissions under subcategory 1.B.1.a.i.4 flaring of drained methane or conversion of methane to CO_2. The TERT recommends that the Party allocate the CO_2 emissions from flaring of coal bed methane under subcategory 1.B.1.a.i.4 flaring of drained methane or conversion of methane to CO_2 in CRT 1.B.1, consistent with the MPGs.	Comparability

3. Exercise 3

3.1 1.B.2.a.v distribution of oil products – CO_2 and CH_4

The 2006 IPCC Guidelines do not contain EFs for this subcategory. In fact, CO_2, CH_4 and N_2O EFs are reported as "NA" in table 4.2.4 (vol. 2, chap. 4, pp. 48-54). Therefore, these emissions are not considered as mandatory for reporting under the MPGs and the use of notation key "NE" does not deserve further consideration for review purposes.

3.2 1.B.2.a.iii oil-transport – CO_2

The 2006 IPCC Guidelines contain CO_2 EFs to estimate emissions from oil transport by (i) pipeline and (ii) tanker trucks and rail cars in table 4.2.4, with m^3 of oil transported as the corresponding AD for these EFs. Considering that there are default CO_2 EFs available and that the Party has already estimated CH_4 emissions from oil transport, the associated CO_2 emissions should have been estimated using the corresponding EFs.

Regarding the indication by the Party in CRT 9 that it considers that CO_2 emissions from oil transport are negligible, this does not mean that the CO_2 emission estimates can be considered insignificant in terms of paragraph 32 of the MPGs because this criterion applies to the entire subcategory but not to individual GHGs. Since CH_4 emissions from oil transport have been estimated, the considerations in paragraph 32 do not apply for this case.

3.3 1.B.2.c N_2O emissions from flaring

The TERT welcomes the indication by the Party about the development of a methodology to estimate N_2O emissions from flaring using data sources used to estimate the corresponding CO_2 and CH_4 emissions. However, since table 4.2.4 of the 2006 IPCC Guidelines contain default N_2O EFs to estimate emissions from flaring for several activities of the oil and gas industry, the Party should use a tier 1 approach to estimate the corresponding N_2O emissions while a country-specific approach is developed.

3.4 Drafting a recommendation in a technical expert review report

Finding classification	*Description of the finding with recommendation*	*Classify by type*
1.B.2.a.iii oil transport – liquid fuels CO_2	Party D has used notation key "NE" to report CO_2 emissions from oil transport while it has estimated the corresponding CH_4 emissions using the IPCC tier 1 method and reported them in CRT 1.B.2. The TERT notes that the 2006 IPCC Guidelines contain CO_2 EFs to estimate emissions from oil transport by (i) pipeline and (ii) tanker trucks and rail cars in tables 4.2.4 and 4.2.5, with m^3 of oil transported as the corresponding AD for these EFs. The TERT also notes that in CRT 9 Party D indicated that it considers that CO_2 emissions from oil transport are negligible. However, the TERT is of the view that the relatively small level of CO_2 emissions does not imply that the CO_2 emission estimates can be considered insignificant in terms of paragraph 32 of the MPGs because this criterion applies to the entire subcategory but not to individual GHGs. Since CH_4 emissions from oil transport have been estimated, the considerations in paragraph 32 do not apply for this case. Considering that there are default CO_2 EFs available and that the Party has already estimated CH_4 emissions from oil transport using the IPCC tier 1 method, the TERT recommends that Party D estimate CO_2 emissions from oil transport using the same method that it has used to estimate the associated CH_4 emissions and report them in CRT 1.B.2.	Completeness
1.B.2.c.ii flaring – liquid fuels, gaseous fuels N_2O	Party D has used notation key "NE" to report N_2O emissions from flaring for all subcategories, oil (1.B.2.c.ii.1), gas (1.B.2.c.ii.2) and combined (1.B.2.c.ii.3), while it has estimated and reported the corresponding CO_2 and CH_4 emissions. The TERT notes that volume 2 of the 2006 IPCC Guidelines includes in chapter 4 an estimation methodology and default N_2O EFs for flaring emissions from upstream oil and gas sources. During the review, the Party indicated its plans to develop a country-specific method to estimate N_2O emissions from flaring. The TERT recommends that, to improve the completeness of its inventory, the Party estimate and report N_2O emissions from all flaring sources in the upstream oil and gas industry in CRT 1.B.2 for the entire time series. If the Party is not able to implement the country-specific method, the TERT recommends that Party D estimate N_2O emissions using the IPCC tier 1 method. If the country-specific method is used, the TERT further recommends that the Party explain the estimation method, AD and EFs in the NID.	Completeness

4. Exercise 4

4.1. Significantly different amounts of natural gas being transmitted and distributed

The TERT noted that the AD reported to estimate the emissions from subcategory 1.B.2.b.iv transmission and storage of natural gas are an order of magnitude higher than those used to estimate the emissions from subcategory 1.B.2.b.v distribution. The TERT would appreciate it if Party B provided explanations for this significant difference and details of the estimation method.

4.2. Consumed versus in-transit natural gas

Finding classification	*Description of the finding with recommendation*	*Classify by type*
1.B.2.b natural gas – gaseous fuels CH_4	In CRT 1.B.2 Party B reported AD for transmission of natural gas that is an order of magnitude higher than the figures provided for distribution. The TERT notes that the NID does not include information indicating that the amount of natural gas distributed is much lower than that transmitted. In response to a question raised by the TERT during the review, Party B explained that most of the high-pressure gas pipelines are transit pipelines and informed the TERT that a tier 3 method has been developed to estimate fugitive emissions from natural gas (production/processing, transmission, distribution and other leakage), which includes country-specific EFs based on laboratory studies of the imported natural gas. The TERT notes that the NID does not include information on the tier 3 estimation method developed by the Party. The TERT recommends that to enhance the transparency of its reporting, the Party include in future NIDs information on the difference between the amount of distributed natural gas and of that transmitted and details of the tier 3 method developed to estimate these emissions. The TERT commends Party B for its development of a higher-tier method, which enhances accuracy.	Transparency

5. Self-check quiz

This quiz is offered so that you can test your skills as a reviewer of fugitive emissions from fuels. It has six questions on the two main categories 1.B.1 and 1.B.2 of the CRT.

1. Coal mining ceased in Party B in 1999 and CH_4 emissions from mining and post-mining activities from underground mines have been estimated for 1990–1999 applying a tier 1 method using saleable coal data from the energy balance as AD. For the rest of the reporting period, emissions are reported as "NO". Emissions from abandoned underground mines are reported as "NO" for the entire time series and the NID does not contain information about this reporting. Do you consider that:

   A. The Party's emission estimates from mining and post-mining are not in line with the 2006 IPCC Guidelines
   B. The Party's emission estimates from mining and post-mining are in line with the 2006 IPCC Guidelines
   C. Reporting emissions from abandoned underground mines as "NO" may imply an underestimation of emissions
   D. A and C

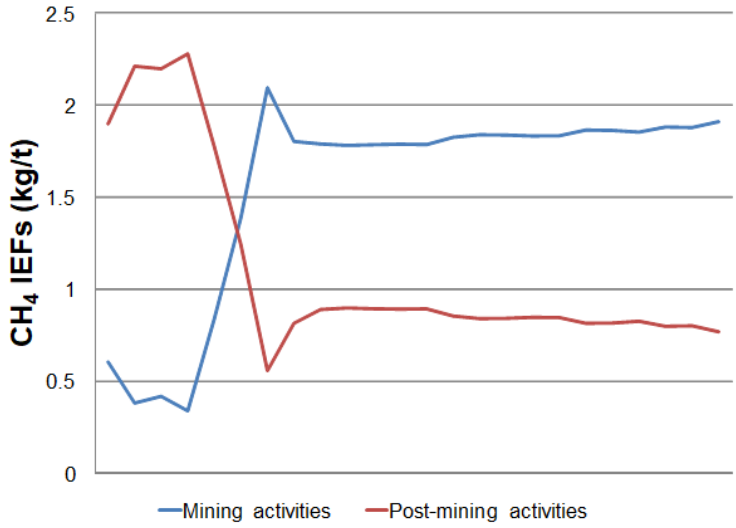
2. Coal mining activities in Party B refer primarily to underground mining, with a small share referred to surface mines. The Party reported CH_4 recovered or flared as "NO" in CRT 1.B.1 for all activities under coal mining and handling. However, the Party reported in its NID that most abandoned coal mines in the country have gas recovery systems and that the recovered gas is used at the place of mining in autonomous cogeneration units. In its coverage of stationary combustion, the NID indicates that subcategory 1.A.1.c manufacture of solid fuels and other energy industries contains fuel combustion in all mining facilities, including that for the production of electricity and heat for own use, but does not explicitly address in this section the use of recovered CH_4 from coal mining and handling for energy purposes.
From the above description, you may identify several inconsistencies with the MPGs. Some possible options are listed below. Select the one that best applies to the findings identified.

   A. Completeness: emissions from abandoned coal mines have not been estimated and reported

B. Completeness: amount of CH_4 recovered from coal mining has not been estimated and reported
C. Transparency: no clear indication in the NID of whether the combustion for energy use of recovered CH_4 was estimated and reported under the corresponding stationary combustion categories
D. Transparency: lack of clear information on the occurrence (or not) of flaring of CH_4 in mining and handling activities
E. All the above

3. Consider the time series of CH_4 IEFs from underground mines reported by Party D, depicted in figure 6.7.

AA. Figure 6.7. CH_4 implied emission factors from mining and post-mining in Party D



In preparing your questions to the Party before the review week, you note that:
A. CH_4 IEFs are time-series consistent
B. There is a time-series consistency issue regarding the reported CH_4 IEFs
C. In the early years, the values of IEFs from mining relative to those from post-mining are not as expected (IEFs for mining < IEFs for post-mining)
D. The values of CH_4 IEFs for mining activities are consistent with IPCC default EF values
E. B and C

4. In its inventory submissions of 2020, Party A does not present in its NID the CO_2 and CH_4 EFs used in estimating emissions from 1.B.2.a oil and 1.B.2.c.ii flaring but it indicates that these EFs are based on data from the industry along with expert estimates. In response to your question raised during the review, Party A provided the EFs used in the calculations and the corresponding references. You note that the references are from 1999 and 2000.
Your finding primarily concerns accuracy, but also refers to transparency.
True
False

5. Party A has used the notation key “NO” to report emissions from 1.B.2.a.i exploration (oil) and 1.B.2.b.i exploration (natural gas), although oil and gas production processes do occur in the country. During the review, in response to a question raised by the TERT, the Party explained that there are only very small amounts of production of natural gas and oil. In your assessment you would consider that:

A. The Party may report these emissions as “NE”

B. The Party may continue to use “NO” to report these emissions

6. The NID indicates that CO_2 emissions that have been vented from hydrogen production facilities at the Party’s oil refineries have been estimated and reported under the stationary combustion subcategory 1.A.1.b petroleum refining. You consider that this reporting is:

A. In line with the 2006 IPCC Guidelines

B. Not in line with the 2006 IPCC Guidelines

5.1. Answer key

1. **The correct answer is D**. CH_4 emission estimates from underground mines are not in accordance with the 2006 IPCC Guidelines, which indicate the use of raw coal production (not saleable coal) as AD for tier 1 and 2 estimates. The Party does not indicate why it considers that activity in abandoned underground mines does not result in fugitive emissions. The Party must provide background information indicating why this activity occurring in the country does not originate any CH_4 emissions and consequently report them as "NA" or estimate and report these emissions.

2. **The correct answer is E**. All listed findings are comprised in the above description of issues regarding CH_4 emissions (and recovery) from coal mining and handling.

3. **The correct answer is E**. The time series of CH_4 IEFs exhibit unusual behaviour for both mining and post-mining activities. Changes in IEFs that reflect changes in operating and emissive conditions may be expected but the depicted behaviour of the CH_4 IEFs is not common and requires explanation. The range of tier 1 IPCC default CH_4 EFs are summarized in the table below (EFs expressed in m^3/t in the 2006 IPCC Guidelines have been converted into kg/t using the default density value of 0.67 kg/m^3).

Underground	Mining		Post-mining	
Level	m^3/t	kg/t	m^3/t	kg/t
Low	10	6.7	0.9	0.6
Average	18	12.1	2.5	1.7
High	25	16.8	4.0	2.7

Within the above framework, all the CH_4 IEF values for mining activities, except one, are below 2 kg/t and noticeably lower than the IPCC default EFs range. In principle there is nothing wrong with country- or mine-specific EFs being lower than the IPCC default values, but it is always good practice that the Party transparently report and document how these EFs have been derived. The CH_4 IEF values for post-mining activities are within the range of the IPCC default EFs; however, the relative order of the earlier years (CH_4 IEFs for post-mining > CH_4 IEFs for mining) and significant fluctuations are far from what is expected.
Some possible situations to explore here are that the Party: (i) has made a mistake in the sectoral background table (e.g. wrong AD reported), (ii) is underestimating emissions from mining activities and (iii) has determined and used country-specific EFs (which may be inconsistent or mistakenly calculated) and not reported related transparent background information in the NID.

4. **The correct answer is ´True´**. The EFs determined more than 20 years ago may no longer be representative of current conditions in the country since it is likely, for instance, that technologies and practices may have changed, facility components renovated and plants revamped. In addition, when nationally appropriate methodologies are used, the Party must transparently explain the national methods, data and/or parameters selected in accordance with paragraph 22 of the MPGs.

5. **The correct answer is A**. Notation key "NO" can only be used for those years when exploration did not occur. However, if the activity occurs, the Party can report these emissions as "NE" since the 2006 IPPC Guidelines do not provide a specific methodology to estimate emissions for overall activities of exploration which corresponds to subcategories 1.B.2.a.i and 1.B.2.b.i. The Party, however, may wish to estimate flaring and venting emissions from well drilling, drill stem testing and well completions (activities that are assumed to be part of exploration), for which EFs are given in tables 4.2.4 and 4.2.5 of the 2006 IPCC Guidelines. In this case, emissions are to be reported under subcategories 1.B.2.c.ii.1

flaring–oil or 1.B.2.c.ii.2 flaring–gas in accordance with the 2006 IPCC Guidelines, using notation key "IE" for subcategories 1.B.2.a.i and 1.B.2.b.i with the corresponding explanation in CRT 9 and the NID.

6. **The correct answer is B**. Fugitive CO_2 emissions from hydrogen production are typically vented unless they are recovered or stored, so these emissions should be allocated to the corresponding fugitive emissions subcategory. GHG emissions from fuel combustion to supply the heat required for the hydrogen production process at the refinery are reported under subcategory 1.A.1.b petroleum refining. The 2006 IPCC Guidelines indicate that the CO_2 resulting from the production of hydrogen at refineries and heavy oil/bitumen upgraders should be reported under oil – venting. Care should be taken with respect to the reporting in the CRT, because this is one of the cases where the categories in the 2006 IPCC Guidelines and the MPGs as implemented in CRT do not coincide. Subcategory 1.B.2.a.i oil–venting in the 2006 IPCC Guidelines corresponds to subcategory 1.B.2.c.i.1 venting–oil in the CRT. Note that where there is such an inconsistent guidance between the 2006 IPCC Guidelines and the CRTs, the guidance in the MPGs as implemented in the CRTs is to be followed.

6. Key points to remember

The main topics to review the fugitive emissions from fuels category were covered in this lesson:

- Fugitives cover all intentional or unintentional release of GHGs that occurs in energy industries;
- They include non-combustion emissions such as leaks, vents, ventilation systems, accidental releases and venting, while flaring is the only combustion activity considered under this category;
- Two large subcategories are included under fugitive emissions from fuels:
  - Solid fuels;
  - Oil and natural gas and other emissions from energy production;
- Coal mining and handling, comprising underground mines (active and abandoned) and surface mines, constitute the main activity under solid fuels and source of fugitive emissions;
- Emissions from the oil and natural gas activities are addressed in their entirety, but in a rather simplified manner by aggregating in major steps the diversity and complexity of the industry;
- CH_4 is the main GHG emitted under this category, followed by CO_2. N_2O emissions are usually only expected from flaring activities;
- Main linkages of the recovery of CH_4 and CO_2 and the purpose of the recovery of these gases occur with other energy categories (stationary combustion and/or CO_2 transport, injection and storage);
- The review of this category requires considering emission sources in all major steps from exploration to commercialization of the fuels;
- The 2006 IPCC Guidelines do not contain methods/EFs for some subcategories included in the CRT (e.g. 1.B.1.b.i, 1.B.1.b.ii, 1.B.1.b.iii, 1.B.1.b.iv, 1.B.1.c, 1.B.2.a.vi.1, 1.B.2.b.vi.1, 1.B.2.b.vi.2 and 1.B.2.d). In these cases, reporting of these emissions is not mandatory.

Annex 6.1. CO_2-rich streams

Streams containing pure or high concentrations of CO_2 may occur in the oil and natural gas industry as by-products of (i) gas treating facilities that remove CO_2 to meet sales of fuel gas specifications and/or (ii) hydrogen production at refineries and heavy oil upgraders.

The 2006 IPCC Guidelines include tier 1 EFs to estimate CO_2 emissions from gas processing plants in tables 4.2.4 and 4.2.5 (vol. 2, chap. 4, pp.4.48-4.63) and indicate that these emissions are to be reported under subcategory 1.B.2.b.i natural gas – venting, equivalent to subcategory 1.B.2.c.i.2 in the CRT.

The 2006 IPCC Guidelines do not provide a specific method to estimate fugitive CO_2 emissions from hydrogen production at refineries and heavy oil upgraders. Parties may use country-specific or plant-specific methods to estimate them. In that case, the 2006 IPCC Guidelines indicate that these fugitive emissions should be reported under subcategory 1.B.2.a.i oil – venting, equivalent to subcategory 1.B.2.c.i.1 in the CRT. Note that hydrogen is also produced at the chemical industry, frequently as part of synthesis gas (the mixture of carbon monoxide and hydrogen), which is an intermediate in the production of chemicals such as ammonia, formaldehyde, methanol and pure hydrogen. CO_2 emissions from these industrial processes should be reported in the IPPU sector under category 2.B.10.

Instead of venting these CO_2-rich streams at gas processing plants or coming from hydrogen production, the oil and gas industry may use them for EOR, EGR or ECBM or send them to a geological storage site. Fugitive emissions associated with EOR and EGR operations or acid gas disposal must be reported as fugitive emissions under oil and natural gas production, in the respective subcategories. Regarding ECBM, since the purpose is to produce coal bed methane, which is treated as natural gas, if the necessary data exist, these fugitive emissions must be reported under natural gas production. All this can be confirmed in the definitions included in table 4.2.2 of the 2006 IPCC Guidelines (vol. 2, chap. 4, p.4.42). Note that tier 1 emission estimates do not distinguish fugitive emissions from EOR, EGR or ECBM. For tier 1 and tier 2 estimates, fugitive emissions from CO_2 capture and injection from EOR, EGR and ECBM or sour gas disposal and fugitive emissions from conventional oil and gas production activities are practically indistinguishable. For this reason, the development/calculation of EFs for tier 1 oil and gas activities includes the contribution of CO_2 emissions from capture and injection.

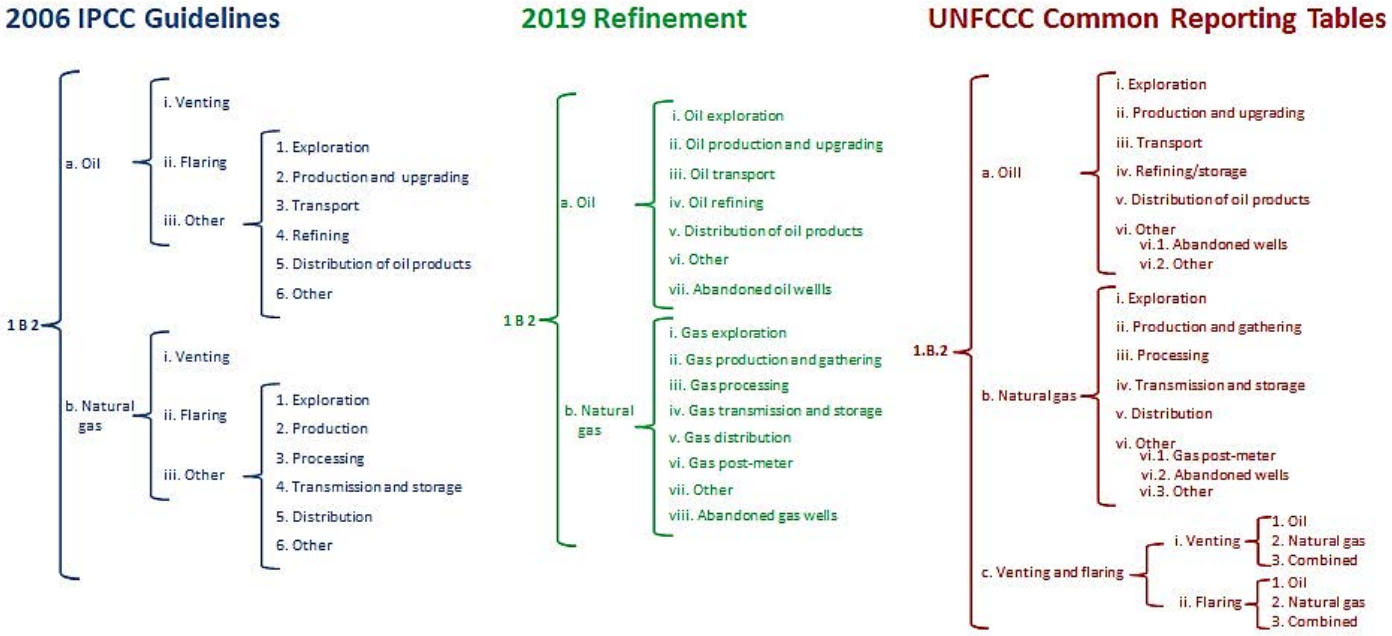
When EOR, EGR or ECBM is done in tandem with CCS, the general guidance is to separate the emissions resulting from CO_2 injection for the disposal of acid gas and improvement of production from the CCS portion of the project. Only for tier 3 estimates these CO_2 emission activities could be somehow separated.

For CO_2 capture and storage projects, emissions from capture should be accounted for in the industry where capture occurs, while emissions from transport, injection and storage activities are estimated using the methods in chapter 5 of the 2006 IPCC Guidelines and reported under category 1.C.

In all cases, check if the reporting of the amounts of CO_2 captured, injected and emitted is transparent and in line with the MPGs.

Annex 6.2. Review of estimates for subcategories 1.B.2.a, 1.B.2.b and 1.B.2.c based on the *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*

The structuring in the 2019 Refinement to the 2006 IPCC Guidelines is based on the major types of activities in the oil and gas industry without explicitly mentioning venting and flaring. A graphical representation of the different structuring in the 2006 IPCC Guidelines, the 2019 Refinement to the 2006 IPCC Guidelines and the CRT is shown is shown below.



The organization of the subcategories is summarized in table 4.2.2 of the 2019 Refinement to the 2006 IPCC Guidelines (vol. 2, chap. 4, pp.4.40–4.41). Although venting and flaring have not been explicitly included in this organization, guidance in estimating the emissions from these two distinct activities is provided.

For the tier 1 method, the 2019 Refinement to the 2006 IPCC Guidelines include default EFs that are aggregates of venting, flaring and leak emissions. These are reported in a set of tables (4.2.4 to 4.2.4k) in section 4.2.2.3 (pp. 4.47–4.83).

Note that to develop separate estimates for venting, flaring and leak emissions from the aggregated emissions estimated using the default tier 1 EFs in section 4.2.2.3, annex 4A.2 to the 2019 Refinement to the 2006 IPCC Guidelines (p.4.128) provides default fractions of emissions in each subcategory. In your review, check that the Party has transparently explained the selection of methods and EFs provided in the 2019 Refinement to the 2006 IPCC Guidelines and reported emissions in line with the MPGs, differentiating leak emissions under the corresponding subcategories 1.B.2.a or 1.B.2.b and venting and/or flaring under the corresponding subcategories 1.B.2.c.i and/or 1.B.2.c.ii.

Lesson 7. CO_2 transport and storage

1. Introduction

CCS systems consist of four major consecutive steps:
1. Capture and compression of CO_2;
2. Transport to a storage location;
3. Injection;
4. Disposal in a geological storage site for long-term isolation from the atmosphere.

In this lesson we address the review of emission estimates from category 1.C CO_2 transport and storage.

This category comprises emissions from steps 2 to 4. CO_2 removals occurring in step 1 are estimated and reported in the combustion- and/or IPPU-relevant categories where CO_2 is captured.

1.1. Learning objectives

At the end of this lesson you should be able to:

- Understand the key tasks to be undertaken to review a Party's reporting of emissions from CO_2 transport and storage;
- Identify whether a Party's reporting of emission estimates for CO_2 transport and storage is consistent with the requirements in the MPGs;
- Be able to draft key recommendations to Parties for estimates for this category.

1.2. Expected time needed to complete lesson 7

- For readers with experience in compilation of energy sector GHG inventories: 35–50 minutes
- For readers with less experience in compilation of energy sector GHG inventories: 70–90 minutes

2. Category overview and methodological information

2.1. Categories within CO_2 transport and storage

Category 1.C CO_2 transport and storage is subdivided in CRTs in three categories:

- Category 1.C.1 transport of CO_2;
- Category 1.C.2 injection and storage;
- Category 1.C.3 other.

To learn more about CO_2 transport and storage categories, see the complete list and definitions in the 2006 IPCC Guidelines (vol. 2, chap. 5, table 5.1, p.5.7).

2.2. Estimation methods

Since there are still very few ongoing CCS projects worldwide experience in developing tier 1 or tier 2 methods is limited. Therefore, only tier 3 methods based on measurements and modelling have been proposed in the 2006 IPCC Guidelines, with the single exception of a tier 1 method to estimate CO_2 emissions from pipeline transport.

When CO_2 geological storage takes place in association with enhanced hydrocarbon recovery, the above-ground operations done solely for the purpose of the latter activity, such as processing CO_2 and recycling, should be clearly differentiated and the associated emissions reported under fugitive emissions from oil and natural gas.

Categories	Methods
1.C.1 transport of CO_2	
a. Pipelines	T1, T3
b. Ships	T3
c. Other	–
1.C.2 injection and storage	
a. Injection	T3
b. Storage	T3
1.C.3 other	–

2.3. Main features by category

1.C.1 Transport of CO_2

Leakage and accidental releases are the main fugitive emissions associated with CO_2 transport. These fugitive CO_2 emissions are estimated and reported according to the transport mode under the following subcategories:

- Subcategory 1.C.1.a pipelines;
- Subcategory 1.C.1.b ships;
- Subcategory 1.C.1.c other (CO_2 emissions from temporary/intermediate storage facilities).

Note that in addition to fugitive CO_2 emissions, pipeline transport generates additional GHG emissions if combustion engines are used to supply the energy needed for initial pumping and intermediate boosters. These emissions from combustion should be reported under subcategory 1.A.3.e.i pipeline transport.

When CO_2 is temporarily stored, if the intermediate storage is a tank, fugitive emissions should be measured and treated as part of the transport system and reported under subcategory 1.C.1.c other; if the intermediate storage is a geological storage reservoir, asociated fugitive emissions can be treated in the same way as for any other geological storage reservoir and reported under category 1.C.3 other.

1.C.2.a injection

CO_2 transmitted via pipeline, ship or other means is transferred to geological storage via one or more injection wells. The amount of CO_2 injected is key AD, which is estimated using metering techniques and reported under this subcategory.

1.C.2.b storage

Storage sites are expected to confine all injected CO_2 for geological time scales. Nevertheless, experience with engineered systems suggests a small fraction of operational storage sites may release CO_2 to the atmosphere. These fugitive emissions are reported under this subcategory.

Note that, according to the MPGs (as defined by the agreed reporting in CRTs), fugitive emissions during above-ground operations such as processing and CO_2 recycling during enhanced oil and gas recovery operations should be reported as fugitive emissions from oil and natural gas, under the appropriate categories.
Note also that the 2006 IPCC Guidelines (vol. 2, chap. 4, section 4.2.2.2, p. 4.46) indicate that "oil and gas projects that involve CO_2 injection as a means of enhancing production (e.g. EOR, EGR and ECBM projects) or as a disposal option (e.g. acid gas injection at sour gas processing plants) should distinguish between the CO_2 capture, transport, injection and sequestering part of the project, and the oil and gas production portion of the project. The net amount of CO_2 sequestered and the fugitive emissions from the CO_2 systems should be determined based on the criteria specified in Chapter 5 for CO_2 capture and storage." Remember that losses from CO_2 transport, injection and storage activities are assessed separately in chapter 5 of volume 2 of the 2006 IPCC Guidelines.
As indicated before, remember that where there is inconsistent guidance between the 2006 IPCC Guidelines and the MPGs (including CRTs), the guidance in the MPGs is the one to be followed.
As a reviewer, you must check that there is not a completeness issue in the reporting, i.e. where leakage from the formation reported under 1.C.2.b is ignored for CO_2 that has been injected as a means of enhancing production.

3. Review approach

3.1. Main review topics across categories

The first fact for you to check is whether there are any CCS projects in the country. The Global CCS Institute database provides updated information on the status of CCS projects worldwide (see <https://co2re.co/>). This database contains data not only on CCS but also on enhanced hydrocarbon recovery. Note that only CO_2 injected into underground reservoirs for geological storage is considered in this category. Emissions from CO_2 injection activities done for the sole purpose of enhanced oil and gas recovery are reported under fugitive emissions from oil and natural gas.
Check if the following information has been provided in the NID:

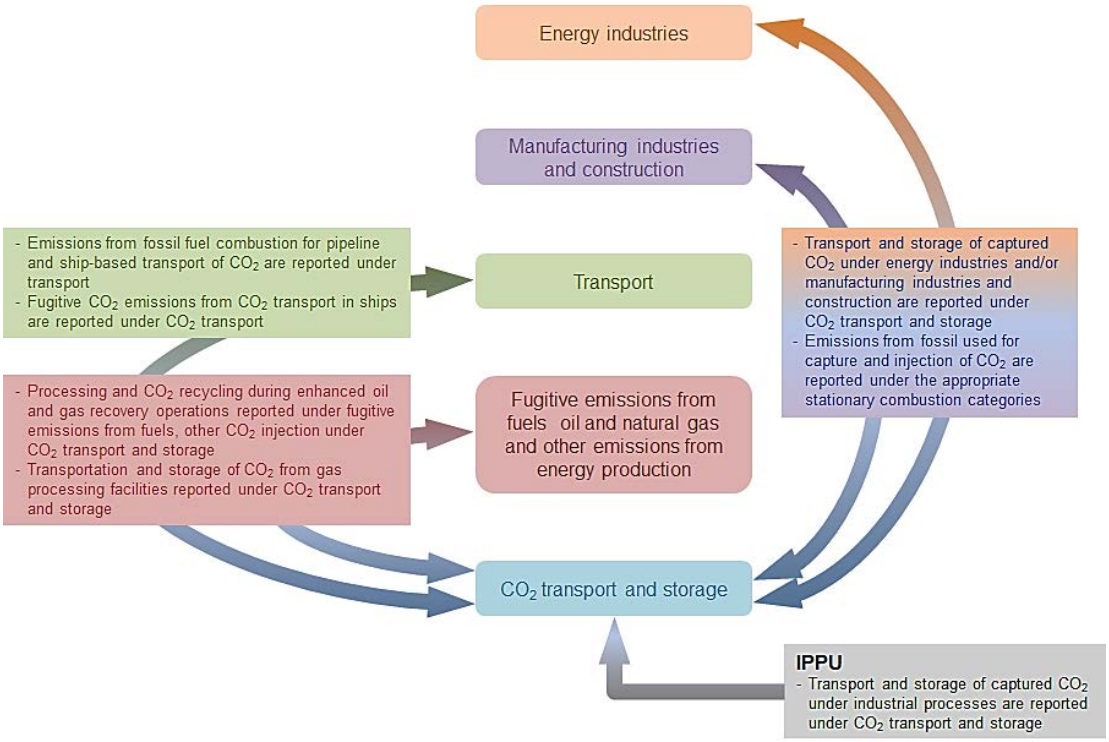
- Collection and sources of data for each component of the CCS system;
- Collection of data by the operator of each storage site and the transfer of this information to the inventory compiler.

Identify whether a formal agreement for data transfer is in effect (e.g. from the operator of the storage site to the inventory compiler).

Identify any possible gap in reporting and confirm that all assumptions used to bridge data gaps are clearly stated.

The main connections between CO_2 transport and storage and other energy categories occur through: (i) capture of CO_2 under stationary combustion and/or oil and gas activities; (ii) CO_2 transport; and (iii) combined CCS with EOR, EGR or ECBM. CO_2 capture from industrial processes links this category with the IPPU sector (figure 7.1).

BB. Figure 7.1. Main connections of CO_2 transport and storage with other inventory categories and subcategories



The main review topics of CO_2 transport and storage are presented below.

3.2. Category-specific considerations

1.C CO_2 transport and storage – general considerations

Check that all projects and applicable activities have been addressed in the estimates

- If any activity or segment of the CCS chain has been reported as "NO", verify that this reporting is consistent with the available information of the specific facility (e.g. if CO_2 is captured in a facility located close enough the storage site, the transport link may not be necessary);
- Check whether emissions from CO_2 transport and storage include both fossil and biogenic CO_2. There is no difference in the treatment of biogenic carbon and fossil carbon once captured;

- Check whether the Party excluded from the AD the recycled CO_2 for enhanced recovery in oil and gas fields;
- If CCS operations are undertaken in territories of different countries, verify that there is no double counting of storage between the two national inventories and that the associated emissions are allocated accordingly. In addition:
  - Check whether the Party considered the transport and, if applicable, injection/storage of CO_2 not captured in the country, but imported;
  - If geological basins cross national boundaries, check how emissions have been allocated.

To learn more, see section 5.10 of the 2006 IPCC Guidelines (vol. 2, chap. 3, pp.5.20–5.21).

Verify that the information items in CRT 1.C have been estimated and reported

- Check whether the amount of CO_2 captured for storage plus CO_2 imported for storage ("Total A" in CRT 1.C) equals the amount of exports for storage plus CO_2 injected at storage sites plus CO_2 injected for operational usage plus total leakage from transport, injection and storage ("Total B" in CRT 1.C). If not, check the potential overestimates or underestimates for exports, imports and potential exclusion of EOR, EGR or ECBM operations associated with storage following the guidance in the 2006 IPCC Guidelines (vol. 2, chap. 5.9, pp.5.18–5.20).
- Check that explanations for any differences are provided in the NID and assess them.

1.C.1 transport of CO_2 – 1.C.1.a pipelines and 1.C.1.b ships

Data checks

Assess whether the reported data include sufficient information to assess the completeness and accuracy of the estimates, for example:

- Transport by pipeline: length;
- Transport by ship: losses estimated on the basis of metered amounts of CO_2 during loading and discharge.

1.C.2 injection and storage – 1.C:2.a injection and 1.C.2.b storage

Information on the geological storage operation

The 2006 IPCC Guidelines provide a list of the information that the inventory compiler should obtain and archive (vol. 2, chap. 5.10, p.5.20). In this respect, check the explanations given by the Party in the NID on (i) national methods, data and/or parameters selected (para. 22 of the MPGs) and (ii) the archiving of all relevant information (para 19(c) of the MPGs). Key information includes:

- The initial year of CO_2 injection and the annual amount and the cumulative mass of CO_2 injected;
- The associated capture, transport and injection components of the system.

Monitoring CO_2 emissions:

- Check whether a national regulatory framework exists for monitoring CO_2 emissions from geological storage systems, and whether the Party described how emissions have been

estimated and reported based on this system and how the approach is consistent with good practice in the 2006 IPCC Guidelines;

- Check whether the monitoring plan for each storage system is transparently described in the NID.

3.3. Key points to consider when reviewing cross-cutting issues

Recalculations and time-series consistency

As improvements in detection capabilities of monitoring equipment and new developments in modelling techniques are expected, recalculations may be necessary. Check if recalculations are documented properly in the NID.

Uncertainty assessment

Check whether the uncertainties of the different contributing components of the emission estimates (i.e. field measurements, monitoring techniques and reservoir simulations) have been estimated on the basis of the corresponding underlying variables (e.g. sampling density and frequency of field measurements, heterogeneity of the geological reservoir).

Remember that developing countries that need flexibility in the light of their capacities are encouraged, not required, to provide quantitative estimates of uncertainty. They are also encouraged to provide a qualitative assessment of uncertainty for key categories (para. 29 of the MPGs).

Quality assurance and quality control

- If the difference between the mass of CO_2 captured and the mass of CO_2 stored plus the fugitive emissions (leakage) reported for the inventory year in CRT 1.C is non-zero, verify if the Party provided an explanation in the NID and assess it.

Remember that developing countries that need flexibility in the light of their capacities are encouraged, not required, to implement and provide information on general inventory QC checks (para. 35 of the MPGs).

3.4. Walk-through examples

You will work in two examples covering the following topics:

1. CCS project in a single reporting Party;
2. Joint CCS project between two Parties.

The examples cover topics such as (1) use of notation keys; (2) reporting requirements; (3) allocation of fugitive CO_2 emissions and amounts of CO_2 captured; and (4) combined EOR and CCS.

1. Carbon dioxide capture and storage project taking place in one Party

1.1. Reporting of amount of CO_2 captured

The NID of Party A reports that it is carrying out a large-scale demonstration project on CCS. The project consists of capturing CO_2 from a coal-fired power plant with storage in a depleted gas field at an offshore location under the sea.
In which CRT sectoral background table should the amount of CO_2 captured from the coal-fired power plant be reported?

Answer

The CO_2 emissions are captured from the flue gases at a coal-fired power plant. The emissions from fuel combustion activities and the associated CO_2 captured amount are to be reported under subcategory 1.A.1.a.i electricity generation in CRT 1.A(a) (sectoral background data for fuel combustion activities – sectoral approach). Note that the total amount of CO_2 captured for storage must also be reported as part of the information item in CRT 1.C.

1.2. Transport of CO_2 captured

Emissions from pipeline transport of CO_2 from the coal-fired power plant to the undersea storage site are reported as "NO" under subcategory 1.C.1.a pipelines because the Party claims that emissions from this activity are negligible.

Review considerations

The coal-fired power plant is likely to be located on the land territory of the country, while the storage site is located offshore; therefore, it is likely that a pipeline is installed connecting the capture plant with the geological storage site. Therefore, the activity probably occurs. The Party should estimate and report the associated emissions. If the Party considers that these emissions are insignificant it may report them as "NE" and provide an explanation supporting its assertion that the likely level of emissions is below the thresholds indicated in paragraph 32 of the MPGs.

2. Joint carbon dioxide capture and storage project between two Parties

2.1. Asking questions for clarification

Consider a collaborative CCS project between Party A and Party B aimed at capturing CO_2 from an industrial source, transporting it by ship and injecting it into an oilfield under the sea for enhanced oil recovery and subsequent geological storage. This joint project may involve cross-border CCS operations. The information provided in the NID is limited and insufficient to assess the reporting by the Party.

Two basic questions that would help to clarify this issue are:

- In which country is CO_2 captured?
- In which country is the storage site?

These two "simple" questions are key for understanding the issues and the reporting of the emissions associated with the capture process and those from CO_2 transport and storage.

2.2. Reporting

If the amount of captured CO_2 is transported from Party A to the storage site in Party B, in your review you must consider the following points with regard to the allocation to the national inventory of each country of the emissions from CO_2 transport by ship:

- Fugitive emissions during CO_2 loading are metered, estimated and reported in the national inventory of Party A while those occurring during CO_2 discharge are allocated to the national inventory of Party B;
- The emissions from any intermediate storage facility (or buffer) located in each country are measured/monitored and the corresponding estimates are reported under category 1.C.1.c in the inventory of the Party in which the buffer is located;
- The 2006 IPCC Guidelines do not provide clear guidance on reporting fugitive CO_2 emissions during cross-border transport by ship. For cross-border CCS operations the 2006 IPCC Guidelines indicate only that each country should report any emissions from transport that take place in the country. While this guidance is clearly applicable to pipeline transport, it is not clear for ship transport. You should ask the Parties how the losses during transport by ship have been allocated to each country; use your expert judgment and the views of the TERT to assess this issue.

2.3. Double fate of captured CO_2

In this project, geological CO_2 storage takes place at a site for which CO_2 storage is done in tandem with EOR.

Review check regarding enhanced oil recovery

For national GHG inventories, CO_2 geological storage refers to long-term storage. When this storage takes place in association with EOR, the above-ground operations done for the sole purpose of this activity, such as processing CO_2 and recycling, should be clearly differentiated. You should check if the associated emissions were allocated to EOR activities and reported under fugitive emissions from oil and natural gas.

4. Exercises

Exercises are provided below for you to practise your skills as an expert reviewer of category 1.C CO_2 transport and storage.
You will work with exercises on the following topics:

- Exercise 1: Transport of CO_2;
- Exercise 2: QC for the entire CCS system.

4.1. Exercise 1: Transport of CO_2

1.1. Reporting of CO_2 emissions

Consider CRT 1.C submitted by Party A available in the Supplementary Materials at https://unfccc.int/resource/tet/be/be7-01_en7_excrs_1.xlsx.
Analyse the reporting of AD and emissions for the transport of CO_2 by pipeline (subcategory 1.C.1.a) and ask the Party a preliminary question referred to the unique feature of the vales reported.

1.2. Drafting a recommendation in the technical expert review report

In response to the question by the TERT, Party A stated that the uncertainties around measurements of CO_2 entering the pipeline and delivered to the injection site were too high to be used to determine if there were any leaks.
Based on your finding and the response by the Party, draft a recommendation for the TERR using the template available at https://unfccc.int/resource/tet/be/be7-02_en_terr_template.docx.

4.2. Exercise 2: Quality control for the entire carbon dioxide capture and storage system

Information item in CRT 1.C

The 2006 IPCC Guidelines indicate that it should be checked that the mass of CO_2 captured does not exceed the mass of CO_2 stored plus the reported fugitive emissions in the inventory year (vol. 2, chap. 5, pp.5.18–5.19). Reporting of this check is done under the information item in CRT 1.C. Consider the reporting of three Parties available in the Supplementary Materials at https://unfccc.int/resource/tet/be/be7-03_en7_excrs_2.xlsx.
Although the information item summarizes key information on the amounts of CO_2 involved in the CCS operations of each Party, for a conclusive assessment you would need to consult the NID and the tables of the energy sector and/or the IPPU sector where the information on CO_2 capture is provided. This is not done in this exercise, which simply aims at familiarizing you with the information item in CRT 1.C. Analyse similarities and differences in the reporting of the information item in CRT 1.C among the three reporting Parties.

4.3. Answer key

1. Exercise 1

1.1. Reporting of CO_2 emissions

Party A reported in CRT 1.C that 900.02 kt CO_2 were transported by pipeline; however, the TERT notes that the resulting CO_2 emissions from this activity were reported as “NO”. The TERT would appreciate it if Party A explained the reasons for such reporting.

1.2. Drafting a recommendation in the technical expert review report

Recommendation by the technical expert review team

Finding classification	*Description of the finding with recommendation*	*Classify by type*
1.C.1.a pipelines CO_2	The TERT noted that AD for the transport of CO_2 by pipeline are reported in CRT table 1.C (900.02 kt in the latest reported year) but emissions are reported as “NO”. During the review, Party A stated that the uncertainties around measurements of CO_2 entering the pipeline and delivered to the injection site were too high to be used to determine if there were any leaks. The TERT notes that the 2006 IPCC Guidelines (vol. 2, chap. 5, pp.5.8–5.10) provide tier 1 default CO_2 EFs that allow estimating emissions from pipeline transport. The TERT recommends that Party A estimate CO_2 emissions for this subcategory in accordance with the 2006 IPCC Guidelines. Alternatively, the TERT recommends that the Party use notation key “NE” if it is not able to report these emissions.	Completeness

2. Exercise 2

The suggested answer contains clarifications extracted from the NIDs to which you did not have access.
Total amount captured for storage: reported by the three Parties.
Total amount of imports for storage: Party A reported a numerical value, which indicates that the Party imports CO_2. Note that the amount of CO_2 captured and imported (993.19 kt) is equal to the amount of CO_2 transported by pipeline. This indicates that the imported CO_2 gets to Party A via a pipeline, which has implications on the allocation of the associated emissions. The other two Parties used notation key "NO".
Total amount of exports for storage: the three Parties used notation key "NO"; none exports CO_2.
Total amount of CO_2 injected at storage sites: Parties A, B and C reported numerical values. The amount reported by Parties A and B is equal to the AD reported under 1.C.2.b storage. The amount reported by Party C (511.70 kt) is much smaller than that under 1.C.2.b (10,026.96 kt): The NID of Party C indicates that the value reported under 1.C.2.b is the cumulative amount of CO_2 stored at the geological site. Note that the 2006 IPCC Guidelines do not provide guidance on the amount (annual or cumulative) to be reported under this item. The amount reported by Parties B and C is equal to that reported under 1.B.2.a injection. With respect to Party A, see below.
CO_2 injected for operational usage: Party A reported a numerical value, which according to the NID corresponds to its usage for EOR. The other two Parties used notation key "NO".
Total leakage from transport, injection and storage: Parties A and C reported numerical values. Party B used notation key "NE" and provided an explanation for this reporting in the NID in relation to paragraph 32 of the MPGs.
Difference (*total A – total B*): for the three Parties the difference is equal to zero.

5. Self-check quiz

1. The amount of CO_2 captured from different activities in the energy sector that is sent to geological storage is reported in the CRT sectoral background data tables. Which activities are those?

A. Stationary combustion (CRT 1.A(a) (sheets 1, 2 and 4))
B. Mobile combustion (CRT 1.A(a) (sheet 3))
C. Fugitive emissions from fuels (CRT 1.B.1 and 1.B.2)
D. A and C

2. Consider the report by Party E in CRT 1.C (available in the Supplementary Materials at https://unfccc.int/resource/tet/be/be7-04_en7_quiz_2.xlsx) and the following description provided in the NID:
"CO_2 used for EOR or stored geologically is captured from natural gas processing plants and ammonia plants and subsequently transported to the injection sites. A tier 2 method was used to estimate CO_2 emissions from EOR. The corresponding country-specific EF includes CO_2 that was originally injected and is emitted along with other gas from leak, venting, and flaring pathways, as measurement data used to develop these factors would not be able to distinguish between CO_2 from EOR and CO_2 occurring in the produced natural gas. Therefore, EOR CO_2 emitted through those pathways is included in CO_2 estimates under 1.B.2. Facilities that conduct geologic sequestration of CO_2 and facilities that inject CO_2 underground have implemented approved site-specific monitoring, reporting and verification plan, and report the amount of CO_2 sequestered using a mass balance approach. Data relevant for this inventory estimate consists of national-level annual quantities of CO_2 captured and extracted for EOR applications and for geologic sequestration."

In addition to the information reported in CRT 1.C and the NID, you checked the website of the Global CCS Institute (https://co2re.co/) and corroborated that there are several facilities in the country undertaking EOR operations and/or CO_2 geological storage. You consider that the reporting by the Party regarding CO_2 transport and geological storage is:

A. Transparent
B. Not transparent

3. The Party reported the use of a tier 2 approach to estimate CO_2 releases from geological storage under CCS. However, the NID does not transparently explain how the national method was developed, and the data and/or parameters selected. Because of this lack of information with regard to the development of a country-specific method, the reporting by the Party is not consistent with the MPGs, more specifically with paragraph 22. In addition, you consider that at present the use of a tier 2 approach to estimate CO_2 emissions from geological storage is:

A. Likely
B. Unlikely

4. Regarding CO_2 injection, the Party should estimate and report:

A. The mass of CO_2 injected only
B. CO_2 leakage only
C. Both the mass of CO_2 injected and the amount of CO_2 that has leaked to the atmosphere

5. The 2006 IPCC Guidelines indicate five key components that the national inventory compiler must consider with regard to the method to estimate CO_2 emissions from the storage site (2006 IPCC Guidelines, vol. 2, chap. 5, pp.5.15–5.16). Two of these components are:

A. A comprehensive description of the site's monitoring programme
B. The operator's assessment of the potential for leakage at the storage site
C. A comparative assessment of the project's storage site with storage sites located in jurisdictions of other Parties
D. A and B

5.1. Answer key

1. **The correct answer is D**. CO_2 may be captured from stationary combustion, mining and oil and gas activities, but not from transport activities.

2. **The correct answer is B**. The reporting in CRT 1.C (mainly "IE") and the information provided in the NID are insufficient to understand how the inventory was compiled. From the brief description in the NID, the Party has estimated CO_2 emissions from EOR combined with other fugitive emissions occurring at natural gas processing plants; therefore, it was not possible to estimate the emissions from EOR alone. However, the NID also indicates that available plant-specific data include annual quantities of CO_2 captured and extracted for EOR applications and for geologic sequestration. This information would allow the Party to fill CRT 1.C with numerical values for the available data instead of populating it with notation key "IE".

3. **The correct answer is B**. The geological storage of CO_2 is a relatively new technology. Although several pilot projects have been carried out and there are few CCS in operations which have monitored

the storage system, it seems unlikely that a Party has collected and processed sufficient information to develop a tier 2 method. Although the development of such a tier 2 method may be possible, it would be expected that the reporting of it in the NID be transparent not only for consistency with the MPGs but also because of its novelty.

4. **The correct answer is C**. It is good practice to report the mass of CO_2 injected as calculated by direct measurements and any CO_2 leakage (routine and accidental), which should be monitored as part of the monitoring activities.

5. **The correct answer is D**. While, as part of the QA/QC activities, it would be good practice to compare monitoring methods and possible leakage scenarios between comparable sites internationally, this is not strictly necessary, especially considering that a relatively small number of CCS projects would be currently operative.

6. Key points to remember

The main topics to review the emission estimates from category 1.C CO_2 transport and storage were covered in this lesson:

- Only CO_2 emissions are considered in this category;
- The three steps of a CCS system covered in this category (transport of CO_2, injection and storage) are potential emitters;
- Except for transport, for which the 2006 IPCC Guidelines provide a tier 1 method, only tier 3 methods are considered in the 2006 IPCC Guidelines;
- The capture step is not estimated and reported under this category but in the energy or IPPU categories where it takes place; however, the total amount of CO_2 captured for storage is reported in CRT 1.C as an information item;
- Captured CO_2 may be used for purposes other than geological storage, such as EOR or producing carbonates (not covered by the 2006 IPCC Guidelines). These purposes must be transparently disaggregated, allocated in the corresponding categories and transparently reported in the NID.

List of References

IPCC. 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. S Eggleston, L Buendia, K Miwa, et al. (eds.). Hayama, Japan: Institute for Global Environmental Strategies. Available at http://www.ipcc-nggip.iges.or.jp/public/2006gl.

IPCC. 2019. 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. E Calvo Buendia, K Tanabe, A Kranjc, et al. (eds.). Geneva: IPCC. Available at https://www.ipcc-nggip.iges.or.jp/public/2019rf/index.html.