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 B3: INDUSTRIAL PROCESSES AND PRODUCT USE SECTOR

FIRST EDITION
September 2023

Greenhouse gas inventory review training course

Industrial processes and product use sector

United Nations Framework Convention on Climate Change

Abbreviations and acronyms

2006 IPCC Guidelines	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	confidential
CaC_2	calcium carbide
$CaCO_3$	calcium carbonate
CCS	carbon dioxide capture and storage
CH_4	methane
C_2H_2	acetylene
CO	carbon monoxide
CO_2	carbon dioxide
CO_2 eq	carbon dioxide equivalent
CRT	common reporting table
CVD	chemical vapour deposition
EF	emission factor
ETF	enhanced transparency framework of the Paris Agreement
EU ETS	European Union Emissions Trading System
FC	fluorinated compound
F-gas	fluorinated gas
GDP	gross domestic product
GHG	greenhouse gas
GWP	global warming potential
IE	included elsewhere
IEF	implied emission factor
HFC	hydrofluorocarbon
IPCC	Intergovernmental Panel on Climate Change
IPPU	industrial processes and product use
LULUCF	land use, land-use change and forestry
MDI	metered dose inhalers
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
NA	not applicable
NDC	nationally determined contribution
NE	not estimated
NF_3	nitrogen trifluoride
NID	national inventory document
NMVOC	non-methane volatile organic compounds
NO	not occurring
NO_X	nitrogen oxides
N_2O	nitrous oxide
NSCR	non-selective catalytic reduction
PFC	perfluorocarbon

ODS	ozone-depleting substance(s)
QA/QC	quality assurance/quality control
SF_6	sulfur hexafluoride
SCR	selective catalytic reduction
TERR	technical expert review report
TERT	technical expert review team
TFT-FPD	thin-film-transistor flat panel display
TiO_2	titanium dioxide
UNFCCC Annex I inventory reporting guidelines	"Guidelines for the technical review of information reported under the Convention related to greenhouse gas inventories, biennial reports and national communications by Parties included in Annex I to the Convention, Part III: UNFCCC guidelines for the technical review of greenhouse gas inventories from Parties included in Annex I to the Convention"

Table of Contents

Lesson 1. Introduction 12
1. Overview and learning objectives 12
1.1. Course outline 12
1.2. Learning objectives 12
2. Basic documentation 13
2.1. Reference documentation under the Paris Agreement 13
2.2. Methodological background 13
2.3. Other documentation 16
3. Initial quiz 16
3.1. Questions 17
3.2. Answers 20
Lesson 2. Technical review of the IPPU sector 25
1. Introduction 25
1.1. Lesson outline 25
1.2. Learning objectives 25
2. Overview of the sector 26
2.1. Description of the sector 26
2.2. Reporting GHG emissions from the IPPU sector 26
2.3. Categories in the IPPU sector 27
2.4. Structure of the lessons 27
3. Cross-sectoral issues 28
3.1. Relationship between the IPPU sector and other sectors 28
3.2. Emissions capture, use and destruction 29
3.3. Non-energy uses of fuels 30
3.4. Overview of IPPU sector reporting tables 31
4. General approach in reviewing the IPPU sector 31
4.1. Preparing for the review 31
5. Practical exercises 32
5.1. Exercise 1 32
5.2. Exercise 2 35
5.3. Exercise 3 37

6. Self-check quiz 38
6.1. Questions 38
6.2. Answers 43
7. Key points to remember 46
Lesson 3. Mineral industry 47
1. Introduction and objectives of the lesson 47
1.1. Lesson outline 47
1.2. Categories in mineral industry 47
1.3. Learning objectives 48
2. Category overview and methodological information 48
2.1. Overview 48
2.2. Cement production (category 2.A.1) 49
2.3. Lime production (category 2.A.2) 51
2.4. Glass production (category 2.A.3) 53
2.5. Other process uses of carbonates (category 2.A.4) 56
3. Review approach 58
3.1. Overview 58
Case 1 (verifying implementation of previous recommendations) 58
Case 2 (new findings) 61
4. Practical exercises 64
4.1. Exercise 1 (cement) 64
4.2. Exercise 2 (Lime as part of sugar production) 66
4.3. Exercise 3 (glass) 67
5. Self-check quiz 69
5.1. Questions 69
5.2. Answers 72
6. Key points to remember 73
Lesson 4: Chemical industry 74
1. Introduction and objectives of the lesson 74
1.1. Lesson outline 74
1.2. Categories in chemical industry 74
1.3. Learning objectives 75
1.4. CO_2 capture 75

2. Category overview and methodological information 76
2.1. Ammonia production (category 2.B.1) 76
2.2. Nitric acid production, adipic acid production, caprolactam, glyoxal and glyoxylic acid production 78
2.3. Carbide production (SiC and CaC_2) (category 2.B.5) 80
2.4. Titanium dioxide production (category 2.B.6) 82
2.5. Soda ash production (category 2.B.7) 84
2.6. Petrochemical and carbon black production (category 2.B.8) 85
2.7. Fluorochemical production (category 2.B.9) 90
3. Review approach 95
3.1. Overview 95
Case 1 (verifying implementation of previous recommendations) 96
Case 2 (new findings) 99
4. Practical exercises 102
4.1. Exercise 1 (ammonia production) 102
4.2. Exercise 2 (calcium carbide) 104
5. Self-check quiz 107
5.1. Questions 107
5.2. Answers 111
6. Key points to remember 113
Lesson 5. Metal industry 114
1. Introduction and objectives of the lesson 114
1.1. Lesson outline 114
1.2. Categories in metal industry 114
1.3. Learning objectives 115
2. Category overview and methodological information 115
2.1. Overview 115
2.2. Iron and steel production (category 2.C.1) 116
2.3. Ferroalloys production (category 2.C.2) 119
2.4. Aluminium production (category 2.C.3) 122
2.5. Magnesium production (category 2.C.4) 125
2.6. Lead production (category 2.C.5), zinc production (2.C.6) and other metals (2.C.7) 128
3. Review approach 130
3.1. Overview 130

Case 1 (verifying implementation of previous recommendations) 130
Case 2 (new findings) 133
4. Practical exercises 136
4.1. Exercise 1 (iron and steel production) 136
4.2. Exercise 2 (aluminium production) 138
4.3. Exercise 3 (lead and zinc production) 139
5. Self-check quiz 141
5.1. Questions 141
5.2. Answers 143
6. Key points to remember 144
Lesson 6. Non-energy products from fuels and solvent use 145
1. Introduction and objectives of the lesson 145
1.1. Lesson outline 145
1.2. Categories in non-energy products from fuels and solvent use 145
1.3. Learning objectives 146
2. Category overview and methodological information 146
2.1. Overview 146
2.2. Lubricant use (category 2.D.1) 146
2.3. Paraffin wax use (category 2.D.2) 148
2.4. Other (bitumen/asphalt, solvents and any others) (category 2.D.3) 149
3. Review approach 149
3.1. Overview 149
Case 1 (verifying implementation of previous recommendations) 150
Case 2 (new findings) 151
4. Practical exercises 155
4.1. Exercise 1 (CH_4 and N_2O) 155
5. Self-check quiz 156
5.1. Questions 156
5.2. Answers 157
6. Key points to remember 158
Lesson 7. Electronics industry 159
1. Introduction and objectives of the lesson 159
1.1. Lesson outline 159

1.2. Categories in electronics industry (2.E) 159
1.3. Learning objectives 160
2. Category overview and methodological information 160
2.1. Overview 160
2.2. Etching and CVD cleaning in integrated circuit or semiconductor, TFT-FPDs and photovoltaics 161
2.3. Heat transfer fluids in the electronics industry (category 2.E.4) 162
3. Review approach 164
3.1. Overview 164
3.2. Case 1 (verifying the implementation of previous recommendations) 164
3.3. Case 2 (new findings) 167
4. Practical exercises 173
4.1. Exercise #1 (semiconductor manufacturing) 173
4.2. Exercise #2.a (PFCs for heat transfer) 173
4.3. Exercise #2.b (PFCs for heat transfer) 174
5. Self-check quiz 175
5.1. Questions 175
5.2. Answers 176
6. Key points to remember 176
Lesson 8. Product uses as substitutes for ozone-depleting substances 177
1. Introduction and objectives of the lesson 177
1.1. Lesson outline 177
1.2. Categories in product uses as substitutes for ozone-depleting substances 177
1.3. Learning objectives 178
2. Category overview and methodological information 178
2.1. Categories in the lesson 178
2.2. Refrigeration and air conditioning (category 2.F.1) 180
2.3. Foam blowing agents (category 2.F.2) 182
2.4. Fire protection (category 2.F.3) 184
2.5. Aerosols (category 2.F.4) 186
2.6. Solvents (non-aerosols) (category 2.F.5) 189
2.7. Other applications (category 2.F.6) 191
3. Review approach 193
3.1. Overview 193

4. Practical exercises 196
4.1. Exercise 1 (2.F.4 HFC emissions from aerosols) 196
4.2. Exercise 2 (2.F.4 Aerosols) 198
5. Self-check quiz 200
5.1. Questions 200
5.2. Answers 200
6. Key points to remember 201
Lesson 9. Other manufacture and use 202
1. Introduction and objectives of the lesson 202
1.1. Lesson outline 202
1.2. Categories in other manufacture and use 202
1.3. Learning objectives 203
2. Category overview and methodological information 203
2.1. Electrical equipment 203
2.2. SF_6 and PFCs emissions from other product use 205
2.3. N_2O from product uses 208
3. Review approach 209
3.1. Overview 209
3.2. Case 1 (verifying the implementation of previous recommendations) 209
3.3. Case 2 (new findings) 212
4. Practical exercises 214
4.1. Exercise 1 (2.G. Consumption of halocarbon and SF_6 – HFCs) 214
4.2. Exercise 2 (2.G.1 SF_6 emissions from electrical equipment) 215
4.3. Exercise 3 (2.G.2 SF_6 in double-glazed sound-proof windows) 216
5. Self-check quiz 218
6. Key points to remember 218

List of Figures

A. Figure 1-1 the structure of the IPPU course. 12
B. Figure 1-2. Industrial processes and product use categories in the 2006 IPCC Guidelines 15
C. Figure 2-1. Interactions between the IPPU sector and other inventory sectors 28
D. Figure 2-2. Main tasks for each stage of the review of the inventory 32
E. Figure 3-1. 2006 IPCC Guidelines decision tree for estimation of CO_2 emissions from cement production 49
F. Figure 3-2. 2006 IPCC Guidelines decision tree for estimation of CO_2 emissions from lime production 51
G.Figure 3-3. 2006 IPCC Guidelines decision tree for estimation of CO_2 emissions from glass production 54
H. Figure 3-4. 2006 IPCC Guidelines decision tree for estimation of CO_2 emissions from other processes use of carbonates 56
I. Figure 3-5. Time series of IEFs 64
J. Figure 4-1. 2006 IPCC Guidelines decision tree for estimation of CO_2 emissions from ammonia production 76
K. Figure 4-2. 2006 IPCC Guidelines decision tree for estimation of CO_2 emissions from nitric acid production 79
L. Figure 4-3. 2006 IPCC Guidelines decision tree for estimation of CO_2 and CH_4 emissions from carbide production 81
M. Figure 4-4. 2006 IPCC Guidelines decision tree for estimation of CO_2 emissions from TiO_2 production 83
N. Figure 4-5. 2006 IPCC Guidelines decision tree for estimation of CO_2 emissions from soda ash production 85
O. Figure 4-6. 2006 IPCC Guidelines decision tree for estimation of CO_2 emissions from the petrochemical industry and carbon black industry 87
P. Figure 4-7. 2006 IPCC Guidelines decision tree for estimation of CH_4 emissions from the petrochemical industry and carbon black industry 88
Q. Figure 4-8. 2006 IPCC Guidelines decision tree for estimation of HFC-23 emissions from HCFC-22 production 92
R. Figure 4-9. 2006 IPCC Guidelines decision tree for estimation of F-gas emissions (fugitive and by-product) from production processes 94
S. Figure 5-1. 2006 IPCC Guidelines decision tree for estimation of CO_2 emissions from iron and steel production 117
T. Figure 5-2. 2006 IPCC Guidelines decision tree for estimation of CH_4 emissions from iron and steel production 117
U. Figure 5-3. 2006 IPCC Guidelines decision tree for estimation of CO_2 emissions from ferroalloy production 120
V. Figure 5-4. 2006 IPCC Guidelines decision tree for estimation of CH4 emissions from ferroalloy production 121
W. Figure 5-5. 2006 IPCC Guidelines decision tree for estimation of CO_2 emissions from primary aluminium production processes 123

X. Figure 5-6. 2006 IPCC Guidelines decision tree for estimation of PFC emissions from primary aluminium production processes 124
Y. Figure 5-7. 2006 IPCC Guidelines decision tree for estimation of CO_2 emissions from magnesium production 126
Z. Figure 5-8. 2006 IPCC Guidelines decision tree for estimation of SF_6 emissions from magnesium production 127
AA. Figure 5-9. 2006 IPCC Guidelines decision tree for estimating CO_2 emissions from lead production 129
BB. Figure 6-1. Sectoral allocation of emissions from lubricants and waxes 148
CC. Figure 7-1. 2006 IPCC Guidelines decision tree for estimation of fluorinated compound emissions from electronics manufacturing 162
DD. Figure 7-2. 2006 IPCC Guidelines decision tree for estimation of fluorinated compounds emissions from heat transfer fluid loss from electronics manufacturing 163
EE. Figure 8-1. 2006 IPCC Guidelines decision tree for estimation of emissions from refrigeration and air-conditioning equipment 181
FF. Figure 8-2. 2006 IPCC Guidelines decision tree for estimation of emissions from foam blowing 183
GG. Figure 8-3. 2006 IPCC Guidelines decision tree for estimation of emissions from fire protection applications 185
HH. Figure 8-4. 2006 IPCC Guidelines decision tree for estimation of emissions from aerosol applications 188
II. Figure 8-5. 2006 IPCC Guidelines decision tree for estimation of emissions from the solvents application 190
JJ. Figure 8-6. 2006 IPCC Guidelines decision tree for estimating HFCs and PFCs emissions from other applications 192
KK. Figure 9-1. 2006 IPCC Guidelines decision tree for estimation of SF_6 and perfluorocarbon emissions from electrical equipment (note: in this figure, "SF_6" indicates "SF_6 and/or perfluorocarbons") 204
LL. Figure 9-2. 2006 IPCC Guidelines decision tree for estimation of SF_6 emissions from airborne early warning and control systems 206
MM. Figure 9-3. 2006 IPCC Guidelines decision tree for estimation of SF_6 emissions from research accelerators 207

Lesson 1. Introduction

1. Overview and learning objectives

1.1. Course outline

This course covers the technical review of the Industrial Processes and Product Use (IPPU) sector in the national greenhouse gas (GHG) inventory. The structure of the industrial processes and product use course is as follows:

A. Figure 1-1 the structure of the IPPU course.

Lesson 1. Introduction
Lesson 2. Review of the IPPU sector
Lesson 3. Mineral industry
Lesson 4. Chemical industry
Lesson 5. Metal industry
Lesson 6. Non-energy products and solvents
Lesson 7. Product uses as ODS substitutes
Lesson 8. Electronics and other IPPU categories
Lesson 9. Other manufacture and use

The course contains nine lessons that reflect the structure of the IPPU sector in terms of how Parties are required to report GHG emissions from the sector in their national GHG inventory. The course will provide you with the knowledge needed to review the IPPU sector of Parties' national GHG inventories. Each lesson includes exercises and quizzes to train you and test your knowledge. Figure 1-1 above shows the structure of the IPPU course. You must study all lessons in the sequential order indicated in figure 1-1, unless you feel confident about your knowledge, in which case you can follow the order of your choice for lessons 4–-9. In either case, you must firstly study lesson 2 before continuing with the remaining lessons.

1.2. Learning objectives

This course provides you with background information on the main aspects that a review expert needs to comprehend and consider as a member of a technical expert review team (TERT), as well as on GHG emissions from the IPPU sector, under the Enhanced Transparency Framework (ETF). Completing the course will enable you to advance your skills as an expert reviewer of the IPPU sector, in the sense that you will:

- Enhance your overall knowledge on the methodological background on estimating and reporting GHG emissions from the IPPU sector;
- Enhance your knowledge on cross-cutting issues relevant for the IPPU sector;

- Be able, according to the modalities, procedures and guidelines (MPGs) adopted by decision 18/CMA.1 (click here to access decision 18/CMA.1), to successfully assess the quality of information reported for the IPPU sector in a Party's national GHG inventory, and conduct the technical review of its national inventory report, consisting of an national inventory document (NID) and the set of common reporting tables (CRTs).

At the end of this lesson, you will be asked to take an initial quiz to test the level of your knowledge on the IPPU GHG inventory and the 2006 IPCC Guidelines.

The expected time needed to complete lesson 1 depends on the level of your knowledge on GHG inventories for the IPPU sector under the ETF and the 2006 IPCC Guidelines:

- For readers with experience: 15–30 minutes
- For readers with less experience: 30–50 minutes

2. Basic documentation

2.1. Reference documentation under the Paris Agreement

The main guidance and overarching principles related to the technical expert review of national GHG inventories according to the MPGs are discussed in the overview and cross-cutting course.

Specific documentation for the IPPU sector is included in decision 5/CMA.3, which contains the set of CRTs (click here to open the CRTs from the UNFCCC website). Annex V to the same decision contains the outline of the NID, including a suggested outline for reporting on the IPPU GHG inventory.

2.2. Methodological background

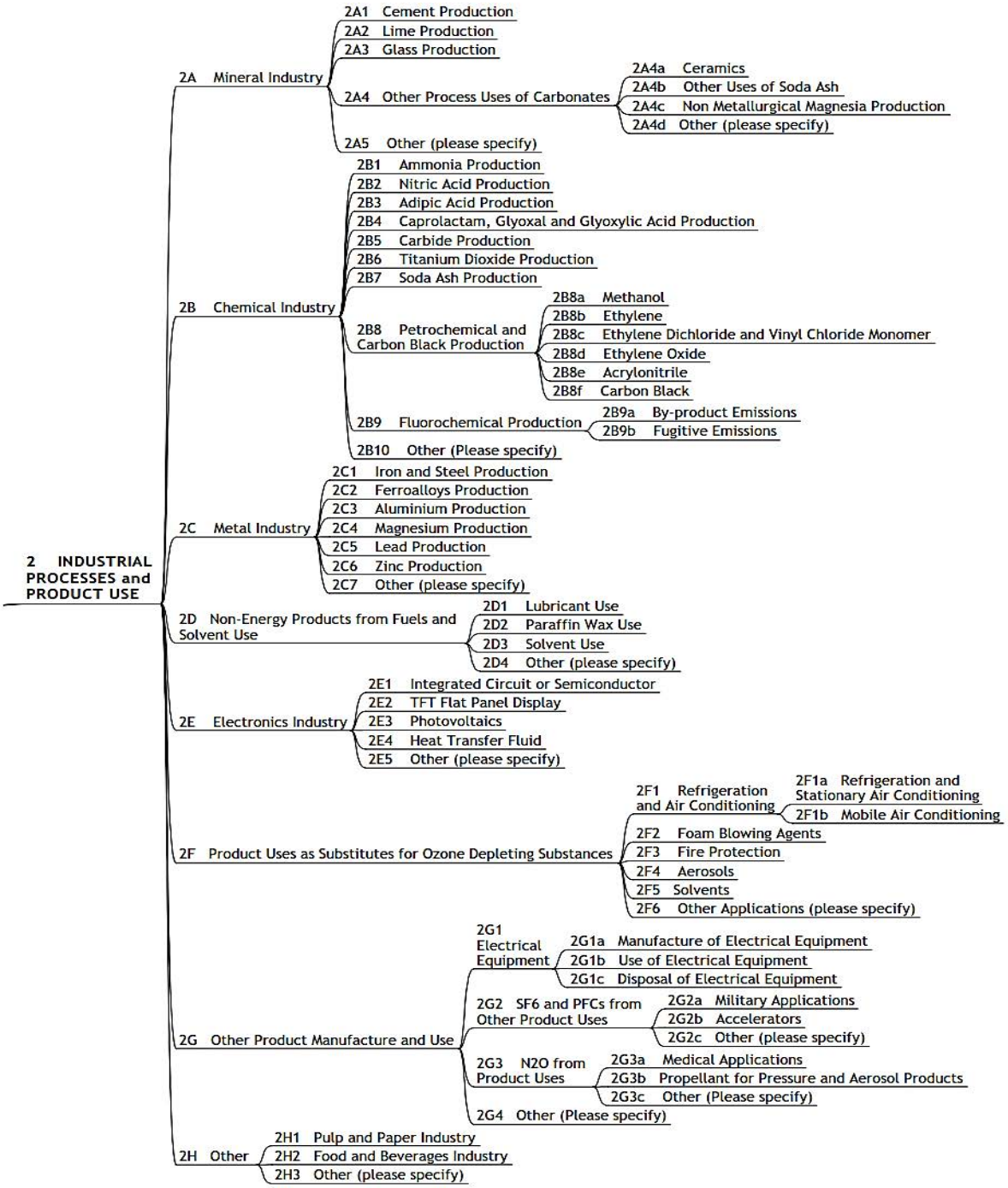
Volume 3 of the 2006 IPCC Guidelines provides the specific methodological background for the development of the IPPU GHG inventory.

Volume 1 of the 2006 IPCC Guidelines covers general cross-cutting issues. They have been considered previously in the overview and cross-cutting issues ETF training course.

Eight broad IPPU subsectors are covered in the 2006 IPCC Guidelines:

- 2.A Mineral industry
- 2.B Chemical industry
- 2.C Metal industry
- 2.D Non-energy products from fuels and solvent uses
- 2.E Electronics
- 2.F Fluorinated substitutes for ozone-depleting substances
- 2.G Other product manufacture and use
- 2.H Other.

Figure 1-2 below shows the categorization in the 2006 IPCC Guidelines. However, please note that the official categorization for the IPPU sector under the ETF is established in the CRTs included in decision 5/CMA.3, and there may be differences between the categorization in the 2006 IPCC Guidelines and in the CRTs.



B. Figure 1-2. Industrial processes and product use categories in the 2006 IPCC Guidelines

2.3. Other documentation

Other documentation you need to consider when conducting the technical review of the IPPU national inventory report is volume 1 of the 2006 IPCC Guidelines.

Volume 1 of the 2006 IPCC Guidelines can be downloaded from the following link:

www.ipcc-nggip.iges.or.jp/public/2006gl/vol1.html

During the course we will refer many times to these 2006 IPCC guidelines and the CRTs, therefore we suggest that you have them to hand and consult them as necessary.

Note that in addition to the originally published English version of the 2006 IPCC Guidelines there are five other versions (Arabic, Chinese, French, Russian and Spanish); however, the corrections (corrigenda) are mainly updated in the English version only, hence you are recommended to consult the English version when drawing up any final conclusions. Because the corrections are made from time to time, you should download the latest version of the 2006 IPCC Guidelines to ensure that you use the version that reflects all corrigenda since 2007.

Note that technical knowledge of the methodologies in the 2006 IPCC Guidelines is a prerequisite to taking part in the overview and cross-cutting course and this IPPU sector course. These courses have been devised for technical expert reviewers of national GHG inventories who would like to become IPPU expert reviewers under the ETF. Therefore, this course does not replace the need to be familiar with methods and guidance reported as good practice in the above-mentioned IPCC guidelines.

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 emissions from some of the IPPU categories. You will find specific reference to these guidelines whenever relevant.

3. Initial quiz

This initial quiz will test your knowledge of the IPPU sector of the 2006 IPCC Guidelines. If you feel that you are not experienced enough in this field and you are still interested in becoming an expert reviewer, you will need to make an extra effort to study the methodological guidance in volume 3 of the 2006 IPCC Guidelines, in addition to studying this course. It is suggested that you take this initial quiz without consulting the 2006 IPCC Guidelines in order to assess the level of your knowledge.

After answering each question of the initial quiz, you can consult the correct answer and the corresponding explanation. For further information, a reference to the corresponding section(s) of the 2006 IPCC Guidelines is also provided.

3.1. Questions

Question 1

The term “feedstock” in the context of emissions accounting for the industrial processes and product use sector means:

Select one:

A. Any fossil fuel
B. Any fossil fuel or substance that is fed into an industrial process in order to produce primarily organic chemicals and, to a lesser extent, inorganic chemicals (such as ammonia)
C. Any fossil fuel or substance used for the primary purpose of generating heat in some industrial production processes
D. Both b and c

Question 2

How should emissions resulting from the disposal of used lubricants (e.g. combustion of waste oils) be reported?

Select one:

A. They should be reported under the energy sector
B. They should be reported under the waste sector
C. Both A and C depending on whether the treatment occurs with or without energy recovery

Question 3

Is the following statement correct? “Incomplete reporting of lime production will be indicated by an unusually low implied emission factor (IEF)”.

Select one:

A. True
B. False

Question 4

When is the following statement correct? “To estimate CO_2 emissions from cement production it is necessary to know the amount of clinker and/or the types and amount of carbonates used to produce clinker”

Select one:

A. Always
B. Yes, except when applying the tier 1 method, where the amount of cement is used
C. Never

Question 5

Some industries produce lime and consume it for their operations. For example, lime can be produced at sugar mills for sugar refining processes. Which of the following statements is true?

Select one:

A. In case of lime produced at sugar mills, emissions should be reported under Lime production
B. In case of lime produced at sugar mills, emissions should be reported under Food and beverages industry
C. The process of lime production at sugar mills may not result in CO_2 emissions
D. Both A and C

Question 6

The most common feedstock used in the production of ammonia is:

Select one:

A. Natural gas
B. Heavy oil
C. Externally supplied hydrogen

Question 7

When estimating the N_2O emissions from adipic acid and nitric acid production it is important to take into account the destruction factor, as it may be:

Select one:

A. As high as 50 per cent
B. More than 92 per cent
C. None of the above

Question 8

The primary use of SF_6 in magnesium casting foundries is:

Select one:

A. As a cover gas
B. As a cleaning agent to essure the high quality of the casting process
C. As insulation to avoid electrical discharge

Question 9

PFC emissions occur from primary aluminium production. Different parameters are needed to estimate PFC emissions from this process according to the tier used. Which of the following parameters is not used in the estimation process in any of the tiers?

Select one:

A. Cell technology type
B. Metal production
C. Slope coefficient
D. Anode effect minutes per cell day data or accurate overvoltage data for all cell types
E. All of the above are used in one or more estimation methods

Question 10

Which emissions result from primary aluminium production?

Select one:

A. PFC emissions, which may result from anode effects
B. CO_2 emissions, deriving from the consumption of carbon anodes
C. Both A and B

Question 11

Which GHGs (or classes of GHGs) may be reported in the IPPU sector?

Select one:

A. CO_2, CH_4, and N_2O
B. HFCs, PFCs, SF_6 and NF_3.
C. Both A and B.

Question 12

In ammonia production no distinction is made between fuel and feedstock emissions, with all emissions accounted for in the IPPU sector.

Select one:

A. The above statement is true

B. The above statement is false

Question 13

In the context of the IPPU sector, in general, what will the small amount of GHG emissions from asphalt production, asphalt roofing and road paving primarily consist of?

Select one:

A. The amount of NMVOC emitted multiplied by its GWP value
B. The CO_2 resulting from oxidation of NMVOCs and CO
C. The CO_2 from the fuel used to provide heat for paving

3.2. Answers

Answer 1

The correct answer is (B).

In general, a feedstock is any fossil fuel that is fed into an industrial process but is not used for the primary purpose of generating heat. To verify the consistency and completeness of carbon emissions from the non-energy use of feedstock it is important to check that feedstock requirements of processes included in the inventory are in balance with the feedstock supply as recorded in the energy statistics. However, in some cases, the energy statistics may not consider all the feedstocks actually used in the processes (i.e. the statistics may not include the consumption of some fuels used as non-energy substances; they may not have been reported or they may have been deducted from the statistics)

To learn more on feedstocks, consult sections 1.3.2 and 1.4.3.2, chapter 1, volume 3 of the 2006 IPCC Guidelines.

Feedstock

Feedstocks are fossil fuels that are used as raw materials in chemical conversion processes that produce primarily organic chemicals and, to a lesser extent, inorganic chemicals (especially ammonia) and their derivatives. In most cases part of the carbon remains embodied in the manufactured product. The use of hydrocarbon feedstocks in chemical conversion processes is almost entirely confined to the chemical and petrochemical industries.

Answer 2

The correct answer is (C).

After their use, waste lubricants are collected and treated according to the Party's legislation. If the amount of waste lubricants is combusted with energy recovery, emissions are to be reported under the energy sector; if they are treated as waste oil without energy recovery, then emissions are reported under waste.

To learn more on the use of lubricants, consult section 5.2, chapter 5, volume 3 of the 2006 IPCC Guidelines.

Answer 3

The correct answer is (B) (False).

Incomplete activity data (AD) will most often not affect a Party's IEF because the IEF is the ratio between the reported emissions estimate and the reported AD. Emissions from lime production are based on the stoichiometry of the reaction of the carbonates. Therefore, IEFs are not a good indicator of the completeness of reporting. You could find a category where the value of the IEF is within the expected range but the reporting is incomplete: part of the AD and, as a result, part of the emissions, have not been reported.

To learn more on lime production, consult section 2.3, chapter 2, volume 3 of the 2006 IPCC Guidelines.

Answer 4

The correct answer is (B).

Applying the tier 1 method, the data on the types of cement should be collected and a default fraction of clinker per unit of cement produced is applied to estimate clinker production.

To learn more on the methods for estimating emissions from cement production, consult section 2.2.1, chapter 2, volume 3 of the 2006 IPCC Guidelines.

Answer 5

The correct answer is (D).

Some industries produce lime and consume it for their operations. This quantity of lime may never be introduced into the market (i.e. it is non-marketed lime). It is important when collecting AD for lime production that both marketed and non-marketed lime production are included. In all cases, emissions from lime production should always be accounted for under Lime production, irrespective of the production industry (metallurgy, pulp and paper, sugar refining, water softeners).

It is also true that CO_2 emissions may be recovered wherever the lime production process occurs. For example, during the process of sugar refining, lime is used to remove impurities from the raw cane juice; any excess lime can be removed through carbonation. Any recarbonation in these specific industries may be calculated and reported only where proven and validated methods are used to

calculate the amount of CO_2 that reacts with lime to re-form $CaCO_3$. Where these conditions are met, CO_2 emissions may be reported under category 2.H, Other.

To learn more on the completeness of AD and the reporting of emissions related to lime production, consult sections 2.3.1.3 and 2.3.3, chapter 2, volume 3 of the 2006 IPCC Guidelines.

Answer 6

The correct answer is (A).

The most common feedstock used in the production of ammonia is natural gas, and this category constitutes a significant non-energy source of industrial CO_2 emissions. If externally supplied hydrogen is used as feedstock in the process there are no emissions from the ammonia production, but emissions may occur where the hydrogen is produced.

To learn more on the estimation of emissions from ammonia production, consult section 3.2.2, chapter 3, volume 3 of the 2006 IPCC Guidelines.

Answer 7

The correct answer is (B).

The N_2O destruction factor may be as high as 99 per cent for these two processes. When estimating the emissions, the utilization factor of the abatement system (i.e. how often the abatement system is working) must also be taken into account.

To learn more on abatement processes for nitric acid emissions, consult section 3.3.2, chapter 3, volume 3 of the 2006 IPCC Guidelines.

Answer 8

The correct answer is (A).

In the magnesium industry, SF_6 is used as a cover gas to prevent the violent oxidation of molten magnesium. The underlying assumption of the tier 1 method is that all SF_6 employed in the process is emitted to the atmosphere.

To learn more on SF_6 emissions from magnesium processing, consult section 4.5.2, chapter 4, volume 3 of the 2006 IPCC Guidelines.

Answer 9

The correct answer is (E).

Except for tier 1, the other two methods (tier 2 and tier 3) for estimating emissions are related to the process control in use but they are both based on the relationship between anode effect and performance (i.e. the slope and overvoltage coefficient equations). All parameters are used in one or more of the estimation methods.

To learn more on PFC emissions from aluminium production, consult section 4.4.2.3, chapter 4, volume 3 of the 2006 IPCC Guidelines.

Answer 10

The correct answer is (C).

CO_2 emissions occur from the consumption of carbon anodes in the reaction to convert aluminium oxide to aluminium metal, whereas PFC emissions may be derived during an anode effect condition where an insufficient amount of alumina is dissolved in the electrolyte, causing voltage elevated above the normal operating range.

To learn more on PFC emissions from aluminium production, consult section 4.4.2.3, chapter 4, volume 3 of the 2006 IPCC Guidelines.

Answer 11

The correct answer is (C).

Parties are required to report emissions of CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3.

Every developing country Party that needs flexibility in the light of its capacity has the flexibility to report just three gases (CO_2, CH_4 and N_2O) as well as any of the additional four gases (HFCs, PFCs, SF_6 and NF_3) that are included in the Party's NDC under Article 4 of the Paris Agreement; are covered by an activity under Article 6 of the Paris Agreement; or have been previously reported by the Party (see decision 18/CMA.1, annex, paras. 17–58)

Answer 12

The correct answer is (A).

In ammonia production no distinction is made between fuel and feedstock emissions and all emissions are accounted for in the IPPU sector

To learn more on emissions from ammonia production, consult section 3.2.2.1, chapter 3, volume 3 of the 2006 IPCC Guidelines.

Answer 13

The correct answer is (B).

NMVOCs oxidize in the atmosphere and generate CO_2 that should be reported when the source of the NMVOCs is a fossil fuel.

To learn more on emissions from asphalt production and use, consult section 5.4, chapter 5, volume 3 of the 2006 IPCC Guidelines.

Lesson 2. Technical review of the IPPU sector

1. Introduction

1.1. Lesson outline

This is the second lesson in the IPPU course. This lesson is divided into seven sections to help you choose what best complements your prior knowledge of the topic.

1. Introduction and objectives of the lesson
2. Overview of the sector
3. Cross-sectoral issues
4. General approach in reviewing the sector
5. Practical exercises
6. Self-check quiz
7. Key points to remember

1.2. Learning objectives

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

- Identify the major categories and gases emitted in the IPPU sector;
- Identify key areas to watch out for when reviewing the IPPU sector, in particular possible double counting or omissions in reporting among sectors (especially with the energy sector);
- Understand how to apply the general assessment of cross-cutting issues to the review of the IPPU sector.

We expect that you already have a good understanding of GHG inventories before starting this training course. In particular, we expect you to be familiar with the methods for estimating the emissions and the decision trees in all the IPPU chapters of the 2006 IPCC Guidelines (please refer to the 2006 IPCC Guidelines, vol. 3). This course will concentrate on the particular issues relevant for the review of the IPPU sector.

The expected time needed to complete lesson 2 depends on the level of your knowledge of GHG inventories for the IPPU sector under the ETF and the 2006 IPCC Guidelines:

- For readers with experience: 15–30 minutes
- For readers with less experience: 30–50 minutes

2. Overview of the sector

2.1. Description of the sector

The IPPU sector deals with GHG emissions from the manufacture of various materials, from the use of GHGs in products, and from non-energy uses of fossil fuelss. Let's discuss them briefly.

Most emissions in the IPPU sector are released by industrial processes that transform materials chemically or physically. During these processes, many different GHGs can be produced, including CO_2, CH_4, N_2O, HFCs, PFCs and NF_3. For example, CO_2 emissions from the calcination of $CaCO_3$ for the production of cement.

In addition, GHGs are often used in equipment (e.g. refrigerators) and products (e.g. foams and aerosol cans). For example, HFCs are used as alternatives to ODS in various types of product applications. Similarly, SF_6 and N_2O are used in industrial and consumer devices (e.g. SF_6 is used in electrical equipment and N_2O is used as a propellant in aerosol products, primarily in the food industry) or by end consumers (e.g. SF_6 is used in the soles of some running shoes and N_2O is sometimes used during anaesthesia). In these applications, in many cases, production and import/export data are needed to estimate emissions. Emissions can occur as part of industrial activities but also in non-industrial sectors (retail, services or households).

Several other fluorinated GHGs may be used in industrial processes, for example, in semiconductor manufacture. However, in this course we will only focus on NF_3. NF_3 can be emitted during, for example, electronics and semiconductor manufacturing.

The non-energy uses of fossil fuels encompass their uses as feedstock (e.g. CO_2 emissions from the use of natural gas or other fossil fuels to produce ammonia), reductants (e.g. carbon is used as a reducing agent for the production of some metals, releasing CO_2) and non-energy products (e.g. lubricants and greases) in which their properties are used directly rather than combusted for energy purposes.

2.2. Reporting GHG emissions from the IPPU sector

In the light of the MPGs, some developing country Parties that need flexibility owing to their capacity have to report on at least three gases (CO_2, CH_4 and N_2O) as well as on any of the additional four gases or classes of gases (HFCs, PFCs, SF_6 and NF_3) that are included in the Party's NDC under Article 4 of the Paris Agreement, are covered by an activity under Article 6 of the Paris Agreement, or have been previously reported by the Party.

Paragraph 48 of the MPGs. In place of the mandatory requirement to report on seven gases, flexibility may be used to report on at least three gases (CO_2, CH_4 and N_2O) as well as on any of the additional four gases (HFCs, PFCs, SF_6 and NF_3) that are included in the Party's NDC under Article 4 of the Paris Agreement, are covered by an activity under Article 6 of the Partis Agreement, or have been previously reported by the Party.

2.3. Categories in the IPPU sector

In terms of categories, the IPPU sector contains a large and diverse number of categories. Methods to estimate emissions from the IPPU sector are provided in volume 3 of the 2006 IPCC Guidelines. The guidelines split the IPPU sector into several subsectors and there is one chapter for each subsector. In this lesson, we have organized the "category-specific review issues" section of this course into seven groups or subsectors:

- Mineral industry;
- Chemical industry;
- Metal industry;
- Non-energy products from fuels and solvent use;
- Electronics industry;
- Emissions of fluorinated substitutes for ODS; and
- Other product manufacture and use.

Each of these groups contains a number of categories. In this course, for each category, there is a short introduction to the chemical or physical processes that produce GHG emissions, followed by a discussion of some specific issues you should take into account as an expert reviewer.

These discussions should help you learn how to conduct your future review work.

2.4. Structure of the lessons

Lessons 3–9 each focus on one category. Each lesson is divided into the following six sections:

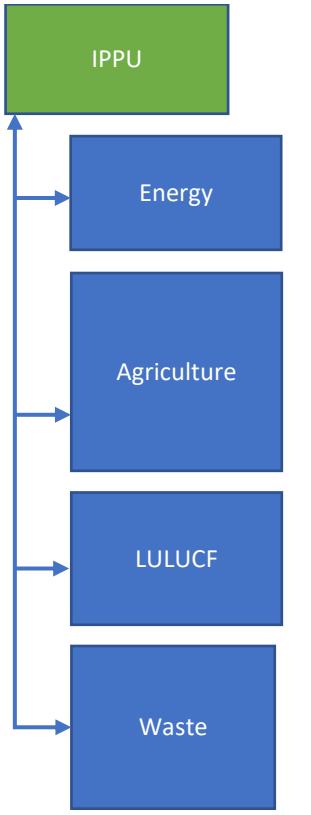
1. Introduction and objectives of the lesson
2. Category overview and methodological information
3. Review approach
4. Practical exercises
5. Self-check quiz
6. Key points to remember

3. Cross-sectoral issues

3.1. Relationship between the IPPU sector and other sectors

There are several common elements to be assessed across sectors when reviewing the quality of a Party's submission. These cross-cutting elements include the assessment of the five inventory principles (transparency, accuracy, completeness, consistency, comparability) including adherence to the MPGs, key category and uncertainty analyses, and QA/QC.

Moreover, different categories in the IPPU sector interact with the categories in other sectors. Figure 2-1 below provides an overview of these interactions.



Reported in the energy sector:
- Energy-related emissions from manufacturing processes*
- Transport and storage of CO_2 captured in the IPPU sector

- Emissions from liming reported in the agriculture sector, emissions from other uses of carbonates in energy and IPPU sectors.
- Emissions from production of urea and its consumption in catalysts is reported in the IPPU sector, emissions from application of urea to soils is reported in the agriculture sector. A Party can account for removals from urea production in IPPU only if it can account for its use.

- Emissions from production of fertilizers are reported in the IPPU sector, emissions from the application of fertilizers under the agriculture or LULUCF sectors.

- Emissions from treatment of industrial solid waste reported under the waste sector
- Emissions from industrial wastewater reported under the waste sector
- F-gas emissions from disposal are reported under the IPPU sector

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

C. Figure 2-1. Interactions between the IPPU sector and other inventory sectors

The logic of the 2006 IPCC Guidelines is that emissions are to be reported where they actually occur in open air. For example, if blast furnace gas is combusted entirely within the iron and steel industry (whether for heating blast air, site power needs or for metal finishing operations), the associated emissions are reported in the IPPU category 2.C.1, Iron and steel production. However, if part of the blast furnace gas is delivered to a nearby brick works for heat production or to an electricity producer, then the emissions are reported in category 1.A.2.f or 1.A.1.a (both under the energy sector).

Other examples may be CO_2 emissions from the production of urea, and its consumption in catalyst, which should be reported in the IPPU sector, and CO_2 emissions from the application of urea to soils, which should be reported under the agriculture sector. The same approach applies to lime and fertilizers production, where applications should be reported under the agriculture and the LULUCF sectors.

Apart for misallocation, you should also carefully review if double counting or omissions of emissions occurs in the IPPU sector. For instance, you should coordinate with the energy sector expert to ensure that emissions from reducing agents and process materials (coal, coke, natural gas, etc.) are not double counted or omitted. You will find specific information in the following IPPU lessons for each category.

3.2. Emissions capture, use and destruction

In certain IPPU categories, particularly those with large point sources of emissions (e.g. factories), emissions can be captured and stored, used or destroyed. The 2006 IPCC Guidelines specifically include methods to account for these activities. Capture is incorporated into equations by means of an additional term that represents either a measured quantity of capture or the efficiency of an abatement system in combination with that system's utilization throughout the year (for energy see 2006 IPCC Guidelines, vol. 2, chap. 2, section 2.3.4; and for IPPU see vol. 3, chap. 1, sections 1.2.2 and 3.1).Often a partial or full abatement of GHG emissions from a process can occur by means of off-gas treatment, for instance the destruction of GHGs by post-combustion. Tier 1 methods are not appropriate for tracking capture or abatement and, in the absence of country-specific data, the assumption should be that no capture or abatement are taking place. Regarding CO_2, quantities of CO_2 captured for later use and short-term storage should not be deducted from CO_2 emissions except when the CO_2 emissions are accounted for elsewhere in the inventory: examples include urea production (2006 IPCC Guidelines, vol. 3, chap. 3, section 3.2) and the use of CO_2 in methanol production (2006 IPCC Guidelines, vol. 3, chap. 3, section 3.9).

To learn more, see volume 2, chapter 2, section 2.3.4 (stationary combustion) and volume 3, chapter 3, sections 1.2.2 and 3.1 (chemicals) of the 2006 IPCC Guidelines.

3.3. Non-energy uses of fuels

The non-energy uses of fossil fuels encompass their uses as feedstock, reductants and non-energy products, in which their properties are used directly rather than combusted for energy purposes. Particularly for the case of fossil fuels being used as feedstock, you should have a thorough understanding of the issues associated with reporting emissions under the IPPU and energy sectors. For a description of these issues, see the text boxes below and section 1.3, chapter 1, volume 3 of the 2006 IPCC Guidelines.

During the review, you need to check whether a Party has differentiated and correctly reported the use of fossil fuels and the associated GHG emissions within the IPPU and energy sectors. You should also check that double counting does not occur and that overestimation or omissions of emissions do not occur. In this regard, close coordination with the energy expert is needed.

Feedstock

Feedstocks are fossil fuels that are used as raw materials in chemical conversion processes in order to produce primarily organic chemicals and, to a lesser extent, inorganic chemicals (especially ammonia) and their derivatives. In most cases, part of the carbon remains embodied in the product manufactured. The use of hydrocarbon feedstocks in chemical conversion processes is almost entirely confined to the chemical and petrochemical industries.

Reductants

Carbon is used as a reducing agent for the production of various metals and inorganic products (see the 2006 IPCC Guidelines, vol. 3, chaps. 4 and 3, respectively). It is either used directly as a reducing agent or indirectly via the intermediate production of electrodes used for electrolysis. In most cases, only very small amounts of carbon are embodied in the product manufactured, while the major part is oxidized during the reduction process.

Non-energy products

Apart from fuels, refineries and coke ovens produce some non-energy products that are used directly (i.e. without chemical conversion) for their physical or diluent properties, or that are sold to the chemical industry as chemical intermediates. Lubricants and greases are used in engines for their lubricating properties; paraffin waxes are used as candles, for paper coating etc.; bitumen is used on roofs and roads for its waterproofing and wear qualities. Refineries also produce white spirits, which are used for their solvent properties.

3.4. Overview of IPPU sector reporting tables

It is convenient to keep the MPGs to hand, which present the information to be reported in the national inventory report of anthropogenic emissions by sources and removals by sinks of GHGs and the general structure of the CRTs; you may also download the complete set of tables at https://unfccc.int/documents/310409.

CRT 2 (sectoral report for IPPU) provides information on reported emissions of each GHG and precursor gases for all categories in the IPPU sector.

More disaggregated information, including emissions of each GHG (in kilotonnes) per each category, is reported in CRT 2(I)A-H (sectoral background data for IPPU).

In addition to the GHG emissions, the reported information includes AD (consumption/production of each main product/substance) and the resulting IEFs. Each IEF is calculated by the reporting software as the ratio between reported emissions and the corresponding AD (usually consumption/production of each type of product/substance).

There may be cases where a Party estimates emissions from a category for which the 2006 IPCC Guidelines do not include a methodology but the 2019 Refinement to the 2006 Guidelines does. For instance, in the drop-down lists of a specific category in the CRT tables, you may find subcategories for which estimation methodologies are included in the 2019 Refinement to the 2006 IPCC Guidelines but not in the 2006 IPCC Guidelines. While estimating emissions from these categories is optional, if a Party estimated those emissions you should review the estimates carefully, because the emissions will be included in the national totals

4. General approach in reviewing the IPPU sector

4.1. Preparing for the review

There is relatively short time available during the review week. It is particularly important, therefore, that as a reviewer you prepare in detail in the weeks **before** the review week by examining the inventory submission and sending preliminary questions to the Party under review to seek necessary clarifications, so that you will already be able to deepen some aspects, discuss with the other review experts and lead reviewers before the review week. You could then finalize the review report during the review week itself.

The review process involves three phases:

Prepare	Download and familiarize yourself with all the materials needed to undertake the review
Assess	Evaluate the follow-up of previous recommendations and make your own evaluation leading to findings (add value)
Draft	Write the components of the IPPU sector in the review report

Communication is also a relevant skill that you need to use during the three phases of the review process. You may refer to lesson 6 of the Overview course for greater detail on that topic. Figure 2-2 below illustrates in more detail the main tasks for each stage.

	Prepare	Assess	Draft
Before review week	• Refresh knowledge of 2006 IPCC Guidelines, latest decisions and LR conclusions • Read submission (CRT and NID) • Identify previous recommendations and encouragements • Familiarize self with latest review tools	• Evaluate whether Party addressed findings contained in previous review report • Detailed analysis of submission against TACCC principles, including AD, EF and parameters, beginning with key categories and using review tools to facilitate work • Assess institutional arrangements for sector • Assess other cross-cutting issues (QA/QC, uncertainty, time-series consistency, recalculations, planned improvements) • If relevant, identify possible capacity building needs • Discuss questions issues with expert team, as needed	• Draft preliminary questions, and follow up questions as necessary • Begin drafting review report based on findings
During review week	• All preparations should be done prior to the review week		• Finalize questions to Party early in week • Draft assessment of implementation of previous recommendations • Draft new recommendations/ encouragements, as appropriate • Fully complete first draft of your report, responding to comments from team • If relevant, consult with Party to draft capacity building needs
After review week			• Finalize draft report • Respond to UNFCCC and Party comments

D. Figure 2-2. Main tasks for each stage of the review of the inventory

5. Practical exercises

5.1. Exercise 1

A Party has calculated its CO_2 emissions from cement production using a tier 1 methodology and the IPCC default EF for clinker after converting the amount of cement produced into clinker consumption data. From the results of the key category analysis, reported in the NID, CO_2 emissions from cement production is a key category for the Party.

Question 1

What step would you take as a reviewer?

Select one:

A. Recommend that the Party use a higher-tier method

B. Review the Party's NID to see if there is a justification for the use of a tier 1 method (e.g. lack of data)
C. If an issue of national circumstances is appropriately justified in the NID, encourage the Party to use a higher-tier method, acknowledging the Party's national circumstances
D. B and C

Answer

The correct answer is (D).

One possible way to approach the issue would be the following:

Prepare

The TERT should first check the 2006 IPCC Guidelines (vol. 3, chap. 2, fig. 2.1), which indicates that when CO_2 emissions from cement production is a key category, Parties should use a tier 2 or 3 method. However, you should then assess the Party's NID to check whether the Party reports national circumstances as a justification for the use of a tier 1 method.

Assess (through communication with the Party)

Assuming that national circumstances are used as a justification for the use of a tier 1 method, the TERT may wish to seek further information from the Party as to why higher tiers have not been applied and attempt to verify the lack of available data to undertake a higher-tier method. If information is not provided in the NID or it is not sufficiently detailed, you would ask the Party to provide more information.

Then you and the other members of the TERT have to decide, based on the TERT's understanding of the national circumstances of the Party, whether to accept the justifications provided by the Party.

Draft

If you and the TERT accept the national circumstances, an encouragement is more appropriate than a recommendation. You may encourage the Party to provide in the improvement plan its future steps towards applying a higher-tier method to estimate emissions from the key category.

If you do not accept that national circumstances justify the use of tier 1, then a recommendation to apply a higher-tier method may be more appropriate.

It is expected that lack of resources due to national circumstances are considered by developing country Parties more than developed countries.

5.2. Exercise 2

Below is an extract of the results of approach 1 of the 2006 IPCC Guidelines applied by a Party to identify its key categories in its 2024 inventory submission.

Question 1

Looking at the values of the table, what considerations can you make regarding the application of approach 1 of the 2006 IPCC Guidelines?

CATEGORIES	2022	Level assessment	Cumulative Percentage
	CO2 eq		
Transport - CO2 Road transportation	95,795.74	0.22	0.22
Other sectors - CO2 commercial, residential, agriculture gaseous fuels	57,523.40	0.13	0.36
Energy industries - CO2 gaseous fuels	48,773.23	0.11	0.47
Manufacturing industries and construction - CO2 gaseous fuels	32,272.02	0.08	0.55
Energy industries - CO2 solid fuels	29,671.55	0.07	0.62
Energy industries - CO2 liquid fuels	16,635.34	0.04	0.66
Other sectors - CO2 commercial, residential, agriculture liquid fuels	15,038.53	0.04	0.69
Enteric Fermentation- CH4	14,202.26	0.03	0.72
Product uses as substitutes for ozone depleting substances - HFCs (Refrigeration/Air conditioning/ Foam blowing)	14,067.94	0.03	0.76
Solid waste disposal - CH4	13,704.33	0.03	0.79
Manufacturing industries and construction - CO2 liquid fuels	12,487.73	0.03	0.82
Mineral industry- CO2 Cement production	7,756.72	0.02	0.84
Manufacturing industries and construction - CO2 solid fuels	7,635.27	0.02	0.86
Direct N2O Emissions from Managed soils	6,709.63	0.02	0.87
Other sectors - CO2 commercial, residential, agriculture other fossil fuels	5,819.98	0.01	0.88
Fugitive - CH4 Oil and natural gas - Natural gas	4,119.89	0.01	0.89
Transport - CO2 Waterborne navigation	4,052.30	0.01	0.90
Manure Management - CH4	3,480.09	0.01	0.91
Wastewater treatment and discharge - CH4	2,443.27	0.01	0.92
Transport - CO2 Civil Aviation	2,318.01	0.01	0.92
Other sectors - CH4 commercial, residential, agriculture biomass	2,233.87	0.01	0.93
Manure Management - N2O	2,188.51	0.01	0.93
Mineral industry- CO2 Lime production	1,868.64	0.00	0.94
Other sectors - N2O commercial, residential, agriculture biomass	1,612.40	0.00	0.94
Indirect N2O Emissions from Managed soils	1,612.21	0.00	0.95
Fugitive - CO2 Oil and natural gas - Oil	1,591.58	0.00	0.95
Rice cultivations - CH4	1,553.04	0.00	0.95
Chemical industry- PFCs Fluorochemical production	1,511.26	0.00	0.96
Metal industry- CO2 Iron and steel production	1,436.24	0.00	0.96
Wastewater treatment and discharge - N2O	1,343.76	0.00	0.96
Non-Energy products from Fuels and Solvent Use - CO2	1,202.16	0.00	0.97

Select one:

A. The Party has followed good practice in disaggregation of categories/gases for the IPPU sector, as provided by the 2006 IPCC Guidelines
B. Further disaggregation may be needed in relation to IPPU categories
C. Three categories are assessed to be key categories for the IPPU sector
D. Both B and C

Answer

The correct answer is (D).

Three IPPU categories have been identified as key: CO_2 emissions from cement production, CO_2 emissions from lime production, and product uses as substitutes for ODS (HFCs from refrigeration, air conditioning and foam blowing). However, the Party has not followed the disaggregation indicated in table 4.1 of the 2006 IPCC Guidelines (vol. 1, chap. 4) for the category Product uses as substitutes for ODS. The guidelines disaggregate this category into six subcategories: 2.F.1 refrigeration and air conditioning; 2.F.2 foam blowing agents; 2.F.3 fire protection; 2.F.4 aerosols; 2.F.5 solvents; and 2.F.6 other applications.

After this assessment you would likely ask the Party the reason for not following the disaggregation indicated in table 4.1 of the 2006 IPCC Guidelines. Some Parties may answer that this is something planned for future submissions.

Finally, you could consider suggesting to the Party to use the category codes, in addition to the category names.

Question 2 (follow-up)

Let's continue with the previous example about the identification of key categories and the different disaggregation. As a reviewer, which is the best choice?

A. You would recommend that the Party follow the disaggregation consistent with the 2006 IPCC Guidelines (vol. 1, chap. 4, table 4.1)
B. You would encourage the Party to follow the disaggregation indicated in the 2006 IPCC Guidelines (vol. 1, chap. 4, table 4.1)

Answer

The correct answer is (B).

The level of disaggregation indicated in table 4.1 of the 2006 IPCC Guidelines (vol. 1, chap. 4) is something that the Party may choose to follow but other levels of disaggregation may be used by the Party.

Key categories are those that, when summed together in descending order of magnitude, add up to 95 per cent of the national sum of the absolute value of emissions and removals, including and excluding LULUCF. Paragraph 25 of the MPGs indicates that flexibility may be used to identify key categories using a threshold no lower than 85 per cent in place of the 95 per cent threshold defined in the 2006 IPCC Guidelines.

Consequently, the Party may use less complex methodologies (i.e. tier 1) to estimate GHG emissions and removals for categories that are not key.

In Exercise 2 above, in the case of flexibility, the Party would identify two key categories in the IPPU sector because CO_2 from lime production would no longer be key.

5.3. Exercise 3

A Party estimates CO_2 emissions from cement production using the tier 2 method of the 2006 IPCC Guidelines based on national data on clinker production and a national emission factor (EF) derived from country-specific data on the amount of lime (CaO) in clinker.

In the absence of detailed information on uncertainty values, the Party uses default IPCC uncertainty figures for both the AD and the EF.

Question 1

As a reviewer, which is the best choice?

Select one:

A. Recommend that the Party develop the appropriate national uncertainty value for each parameter
B. No need to do anything
C. Encourage the Party to develop country-specific uncertainty values

Answer

The correct answer is (C).

A Party may use default uncertainty values, nevertheless it would always be better that a Party derives its country-specific uncertainty values.

In the IPPU sector, uncertainty can be derived: for AD from the statistical offices or data providers; or for the EF and other parameters from the industry itself through values derived by measurements or expert elicitation.

Even though uncertainty should not be confused with variability (see 2006 IPCC Guidelines, vol. 1, chap. 3), it is also true that sometimes the range of variability may be assumed as a measure of uncertainty for a specific parameter.

Paragraph 29 of the MPGs indicates that flexibility may be used to provide, at a minimum, a qualitative discussion of uncertainty for key categories, using the 2006 IPCC Guidelines, for both the latest inventory year and the trend, instead of quantitatively estimating and qualitatively discussing the uncertainty of the emissions and removal estimates for all categories.

6. Self-check quiz

6.1. Questions

Question 1

Is this statement correct? “The qualitative criteria for determining key categories are usually not relevant to the IPPU sector.”

Select one:

A. True
B. False

Question 2

There can be different situations where a Party may report “C” (confidential), instead of reporting the actual figures in a category, especially in the IPPU sector. Which of the following statement(s) is correct?

Select one:

A. A Party may not use “C”for key categories
B. The use of “C” is only allowed for production data
C. The use of “C” is only allowed for emissions
D. None of the above

Question 3

A Party has reported HFC and PFC emissions from the subcategory solvents as "NE" in its NID, but as "NO" in the relevant CRT for the entire time series. In the NID, the Party indicated that it has not been able to estimate the amount of solvents used containing HFCs and PFCs, and that "users were contacted and they provided information that their use of solvents containing HFCs and PFCs is very limited or non-existent".

As a reviewer, what is the best choice?

Select one:

A. Recommend that the Party improve the consistency between the NID and the CRT
B. Recommend that the Party add to the NID a sentence that explicitly reports "the industrial association indicates that solvents are estimated to contribute only a very minor share of the emissions of halocarbons, but it has not been possible to quantify the amount and improve the consistency between the NID and the CRT"
C. Recommend that the Party estimate the emissions or provide evidence of their insignificant levels in accordance with paragraph 32 of the MPGs and improve the consistency between the NID and the CRT

Question 4

A Party reported N_2O emissions from aerosols as "NE" for the entire time series. In response to questions raised during the review, the Party explained that efforts are ongoing to collect data on the used amounts of canned whipped cream and the content of N_2O, but it is not clear when all the data will be available for the GHG inventory.

As a reviewer, which is the best choice?

Select one:

A. The TERT welcomes the Party's efforts and encourages the Party to continue its efforts to collect data and report the emissions in its next submission
B. The TERT recommends that the Party estimate these emissions or provide evidence of their insignificant levels in accordance with paragraph 32 of the MPGs.

Question 5

CO_2 emissions from titanium dioxide production is not a key category for a developed country Party. In CRT 2(I).A-Hs1, the Party reported "IE" for AD and "NE" for CO_2 emissions and recovery. In the related section of the NID, the Party explains that those emissions were insignificant based on a study conducted in the past years, CO_2 emissions from this facility's chloride process are very small, less than 0.05 per cent of the national level, and is therefore considered insignificant (citing decision 18/CMA.1, annex, para. 32).

As a reviewer, which is the best choice?

Select one:

A. You would ask the Party to clarify the use of "IE" for AD
B. You would ask the Party for a rough estimate of these emissions
C. You would need to report back to your colleagues in the TERT to check the sum of insignificant sources to ensure they are below the levels contained in paragraph 32 of the MPGs
D. All of the above

Question 6

A Party estimates PFC emissions from aluminium production using a tier 1 method for 1990–1999 and a tier 2 method from 2000 onwards. As it was not possible for the Party to derive site-specific data from the operators for the first period of the time series, and because the Party documents that technology upgrades in the industry in recent years make tier 2 methods not appropriate for earlier years, the Party decided to retain the two separate methods for the periods (tier 1 for 1990–1999 and tier 2 from 2000).

The Party also reported in its NID a comparison of estimates carried out by applying the two methods in the entire time series ("tier 1 and tier 2") and estimates carried out by extrapolating tier 2 data from 2000 back to 1990.

Is this approach consistent with the 2006 IPCC Guidelines?

Select one:

A. Yes, assuming documentation is sufficient

B. No

Question 7

Let's assume the Party you are reviewing is a developing country Party. In its NID, the Party states that PFC emissions from aluminium production are estimated for 2005 and from 2020 onwards. A tier 1 method has been used by the Party to estimate PFC emissions for 2005 (reference year of the Party's NDC) and 2020, while a tier 2 method was used from 2021 onward.

As a reviewer, which is the best choice?

Select one:

A. You would encourage the Party to recalculate the entire time series using the tier 2 method from the reference year for the Party's NDC onward
B. You would recommend that the Party recalculate the time series using the tier 2 method at least from 2020
C. You would recommend that the Party recalculate the time series using the tier 2 method for all estimated years (2005 and from 2020 onward)
D. You would encourage the Party to recalculate using the tier 2 method at least from the year 2020 because, in the light of flexibility, the Party may choose not to estimate PFC emissions for the entire time series

Question 8

A Party reports in its submission N_2O emissions from adipic acid production. In its NID, the Party explains that these emissions are provided by the relevant national industry. The NID includes the following information on the introduction of the abatement technology from a certain year of the time series: The operator introduced an abatement system in 2005. In 2005, the N_2O catalytic decomposition thermal destruction abatement technology was tested so that the EF declined, taking into account the efficiency and the time (one month) that the technology operated in 2005. The abatement technology has been fully operational since the end of 2006. The average EF in 2007 was equal to 0.05 kg N_2O/kg adipic acid produced and the abatement system operated continuously for 9 months; between 2008 and 2010 the average EF was 0.03 kg N_2O/kg adipic acid produced and the operating time of the abatement system was, on average, 11 months. In 2011 the average EF was 0.019 kg N_2O/kg adipic acid produced while in 2012 the average EF was 0.005 kg N_2O/kg adipic acid produced, with the abatement rate exceeding 98 per cent.

The NID also indicates that the operator has an N_2O monitoring system in place and reports the same information under different national and international directives.

In the review report, the TERT has included the following recommendation: "The TERT recommends that the Party include additional justification for the abatement efficiency of the production facility in its next submission."

What is wrong with this last statement by the TERT?

Select one:

A. Nothing because the abatement efficiency cannot reach the 98 per cent
B. The TERT should have made an encouragement because a lot of information is already there
C. Nothing because the TERT can always recommend the reporting of additional information
D. The recommendation is not focused

Question 9

A Party estimated CO_2 emissions from ammonia production using the tier 1 method of the 2006 IPCC Guidelines, but appled an oxidation factor of 99.5 per cent. In the following submission, the Party submitted estimates that did not include the oxidation factor (i.e. the estimates used 100 per cent oxidation).

The Party included this description in its NID: The country-specific EF inclusive of oxidation has been revised in this submission from 51.15 to 51.41 Gg CO_2/PJ natural gas consumed. This revision amends the assumed oxidation factor of 99.5 per cent to 100 per cent in line with the 2006 IPCC Guidelines. The impact of this revision is set out below:

	Previous submission	Current submission	Change
	kt CO_2 eq.	kt CO_2 eq.	%
1990	2 053	2 057	0.2
2000	3 475	3 480	0.2
2005	5 504	5 513	0.2
2010	6 835	6 848	0.2
2015	6 023	6 035	0.2

Select one:

A. The recalculation is transparently explained and you are satisfied with it. Therefore, you conclude that the recalculations are transparently described in the Party's NID

B. You conclude that a more detailed explanation about the recalculation should have been included and concluded that the description is not detailed enough

6.2. Answers

Answer 1

The correct answer is (B).

Some categories within the IPPU sector result in GHG emissions from new sources or emissions that may be expected to grow significantly in the future. Initially, their emissions may be too small to be listed as key categories using approach 1 to assess the categories by level (even though it may be key by trend). Designating it as a key category using qualitative criteria because it has significant growth potential (on a GWP-weighted basis) may result in using a higher-tier method from the beginning and reduce the need for methodological changes and collection of difficult to obtain historical data at a later stage (when the category becomes key by level or trend). Reviewers should review any qualitative assessment of key categories carried out by the Party in its NID. If a Party has not undertaken such an assessment, the TERT may encourage the Party to do so, noting the relative importance of this assessment for the IPPU sector.

It is worth noting that flexibility may be applied (para. 25 of the MPGs).

Answer 2

The correct answer is (D).

Parties may use confidentiality reasons to avoid disclosure of sensitive information. This rule can be applied at whatever level (emissions, AD, EF and/or related parameters) and category. Nevertheless, the Party should provide transparent information when a question comes from the TERT.

Although a Party may use a notation key for the reporting of AD and emissions for a particular category to avoid disclosure of sensitive information, as a reviewer, you should ask questions to ensure that you are comfortable that the Party has reported the corresponding emissions in the inventory, at a higher level of aggregation. You may also request confidential information from the Party during the review, following established procedures for the protection of confidential information.

Answer 3

The correct answer is (C).

The TERT should recommend that the Party estimate the emissions or provide specific information supporting that emissions are under the threshold indicated in paragraph 32 of the MPGs (Parties may report “NE” for insignificant emissions, but to do so, the Party must provide specific information supporting that emissions are estimated to be under the threshold). The sentence “industrial association indicates that solvents are estimated to only contribute a very minor share of the emissions of halocarbons, but it has not been possible to quantify the amount” would not be sufficient to justify reporting the emissions as “NE”.

The MPGs (para. 32) provide the use of flexibility for developing country Parties who need it in the light of their capacity to consider emissions insignificant if the likely level of emissions is below 0.1 per cent of the national total GHG emissions, excluding LULUCF, or 1,000 kt CO_2 eq, whichever is lower.

For the Parties that do not use this flexibility provision, a category can be considered insignificant only if the likely level of emissions is below 0.05 per cent of the national total GHG emissions, excluding LULUCF, or 500 kt CO_2 eq, whichever is lower.

If flexibility is chosen, the total national aggregate of estimated emissions for all gases from categories considered insignificant shall remain below 0.2 per cent of the national total GHG emissions, excluding LULUCF, as opposed to 0.1 per cent. The Party must provide information on its decision to apply flexibility, its capacity constraints and its time frame for improvements related to those constraints. In addition, the Party must use approximated information to assess the magnitude of the category and provide this information in the NID.

Answer 4

The correct answer is (B).

The estimation of N_2O emissions from product uses (e.g. anaesthesia, food) is mandatory because both a method and a default EF are provided in the 2006 IPCC Guidelines.

To learn more consult section 8.4, chapter 8, volume 3 of the 2006 IPCC Guidelines.

Answer 5

The correct answer is (D).

As a reviewer you would need to check all these issues: if the use of “IE” for AD is correct; a rough estimate of the emissions to check their estimated level; if the emission level is below 0.05 per cent of the national total GHG emissions, excluding LULUCF, or 500 kt CO_2 eq, whichever is lower; and share your finding with the TERT because the generalist needs to check the level all the “NE” categories (the total national aggregate of estimated emissions for all gases from categories considered insignificant must remain below 0.1 per cent of the national total GHG emissions, excluding LULUCF). As this is a developed country Party, it is not able to apply flexibility in the level of the significance threshold.

Answer 6

The correct answer is (A).

In general, the same method and data sources should be used in the estimations for all years. However, it is recognized that, due to the introduction of new gases, new estimation methods, national circumstances (e.g. introduction of a facility-level reporting programme), additional and better data may be available in recent years (even in the absence of changes to the production process) to allow for use of a higher-tier method. Under these circumstances, Parties should make all efforts to apply that method back through the entire time series. Where this is not possible, the 2006 IPCC Guidelines (vol. 1, chap. 5) provide different techniques for "combining" one or more methods (e.g. overlap method, use of surrogate data, interpolation, extrapolation). The best technique to use will depend on many circumstances, to be considered by the Party and documented in the NID.

However, the Party may determine that due to technological changes in the industry or other factors, it is best not to combine methods and that using one method for the earlier part of the time series (up to the change in technology) and another method for the latter part of the time series is most appropriate, as is the case in this example. Proper documentation and justification is necessary.

To learn more, consult chapter 5, volume 1 of the 2006 IPCC Guidelines.

Answer 7

The correct answer is (C).

In the light of flexibility, the Party must report a consistent time series covering at minimum the reference year or period for the Party's NDC and, in addition, a consistent annual time series from at least 2020 onward but the same method should be applied.

Paragraph 57 of the MPGs indicates that in place of the mandatory requirement to report a consistent annual time series starting in 1990, developing country Parties have flexibility to report data covering, at a minimum, the reference year or period for a Party's NDC and, in addition, a consistent annual time series from at least 2020 onward.

Answer 8

The correct answer is (D).

Since the Party has already reported information on the abatement system, the TERT should be clear on what is missing from its point of view (e.g. if the type of abatement technology cannot reach the 98 per cent abatement efficiency; if the values are high compared with those reported in the 2006 IPCC Guidelines; if the TERT is concerned about the information provided for a specific year(s) or for the time series). Since there could often be something to improve in the description of the estimation method, after thinking of what additional information is really essential, there are simple points you

should concentrate on when talking of “transparency”. The most important is avoiding generic statements and vague sentences when asking question to the Party or writing the review report. You should specify what exactly the problem is (i.e. what information is missing), why it is an issue and how it could be solved. Examining what the 2006 IPCC Guidelines suggest be included in the reporting and documentation for a specific category is a good guide for what information in the NID makes reporting of a category “transparent”.

Answer 9

The correct answer is (A).

The recalculation does not affect problems other than the use of an oxidation factor, which is a rather simple recalculation. If you think the description provided is not sufficient you should specify which information is missing from your point of view.

7. Key points to remember

- Get prepared before the review week by examining the Party’s inventory submission and completing the tasks planned for before the review week (see Figure 2-2 in this course).
- Obtain an overall picture of the inventory and check it in terms of transparency, accuracy, completeness, consistency and comparability.
- Recognize that developing country Parties that need flexibility in the light of their capacity may apply this flexibility; as a reviewer you can assess that relevant information is provided in the NID but you may not question the Party’s choice to apply flexibility.
- Consider potential cross-sectoral potential interactions.
- Assess the appropriateness of the key category analysis and methods selection.
- Assess the uncertainty analysis.

Note the relevance of new gases and/or categories (checking whether any of them can be assessed as a key category based on the qualitative criteria, e.g. expected growth is foreseen) and the related uncertainty.

Lesson 3. Mineral industry

1. Introduction and objectives of the lesson

1.1. Lesson outline

This lesson is organized into six sections and helps you focus on what best complements your prior knowledge of the topic:

1. Introduction and objectives of the lesson
2. Category overview and methodological information
3. Review approach
4. Practical exercises
5. Self-check quiz
6. Key points to remember

1.2. Categories in mineral industry

The categories considered in this lesson pertain to the mineral industry, and their codes in the CRTs are as follows:

- 2.A Mineral industry;
- 2.A.1 Cement production;
- 2.A.2 Lime production;
- 2.A.3 Glass production;
- 2.A.4 Other process uses of carbonates:
  - 2.A.4.a Ceramics;
  - 2.A.4.b Other uses of soda ash;
  - 2.A.4.c Non-metallurgical magnesia production;
  - 2.A.4.d Other.

This list of categories is consistent with the set of CRTs. Any of these categories could be a key category for a Party and, as such, should be placed relatively high up on your list of priorities when reviewing it. You should refer to the 2006 IPCC Guidelines (vol.3, ch.1) for the methodologies to estimate emissions from these categories. Some of the main problems you may encounter when reviewing emissions from these categories are also discussed in this lesson.

The expected time needed to complete lesson 3 depends on the level of your knowledge of GHG inventories for the IPPU sector under the ETF and the 2006 IPCC Guidelines

- For readers with experience: 15–30 minutes
- For readers with less experience: 30–50 minutes

1.3. 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 mineral industry;
- Identify whether a Party's reporting for mineral industry is consistent with the requirements of the MPGs;
- Draft key review recommendations to Parties in relation to emissions from mineral industry.

2. Category overview and methodological information

2.1. Overview

With regards to GHG emissions, only CO_2 emissions are relevant for the categories under mineral industry. There are no emissions (or emissions may occur but there are no default EFs in the 2006 IPCC Guidelines; see table 1.1 in vol.3, chapter 1, of the 2006 IPCC Guidelines) for CH_4, N_2O, HFCs, PFCs or NF_3 emissions from categories under the mineral industry. Indirect gases, such as sulfur dioxide, may also be emitted from cement production. The categories in mineral industry share a common approach to methodological tiers for CO_2 emissions. Tiers 1 and 2 are based on estimates of the amount of raw materials consumed or products manufactured, and EFs that represent the amount of CO_2 emitted per unit of mass. Tier 3 describes direct calculations based on the site-specific composition of raw materials. If site-specific raw materials composition data are used, it is crucial that all sources of carbonate in the raw materials and fuels are accounted for (not just the limestone). The basic emission calculations for all carbonate-burning industries are based on common formula weights and CO_2 ratios. The 2006 IPCC Guidelines provide formula weights and CO_2 ratios of common carbonate species that can be used for basic emission calculations for all carbonate-burning industries.

For each category, a brief description of the estimation method is given with reference to the decision trees in the 2006 IPCC Guidelines, the choice of AD and EFs, how to deal with CO_2 capture, and the reporting in the CRTs.

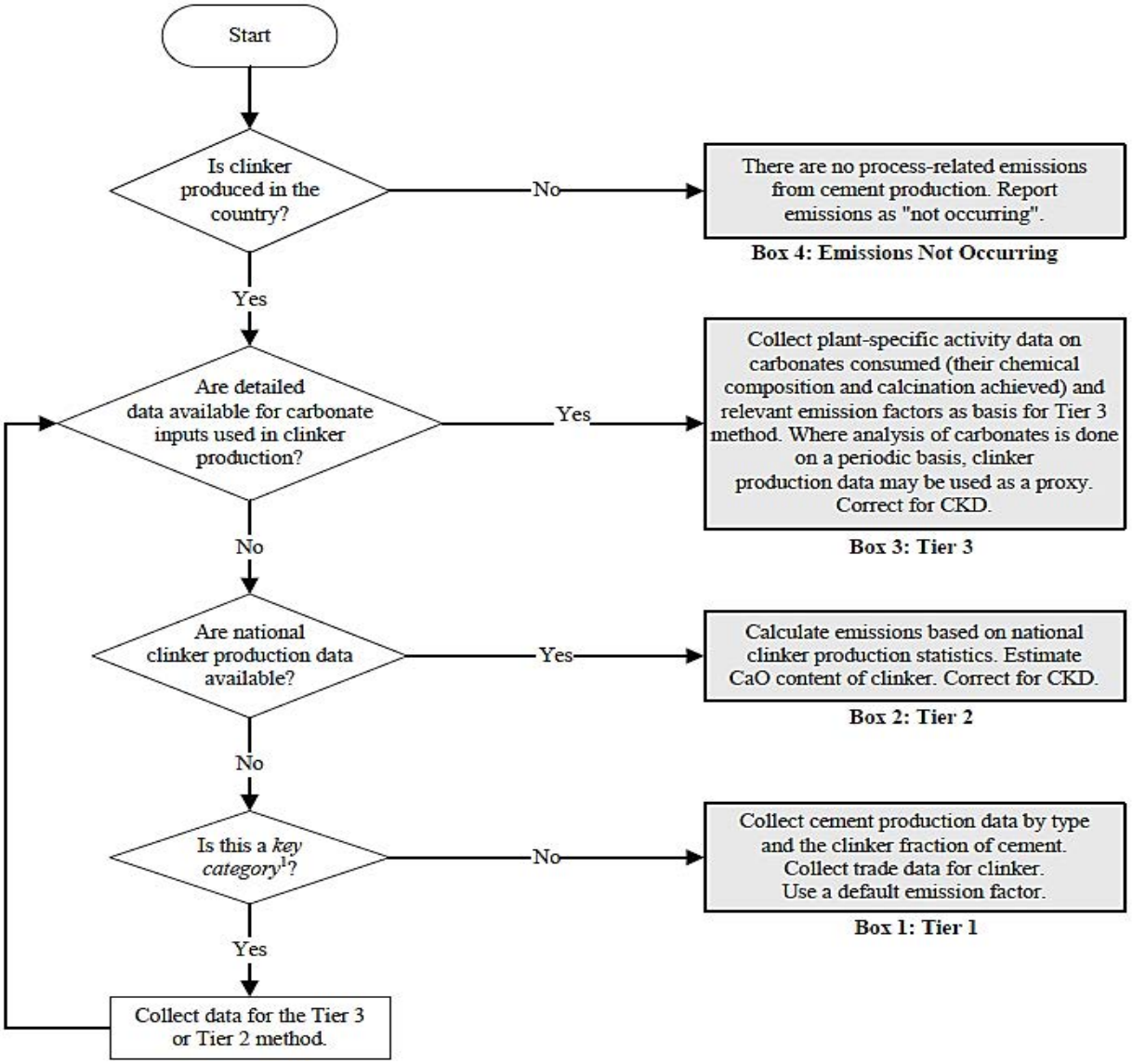
Regarding completeness when plant-specific data are used, comparing, where feasible, total carbonate consumption for the subcategory under 2.A (based on aggregation of subcategory data) with statistical data on carbonate consumption for that subcategory.

2.2. Cement production (category 2.A.1)

CO_2 emissions from cement production is a key category for most Parties, and so it is important that reviewers fully understand the contents of the 2006 IPCC Guidelines for this category (e.g. tiers, data collection, reporting and documentation).

Choice of tier

There are three different methodological tiers available in the 2006 IPCC Guidelines for estimating CO_2 emissions from cement production (see fig. 3-1). See also 2006 IPCC Guidelines, volume 3, chapter 2, section 2.2.



E. Figure 3-1. 2006 IPCC Guidelines decision tree for estimation of CO_2 emissions from cement production

Priorities and potential key issues to consider during a review

For cement production, you should give special attention to *completeness* of the estimates and *time-series consistency*.

Completeness

Regarding completeness, if a Party has estimated emissions from cement production using a tier 1 method (i.e. emissions are based on clinker production), then you should check whether the Party has accurately reflected data on clinker imports and exports in the emission calculations. Emissions from the production of **imported** clinker should not be included in national emission estimates of the importer (i.e. imported clinker should be subtracted from total clinker consumption), as these emissions were produced and accounted for in another country. However, emissions from the production of clinker that is **exported** should be considered when estimating national emissions.

Completeness must also be checked when a Party uses plant-specific data to estimate emissions with a tier 3 method. Even if all plants are considered, care should be taken that all carbonates consumed to make clinker are included in the emission calculations; in some cases, data on the fraction weights of carbonates consumed may not be readily available. A good approach is to compare aggregated plant-specific data with statistical data on cement production, clinker production or carbonate consumption for cement production where available.

If companies provide emission data directly to the Party, care should be taken to avoid not counting or, on the contrary, double counting emissions from the fuel used to fire the kiln (emissions from fuel should be reported in the energy sector, so you should interact with the energy review expert to check the issue). Another potential double counting: reviewers should review the category Other process uses of carbonates to ensure emissions from carbonates used for cement production are not already reported there.

Consistency

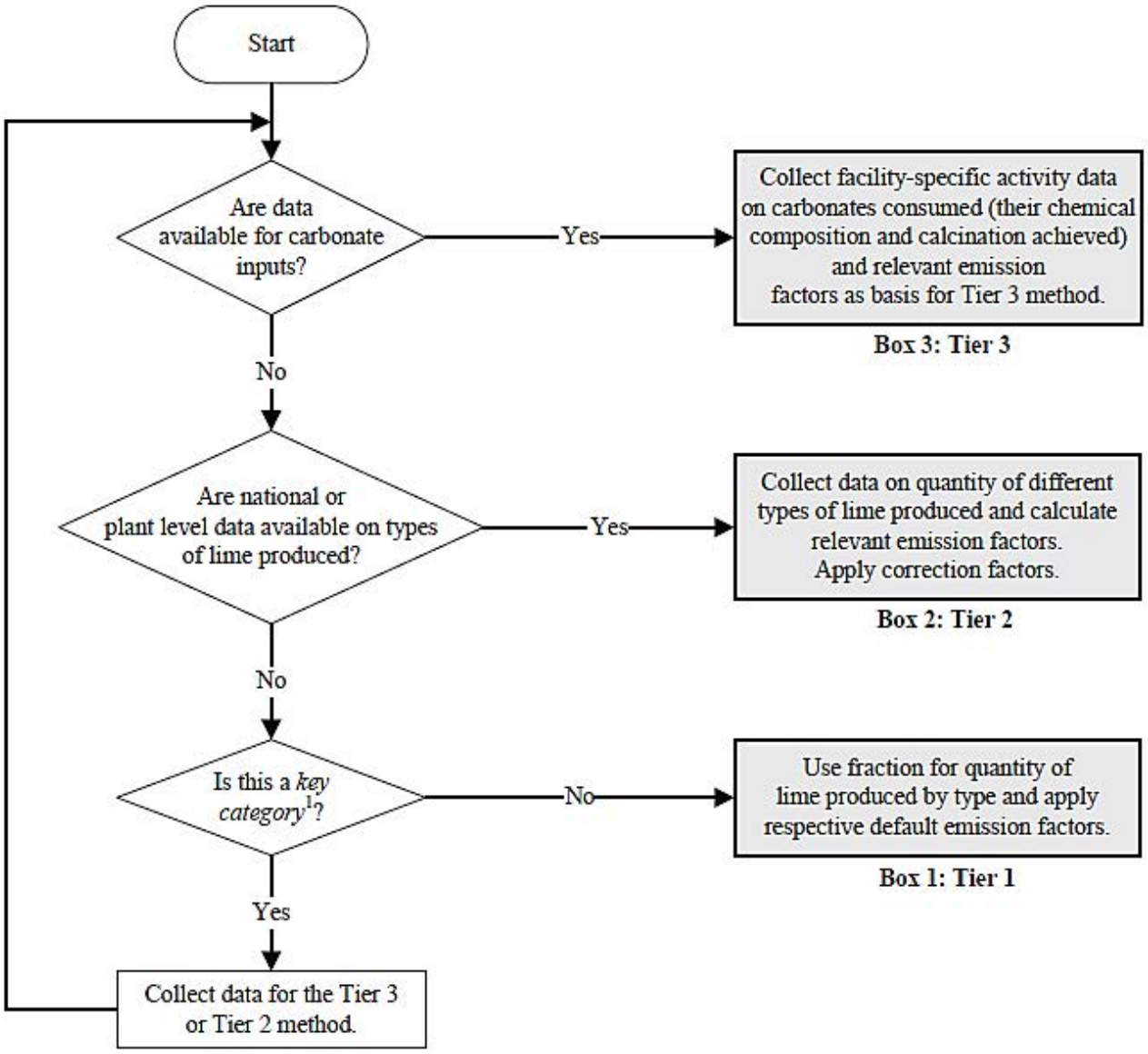
Another issue to consider is the consistency of the time series, with regard to the method applied. Where data to use a higher tier are not available for a part of the time series, for instance on carbonate inputs, the overlap approach may be needed (see the 2006 IPCC Guidelines, vol.1, section 5.3) to recalculate the time series. The relationship between emissions estimated using the tier 3 and the tier 2 method should be relatively constant over time for a given plant, but may fail if the character of the industry in the Party has changed significantly over time. Once that has been established, previous estimates can be recalculated based on this relationship. As a reviewer, you should consider and evaluate whether, when the same method is not used along the time series, the relevant technique has been used by the Party to ensure the consistency of the time series (see the 2006 IPCC Guidelines, vol. 1, table 5.1) or, in case of other techniques chosen by the Party, the appropriate documentation has been provided to justify the choice (e.g. change in technical conditions due to the introduction of mitigation technology).

2.3. Lime production (category 2.A.2)

Default EFs and lime composition values are provided in the 2006 IPCC Guidelines (vol. 3, section 2.3.1.2).

Choice of tier

There are three different methodological tiers available in the 2006 IPCC Guidelines for estimating CO_2 emissions from lime production (see fig. 3-2).



F. Figure 3-2. 2006 IPCC Guidelines decision tree for estimation of CO_2 emissions from lime production

Priorities and potential key issues to consider during a review

Completeness

The accuracy of lime production emission estimates primarily depends on knowing the total amount of lime produced in the country (high-calcium lime, dolomitic lime and hydraulic lime). As these minerals are also used as feedstocks for other industrial processes, complete production statistics might be difficult to obtain, and completeness is an important principle to assess.

You should check carefully whether the Party has submitted complete AD on lime production. Typically, reported production accounts for only a portion of the actual production, if lime production is considered to be the only product that is sold on the market. Use or production of lime as a non-marketed intermediate is often not well accounted for or reported (e.g. production of lime in a steel factory may not be reflected in the national statistics, and the same may be true of other industries producing lime in association with soda ash, CaC_2, magnesia and magnesium metal, or copper smelters, sugar mills, and pulp and paper industries). In addition, industries that regenerate lime from waste $CaCO_3$ (e.g. wood pulp and paper plants) are unlikely to report any lime production. Omission of these data may lead to an underestimation of lime production for a country by a factor of 2 or more.

Double counting

Although underestimating AD for lime production is more likely than double counting of AD, double counting is still possible and should be considered. For example, the reviewer should ensure that the carbonates consumed for lime production are not accounted for in the category other product uses of carbonates. In addition, if the emissions from hydrated lime are accounted for without determining whether this lime is not already included in national statistics, double counting is possible.

If companies provide emission data directly to the Party, care should be taken to avoid not counting or, on the contrary, double counting emissions from the fuel used to fire the kiln. (Emissions from fuel should be reported in the energy sector, so you should interact with the energy review expert to check the issue.)

Recovery

Depending on the use of the lime produced, the production of lime may not result in net emissions of CO_2 to the atmosphere. For example:

- Using hydrated lime for water softening results in CO_2 reacting with lime to form $CaCO_3$, resulting in no net emissions of CO_2. Similarly, precipitated $CaCO_3$, which is used in the paper industry and in other industrial applications, is a product derived from reacting hydrated high-calcium quicklime with CO_2;
- During the process of sugar refining, lime is used to remove impurities from raw cane juice; any excess of lime can be removed through carbonization.

There are two important points for the reviewer to consider when determining if recovered emissions are appropriately accounted for:

- Any recarbonization in these specific industries (water softening, paper industry, sugar refining) may be calculated and reported only where validated methods are used to calculate the amount of CO_2 that reacts with lime to reform $CaCO_3$. Where these conditions are met, this recovery may be reported under category 2.H Other. A Party may provide an attestation

from a company regarding the amount of CO_2 recovered; however, this attestation should also include the necessary information on the methods used;

- In some cases, scum (the waste from the sugar-making process) derived and recovered from the sugar industry may then be reapplied to soils to reduce soil acidity and improve plant growth. In scum is recovered, emissions would be subtracted from the IPPU category and any other use of scum should be reported under the relevant sector (e.g. agriculture) and emissions estimated there.

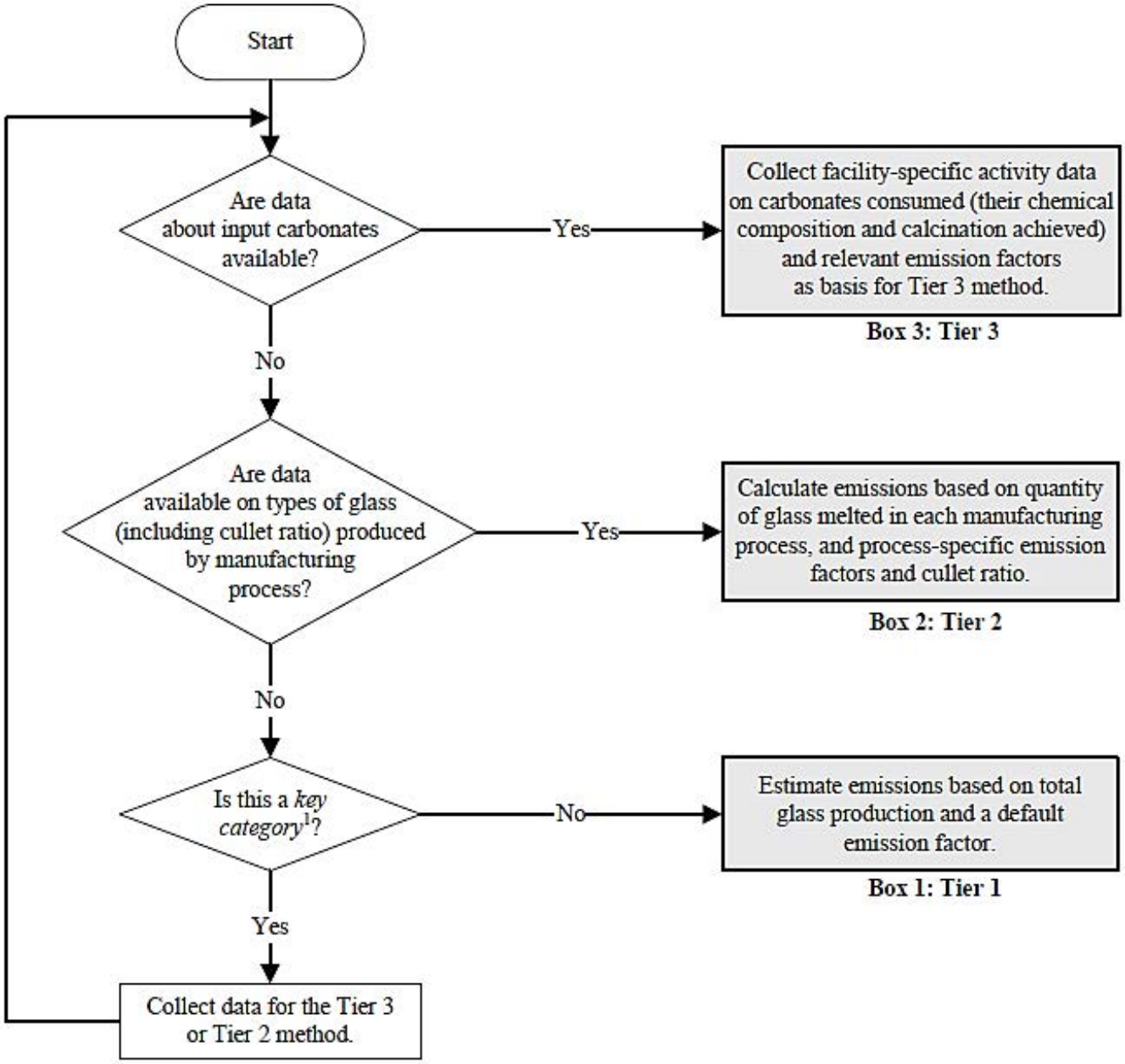
It is good practice to report emissions from the consumption of carbonates in the category where the carbonates are actually consumed and the CO_2 is emitted.

2.4. Glass production (category 2.A.3)

Reference: 2006 IPCC Guidelines (vol. 3, chap. 2, section 2.4).

Choice of tier

There are three different methodological tiers available in the 2006 IPCC Guidelines for estimating CO_2 emissions from glass production (see fig. 3-3).



G.Figure 3-3. 2006 IPCC Guidelines decision tree for estimation of CO_2 emissions from glass production

Priorities and potential key issues to consider during a review

Completeness

Attention should be paid to the completeness of the reporting:

- Where the tier 3 method is used, the reviewer should consider that glass is produced from a variety of raw material carbonates, and it is important to ensure that all species and sources are included in the estimates;
- Most glass manufacturers produce container and/or flat glass, but there may be a number of smaller facilities (e.g. art glass and specialty glass) that are not accounted for in national statistics. Reviewers should make an effort to check whether the Party's AD ensure complete coverage.

Soda ash (Na_2CO_3) is a significant input into glass manufacturing in many countries. CO_2 emissions from soda ash used for glass manufacturing should be reported in this category (2.A.3 glass production), and not under emissions from Other uses of soda ash (2.A.4.b).

The category may include the production of glass wool, a category of mineral wool, where the production process is similar to glass making. The term mineral wool may also be used to refer to natural rock- and slag-based wool. Where the production of rock wool is emissive these emissions should be reported under category 2.A.4 (other process uses of carbonates).

Emissions related to slag production should be reported in the relevant metallurgical source category. The re-melting of slag to make mineral wool does not involve significant process-related emissions and does not need to be reported.

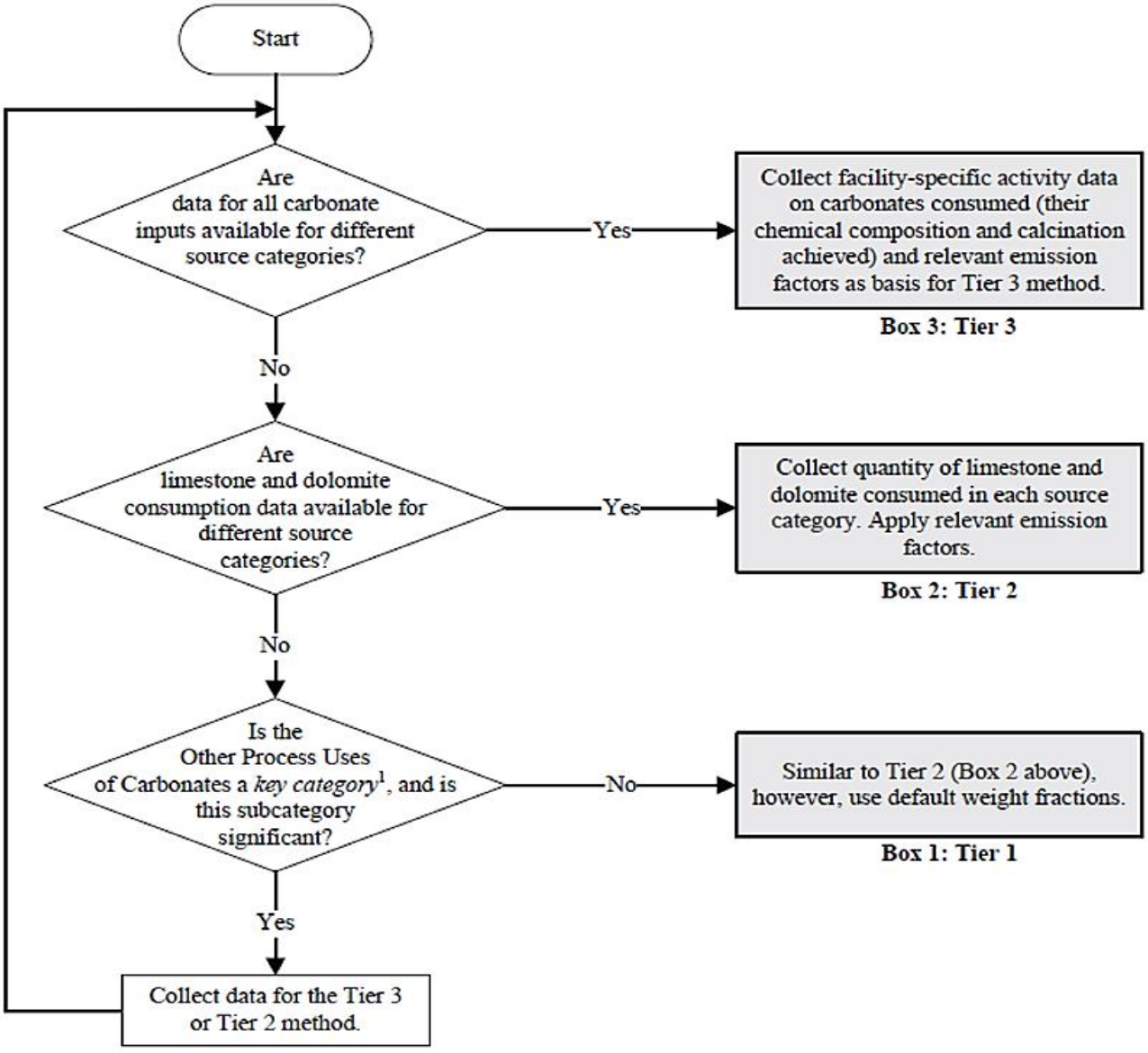
The retention of dissolved CO2 in glass is determined to be relatively insignificant and can be ignored for the purposes of GHG emission estimation.

2.5. Other process uses of carbonates (category 2.A.4)

Reference: 2006 IPCC Guidelines (vol. 3, chap. 2, section 2.5).

Choice of tier

The 2006 IPCC Guidelines provide two primary approaches, broken down into three different methodological tiers, for estimating CO_2 emissions from other process uses of carbonates (see fig. 3-4).



H. Figure 3-4. 2006 IPCC Guidelines decision tree for estimation of CO_2 emissions from other processes use of carbonates

Priorities and potential key issues to consider during a review

Allocation of emissions and time-series consistency

It is important to ensure that the Party has reported the emissions from the consumption of carbonates in the category where the carbonates are consumed and the CO_2 is emitted.

The 2006 IPCC Guidelines (vol. 3, table 2.7) may help in identifying the appropriate emission allocation and cross checks. Uses of carbonates that do not easily fit into one of the end uses shown in that table in the guidelines should be reported under category 2.A.4 (Other process uses of carbonates).

Completeness

Ensuring the completeness of reporting of carbonate uses may be challenging for the Party and the reviewer, not least because of the possibility of underestimating and double counting emissions. Instead of using bottom-up calculations, you may ask for a national mass balance of carbonate consumption, which can help, and may sometimes be necessary, to produce a complete report.

Allocation

Double counting of emissions is a possibility. For example, the subcategory 2.A.4.b Other uses of soda ash should include only those emissions from soda ash not consumed elsewhere (e.g. glass production).

Emissions from soda ash production are to be reported under category 2.B.7 soda ash production, a subcategory under chemical industry (2.B). In addition, for magnesia, where magnesia is produced for use as a fertilizer, emissions should be reported under the chemical industry category 2.B.10 Other.

The reporting of emissions from carbonate use in flue gas desulphurization should be carefully assessed by the reviewer. According to the 2006 IPCC Guidelines (vol. 3, chap. 2, section 2.5), emissions from the carbonate used in flue gas desulphurization should be reported in the category where the carbonates are consumed, which would be the energy sector. It is important to note, however, that the 2006 IPCC Guidelines for the energy sector do not mention emissions from carbonates from desulphurization; the methodological equations and CRTs are fuel specific; and the relevant AD are in terajoules. Parties may have interpreted differently where emissions from this carbonate use should be reported. But emissions from carbonate use in flue gas desulphurization should be reported under CRT category 1.b.2.d (Other (oil, natural gas and other emissions from energy production)) in accordance with the 2006 IPCC Guidelines (vol. 3, chap. 2, section 2.5).

3. Review approach

3.1. Overview

In the following section you will find some examples of potential findings you may be faced with during a review and recommendations you may describe in the relevant tables of the annual review report.

We will consider two cases: in the first you have to fill in a table where recommendations from the previous cycles of reviews are listed; in the second you will need to look for new findings and compile a table in consideration of your own assessment.

- In the table below, you will find some recommendations from the previous reviews. You are asked to indicate if the issue is resolved/not resolved or addressing considering what the Party has reported in its most recent submission (NID/CRT). The type of issue is indicated as Adherence to the MPGs, Completeness, etc.;
- For the new findings, some indications are given so that you will be able to conclude on some issues and give recommendations to the Party. Here you may also indicate the type of issue you have found.

Case 1 (verifying implementation of previous recommendations)

Let's consider an example in the table below.

Status of implementation of issues raised in the previous report of Party K

ID#	Issue classification	Recommendation made in previous review report	TERT assessment and rationale
I.1	2.A.2 Lime production – CO_2 Adherence to decision 18/CMA.1	Collect lime production data so that it may be made available upon request to future TERTs in order to enable them to assess the accuracy, comparability and completeness of the emissions reported under this subcategory in accordance with the UNFCCC review and MPG guidelines.	*Note to the reviewer*: To assess this issue, please read the appropriate section of a Party's NID Lime production (see extract below). We will then conclude whether this issue is resolved or not resolved, explaining the reasons.
I.2	2.A.4 Other process uses of carbonates – CO_2 Completeness	Either estimate and include in the inventory the CO_2 emissions associated with the non-glass use of soda ash or include in the NID a justification, consistent with paragraph 32 of the MPGs, for these emissions being considered insignificant.	*Note to the reviewer*: To assess this issue, you may check the CRT, the relevant cell Other uses of soda ash (2a 4b), and read the appropriate section of the Party's NID (see extract below). We will have all the material to make our conclusion on the issue.

Issue I.1: Party's NID, section on Lime production

The Party's method uses EU ETS data to determine emissions from 2005 onward, pollution inventory (PI) data from 1994 to 2004, and other survey data from 1990 to 1993.

The EU ETS data consist of CO_2 emission estimates (including emissions associated with lime kiln dust) and AD. The AD take various forms (e.g. feedstock or product, depending on site), so the emissions data have been adopted with the lime AD then being back-calculated using a default EF of 121.5 t C/kt limestone or dolomite. This EF is derived by assuming that 85 per cent of national lime production is from limestone and the remaining 15 per cent is from dolomite (based on a recommendation from previous UNFCCC reviews).

For limestone, an EF of 120 t CO_2/kt limestone is assumed, based on the stoichiometry of the chemical reaction. For dolomite, an EF of 130 t CO_2/kt dolomite is used. Prior to 2005 there are no EU ETS data, and data are also missing for 2005–2006 for some lime kilns. Therefore, between 1994 and 2004, CO_2 emission estimates for lime production are based on emissions data published for each site in the PI. The PI data are mostly for total CO_2 (i.e. include emissions from both decarbonization and fuel combustion on a site), but estimates of the CO_2 from decarbonization only are made using EU ETS data and PI data for 2006–2008, both of which give fuel combustion emissions separately from decarbonization.

For 1994–1997 there is less reporting of CO_2 in the PI, so site-specific CO_2 emissions are estimated on the basis of other site-specific data such as emissions data for particulate matter from those sites in the relevant years. The PI data are assumed to cover the same scope as the later EU ETS data (i.e. to include emissions from lime kiln dust as well as lime production).

There are no PI data for 1990–1993, so other survey AD are the only data available to calculate emissions. As emission estimates based on other survey data are consistently lower than emissions from PI and EU ETS sources for 1994 onward it is assumed that survey data for 1990–1993 would also underestimate emissions and the inventory agency has therefore applied a "correction" factor of 1.08 to the survey data for those years.

CRT, relevant cell: Other uses of soda ash (2.A.4.b)

TABLE 2(I).A-H SECTORAL BACKGROUND DATA FOR INDUSTRIAL PROCESSES AND PRODUCT USE Year

Emissions of CO_2, CH_4 and N_2O Submission

(Sheet 1 of 1) Country

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	ACTIVITY DATA		IMPLIED EMISSION FACTORS [2]			EMISSIONS [3]			Recovery/Capture [4] [5]			
	Production/Consumption quantity		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2 fossil	CO_2 biogenic [6]	CH_4	N_2O
	Description [1]	(kt)	(t/t)			(kt)			(kt)			
2.A. Mineral industry						6,249.48			NO	NO		
2.A.1. Cement production	clinker production	7,823.75	0.56			4,409.79			NO	NO		
2.A.2. Lime production	limestone used for lime production	2,361.53	0.45			1,052.06			NO	NO		
2.A.3. Glass production	glass production	2,032.52	0.18			367.98			NO	NO		
2.A.4. Other process uses of carbonates						419.65			NO	NO		
2.A.4.a. Ceramics	bricks production	4,752.32	0.07			312.37			NO	NO		
2.A.4.b. Other uses of soda ash	NO	NO	NO			NO			NO	NO		
2.A.4.c. Non-metallurgical magnesium production	NO	NO				NO			NO	NO		
2.A.4.d. Other	gypsum production	419.42	0.26			107.28			NO	NO		

Here is an extract from the Party's NID, section "Other process uses of carbonates":

Research has been commissioned and is due to report during 2022 on the very low level of emissions from other process uses of carbonates. These new estimates will be reported in the 2025 submission of the Party's GHGI, despite them falling well below the threshold of significance for the inventory.

Status of implementation of issues raised in the previous report of Party K

	Issue classification	Recommendation made in previous review report	TERT assessment and rationale
I.1	2.A.2 Lime production – CO_2 Adherence to decision 18/ CMA.1)	Collect lime production data so that it may be made available upon request to future TERTs in order to enable them to assess the accuracy, comparability and completeness of the emissions reported under this subcategory in accordance with the UNFCCC review guidelines.	Not resolved. The Party was not able to collect complete and consistent lime production data as stated in the section of the NIR. The Party is still using the back-calculation method for determining AD. *Note to the reviewer*: You may also consider whether the Party's method for calculating AD back to the first years of the time series is reliable enough (but you need to ask for some further clarification) and try to conclude and close this issue if the Party states that gathering any further AD from the industry is not practicable
I.2	2.A.4 Other process uses of carbonates – CO_2 Completeness	Either estimate and include in the inventory the CO_2 emissions associated with the non-glass use of soda ash or include in the NIR a justification, consistent with paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines, for these emissions being considered insignificant.	Addressing. Emissions from 2.A.4.b. Other uses of soda ash are reported in the submission by the Party as "NO". The Party has commissioned research on non-glass use of soda ash and made preliminary estimates and stated in the NID that CO_2 emissions resulting from non-glass soda ash use will be reported in future submissions. *Note to the reviewer*: The Party should have proved that these emissions are below the level of significance in accordance with paragraph 32 of the MPGs. If this was the case the Party should at least reported "NE" instead of "NO".

Case 2 (new findings)

We will now look for new findings in a Party's submission.

Let's check a Party's NID for category 2.A.1 Cement production by reading the following extract from the Party's NID:

CO_2 emissions from cement production were calculated using a modified tier 2 method (Equation 3–1) that incorporates country-specific emission factors and emissions from carbon-bearing non-fuel materials (IPCC 2006, volume 3). Since plant-level data on the composition of carbonate raw materials is unavailable, the application of a tier 3 method is not possible.

Disaggregated data on the composition of raw materials and clinker, the calcination degree of cement kiln dust (CKD) and the amount of bypass dust and CKD are not publicly available. However, the National Cement Association has provided national aggregated data expressed as an annual calcination emission factor (EFcl) and annual amounts of bypass dust and CKD for 1990, 2000 and 2002–2014 (Cement Association, 2014). These same quantities have been estimated by the inventory compilers for the remaining reporting years (1991–1999, 2001, 2015–2018). The Cement Association (CAC) receives plant-based data from its member companies.

The calcination CO_2 emission factor (EFcl) varies from year to year and is based on the available data for 1990, 2000 and 2002–2014.

Starting in 2015, the calcination emission factor has not been updated by the CAC and as a result, it has been assumed to be the same as that for 2014. The correction factor for CKD/bypass dust is calculated by the CAC to be 1.012 and is based on the average CKD data from years 1990, 2000 and 2002–2014.

The CAC reports that the raw material contains 0.2 per cent organic carbon and assumes a raw meal/clinker ratio of 1.57. Again, both values are based on data from 1990, 2000 and 2002–2014. These assumptions, combined with the molecular weight ratios of CO_2 to C (44.01/12.01), result in the organic carbon emission factor (EFtoc) of 0.0115 (kt CO_2/kt clinker).

Equation 3.1

$$CO_2 \text{ emissions} = EF_{cl} \times M_{cl} \times CF_{ckd} + EF_{toc} \times M_{cl}$$

EF_{cl}	=	annual emission factor based on clinker production, 0.5260 kt CO_2/kt clinker
M_{cl}	=	clinker production data, kt
CF_{ckd}	=	factor that corrects for the loss of cement kiln dust and by-pass dust, fraction (1.012)
EF_{toc}	=	emission factor for CO_2 emissions from organic carbon in the raw feed, 0.0115 kt CO_2/kt clinker

Clinker production data for 1990–1996 was obtained from the Industrial Energy Data and Analysis Centre (IEDAC, 2010). Clinker production data for 1997–2018 was obtained from National Institute Statistics (NIS, 1990–2019). Provincial/territorial emissions are estimated based on clinker capacity of cement plants across the territory. For 1990–2013, information has been provided directly by the institute of Natural Resources via personal communication. Capacity data has not been made available for 2014–2018 and has therefore been assumed to be the same as the 2013 data.

Nature of the finding

- The finding may be related to application of the method by the Party and the use of updated parameters and EFs.

We may ask the Party a preliminary question with a brief description of the finding. For example, you could ask the Party to provide additional information on the following:

- The Party reports emissions from cement production using a modified tier 2a method from the 2006 IPCC Guidelines. Some parameters seem not updated (CFckd correction factor, EFtoc EF and clinker production capacities were last updated in 2013).
- Does the Party plan to make further investigations on the issue in order to improve the emission estimates with updated parameters and EFs?

Translating the finding into an issue

What did the finding identify?

- The Party applies a country-specific method. The country-specific EF was not updated since 2013.

Why is it a problem?

- The issue may relate to the accuracy of emission estimates.

What is an ideal situation?

- The Party reports that the update of the parameters is planned and the updated parameters will be used in the next submission.

What is the recommendation of the TERT?

- Update the parameters in the next submission or report on the further steps planned to update the parameters of equation 3.1.

Nature of the issue

Accuracy

Reporting the finding

Now, let's report our finding in the review report.

Additional findings made during the individual review of the submission of Party

ID#	Finding classification	Description of the finding with recommendation or encouragement	Is finding an issue/problem?
I.3	2.A.1 Cement production – CO_2	The Party reports emissions from cement production using a modified tier 2a method from the 2006 IPCC Guidelines. Some parameters seem not updated (CFckd correction factor, EFtoc EF and clinker production capacities were last updated in 2013). Also AD for the last three years of the time series were not updated. During the review the TERT asked the Party if there were plans to update EFs and parameters as well as AD used to estimate emissions. The Party replied that this activity is planned for the next year. The TERT recommends that the Party make further investigation with the industry and report emissions using the updated EFs and parameters as well as AD for the last period of the time series.	Yes. Accuracy

4. Practical exercises

4.1. Exercise 1 (cement)

CO_2 emissions from cement production is a key category in a Party's national GHG inventory. The Party estimates these emissions following the tier 2 method specified in the 2006 IPCC Guidelines, considering national clinker production as AD.

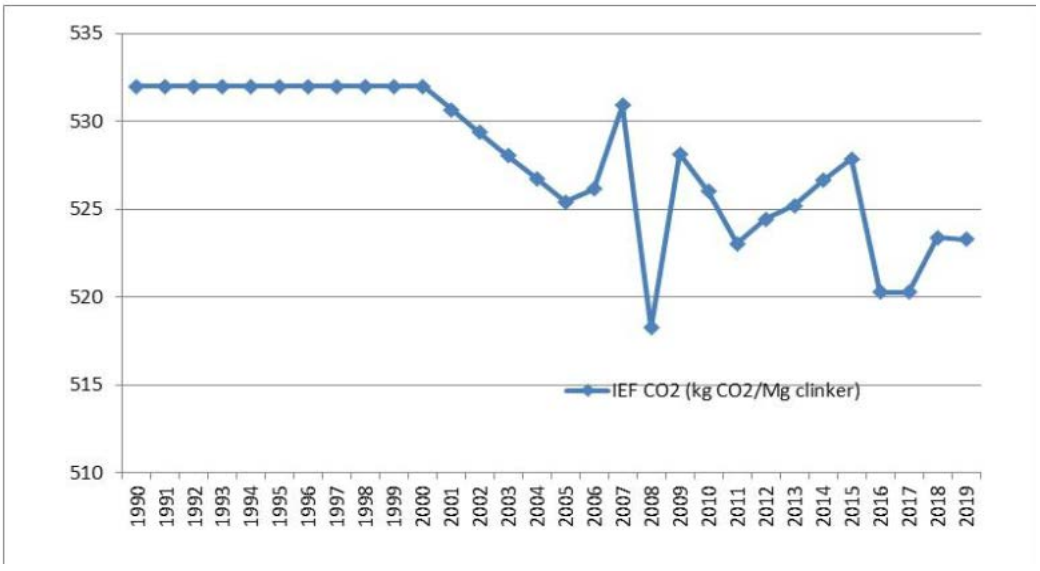
For the EF, the Party has considered the following information:

- From 1990 to 2005, plant data were not available and the cement operators considered a tool provided by the World Business Council for Sustainable Development (https://www.wbcsd.org/) to derive a single country-specific EF based on facility information;
- From 2006 onward, plant data were collected according to national and international legislation and the average EF varies every year.

In addition, in its NID, the Party states that the national operator association has been reporting the overall consumption of natural raw materials by the national cement industry and also the replacement of natural raw material with alternative materials in the national cement facilities, so that:

- Specific consumption of natural raw materials has been varying for recent years;
- The rate of replacement of natural raw materials has been varying for recent years.

The Party considers this information in the EF calculation. The following time series of IEFs, as reported in the graph below, is derived from the Party's submission. The values are proved to fall within the range of the IPCC default EF values (2006 IPCC Guidelines, vol. 3, chap. 2, section 2.2.1.2).



I. Figure 3-5. Time series of IEFs

Question 1

What step would you take as a reviewer?

What are the most important questions you would ask with regard to the trends exhibited between 1990 and 2005, between 2006 and 2013 and onward of the IEFs?

Select one:

A. You would ask for information on the composition of materials in terms of average lime content and contributions of carbonates and additives for the entire time series
B. You would concentrate on the first years of the time series and verify whether the EF derived from the tool is in line with the calculation provided by the 2006 IPCC Guidelines
C. You would concentrate on the strange fluctuations of the recent years of the time series and ask for more detailed background data
D. Both A and B
E. Both A and C

Answer 1

The correct answer is (E).

The most important information to ask for is the average lime content in the product together with the use of carbonates and additives. One possible way to approach the issue would be the following:

Prepare

The TERT should first assess the Party's submission to ensure that this information is not provided.

Assess (through communication with the Party)

Since you know that detailed plant data are not available to the Party in the first period of the time series, it is sufficient to know the tool the operators used to derive the average EF and the input for the calculation. For the recent years of the time series, you can ask for detailed data since these data should be available to the Party.

Question 2

Assuming that the response from the Party has satisfactorily explained the fluctuations of the IEF in the recent years of the time series and you don't have any more concerns, what would be your recommendation to the Party?

Select one:

A. To apply an average EF from the last seven years of the time series back to the past
B. To apply appropriate techniques to interpolate and smooth the values from 1990 to 2004
C. To insert more information on the composition of materials that could justify the IEF time series or otherwise document why the two approaches are the best approaches for estimating emissions during the two time periods

Answer 2

The correct answer is (C).

This issue is relatively common in the IPPU sector and TERTs will have to evaluate the specific circumstances of the Party and the category.

Draft

You may recommend that the Party insert more information on the composition of materials that could justify the IEF in the different periods of the time series or otherwise document why the two approaches are the best approaches for estimating emissions during the two time periods. Therefore, it may be classified as in issue of transparency because, during the review, you received all the information you needed and confirmed that the IEFs were correct and the only pending thing is for the Party to add more information in the next submission.

In some cases, if technologies and practices in the industry have not changed much, TERTs can discuss with the Party if EFs derived from recent data may be appropriate for previous years or if a splicing method may be used consistent with the 2006 IPCC Guidelines to ensure time-series consistency. In other cases, where practices/technologies have changed, the Party may document that the use of two different methods (one for each practice/technology period) does result in the most appropriate EFs.

4.2. Exercise 2 (Lime as part of sugar production)

A Party reported in its NID the production of lime as part of the process of sugar production. The Party also reports that CO_2 is added to the lime, which reacts to form $CaCO_3$, and it indicates that this process represents a CO_2 sink.

The following information is reported in the NID:

Lime is also used in the process of sugar purification. Information provided by the industry at the national level attests that limestone is converted into lime, using coke as fuel, and that all CO_2 resulting from the decarbonizing of limestone and combustion of coke is collected in a closed system and transferred to the purification unit. In the sugar purification unit, lime is added to the raw sugar solution and, in a subsequent step, all CO_2 collected during decarbonization is injected into the solution. In this step, CO_2 and lime react to produce limestone, which is sedimented and collected.

Question

Would you be satisfied with the explanation provided by the Party regarding the sugar purification process?

Select one:

A. Yes, the Party provided a justification and a full description of the CO_2 sequestered
B. No, the Party should provide additional evidence, including but not limited to a declaration by the industry regarding the practices and resulting CO_2 emissions

Answer

The correct answer is (B).

You should ask for some more evidence of the process, either a declaration from the industry or some references that can be published (or information found on a website). You should also ask the Party to demonstrate that all sugar producers in the country use the same production process, and that the CO_2 produced during the calcination process is not emitted into the atmosphere (the exhaust gases are completely sequestered in the produced lime). One possible way to approach the issue would be the following:

Prepare

The TERT should first assess the Party's submission to ensure that this information is not provided.

Assess (through communication with the Party)

You should ask for some more evidence of the process, either a declaration from the industry or some references that can be published.

Assuming that the Party provides the requested references and has documented that no CO_2 emissions actually occur from the decarbonizing process you would end with a recommendation that the Party provide this information in the next submission.

Draft

The assessment has led to an issue and you recommend that the Party provide references explain that no CO_2 emissions actually occur from the decarbonizing process, in the next submission.

4.3. Exercise 3 (glass)

A Party reported in its NID the following extract on the production of glass:

Glass Production (CRF Category 2.A.3)

The CO_2 emissions associated with soda ash and limestone consumed in national glass production are included in this category. Soda ash has been the predominant source of CO_2 emissions from glass production throughout the entire time series. National CO_2 emissions are calculated using a tier 1 method that applies the stoichiometric carbon EFs to the estimated quantities of soda ash and limestone consumed in glass production.

The quantity of soda ash consumed in glass production is estimated by applying the ratio of soda ash used for glass production in a neighbour country to the total national consumption. The quantity of limestone consumed in glass production is based on limestone production statistics collected by the National Statistical Institute.

Question

Would you be satisfied with the information provided by the Party regarding the process?

Select one:

A. Yes, the Party provided sufficient information in relation to the application of a tier1
B. No, the Party should provide additional information on the use of soda ash in the production process
C. No, the Party should better explain the use of the tier1
D. Both B and C

Answer

The correct answer is (D).

Tier 1 requires information on national production, by weight, and the amount of cullet used; tier 2 requires information on the quantity of glass manufactured, by type of process; tier 3 requires the collection of plant-level AD on carbonates consumed in the industry. It is not clear how the tier 1 method was applied by the Party and there is no information in its NID on the AD or EFs used.

Furthermore, the information on soda ash consumption for glass production is not transparent, the value of the ratio of soda ash used for glass production (derived using a value from a neighbouring country) is not reported, and there is no transparent information on how the quantity of limestone consumed in glass production is estimated. One possible way to approach the issue would be the following:

Prepare

The TERT should first assess the Party's submission to understand the type of tier applied.

Assess (through communication with the Party)

You should ask for further details on the method applied in terms of AD and EFs used. You may also ask for the ratio of soda ash used for glass production applied to the total national consumption (derived using a value from a neighbouring country), and whether there has been any assumption to derive the quantity of limestone used for the glass production process from the production statistics.

Draft

You would recommend that the Party provide more explanation on the method applied and of AD and EFs used in the time series. You would also recommend that the Party provide the assumption on the ratio of soda ash consumed in glass production, as derived by applying the ratio of soda ash used for glass production in a neighbour country to the total national consumption. In addition, another recommendation would be that the Party report in its NID whether the quantity of limestone consumed in glass production is estimated from the total limestone production statistics. These issues may be classified as transparency issues but, depending on the method applied, may also affect the accuracy of the emission estimates.

5. Self-check quiz

5.1. Questions

Question 1 (lime production)

Assuming from the description in a Party's NID of the entire lime production process that no net CO_2 emissions actually occur from the decarbonization process, would you expect some other source of CO_2 emissions associated with lime production and use?

Select one:

A. Yes, emissions in the agriculture sector
B. Yes, emissions in the energy sector
C. Both A and B

Question 2 (cement and glass)

Please consider the following statement from a Party's review report:

The TERT noted that the Party does not demonstrate consistency along the time series especially in categories, for example cement production and glass production, where emission estimates from 2006 onward are based on plant-specific data whereas, for previous years, default EFs from the 2006 IPCC Guidelines are used. The TERT recommends that the Party demonstrate the consistency of the time series and report its findings and the explanations for all recalculations in its NID.

Is the recommendation made by the TERT appropriate?

Select one:

A. Yes, the Party will make its recalculations and report back in the next submission, so the following review process will evaluate the appropriateness of the choice
B. No, further explanation on how to ensure consistency should have been indicated, suggesting splicing techniques from the 2006 IPCC Guidelines as possible approaches to consider, for example, the "overlap approach"
C. No, further explanation on how to ensure consistency should have been indicated, specifying the need to collect data on input carbonates for the years preceding 2005
D. No, further explanation on how to ensure consistency should have been indicated, specifying the need to apply an average EF derived from 2006–2013 plant data back for the entire time series

Question 3

CO_2 emissions from cement production from 1990 to 2005 were estimated considering data on consumption of raw materials instead of cement or clinker production, provided by the national industrial operators, and applying default IPCC EFs. For the period from 2006 onward, emission estimates were based on data reported by cement factories, both raw material consumption and emissions.

For glass production, the Party used an average CO_2 EF for the entire time series. The Party derived that EF from plant data collected from 2006 onward.

As a reviewer, what would be the best action?

Select one:

A. You would accept the estimations for cement production because AD from 1990 to 2005 have been estimated using the highest tier and are based on operator data
B. You would accept the estimations for glass production because EFs from 1990 to 2005 already take into consideration the composition of the final product
C. You would ask the Party to apply an average EF for cement production derived by the 2006–2013 data
D. You would ask for information on the types of glass to check whether the application of a tier 2 methodology is possible
E. Both A and B
F. Both A and D

Question 4

CO_2 emissions from category 2.A.4 Other uses of carbonates is a key category for a Party.

Upon checking the CRT, AD and CO_2 emissions from "other uses of soda ash" are reported as "NO" for 1990 and 1991, as shown below.

CRT 2(I)A – Other uses of soda ash (1991)

TABLE 2(I).A-H SECTORAL BACKGROUND DATA FOR INDUSTRIAL PROCESSES AND PRODUCT USE — Year

Emissions of CO_2, CH_4 and N_2O — Submission

(Sheet 1 of 1) — Country

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	ACTIVITY DATA		IMPLIED EMISSION FACTORS (2)			EMISSIONS (3)			Recovery/Capture (4) (5)			
	Production/Consumption quantity		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2 fossil	CO_2 biogenic (6)	CH_4	N_2O
	Description (1)	(kt)	(t/t)			(kt)			(kt)			
2.A. Mineral industry						863.47			NO	NO		
2.A.1. Cement production	clinker production	1,337.12	0.53			702.56			NO	NO		
2.A.2. Lime production	lime production	165.40	0.74			121.74			NO	NO		
2.A.3. Glass production	glass production	252.94	0.14			34.39			NO	NO		
2.A.4. Other process uses of carbonates						4.78			NO	NO		
2.A.4.a. Ceramics	carbonates consumption	10.20	0.48			4.78			NO	NO		
2.A.4.b. Other uses of soda ash	soda ash consumption	NO	NO			NO			NO	NO		
2.A.4.c. Non-metallurgical magnesium production		NO				NO			NO	NO		
2.A.4.d. Other		NO	NO			NO			NO	NO		

In the relevant section in the NID, the following text and table are reported:

Activity data is taken from the report 'Foreign trade in goods statistics'; data is corresponding with FAO data. Since data for 1990 and 1991 were not available, figures were extrapolated based from the trend 1992–1996.

Table 4.5-1: Data for the use of limestone, dolomite, soda ash and lithium carbonate (1990 - 2013)

Year	Limestone use (tonnes)	Dolomite and other es* use (tonnes)	Soda ash use (tonnes)
1990	0	12,098	0
1991	0	10,018	0
1992	0	9,173	13,753
1993	677	7,632	10,020
1994	676	15,722	12,960
1995	575	6,541	17,053
1996	731	8,323	13,367
1997	784	0	13,776
1998	826	0	10,956
1999	529	0	12,862
2000	6,969	585	14,037
2001	9,126	623	14,747

As a reviewer, what would be the best actions to take?

Select one:

A. Ask the Party for an explanation on the reason for the missing data (AD and emissions) in CRT table 2(I)A and in table 4.5-1 of the NID
B. Ask the Party for the results of the extrapolation for the two years
C. Ask the Party the reason for the incoherence between the text in the NID and the figures reported in the CRT
D. Ask the Party to ensure completeness by providing information on the missing AD and CO_2 emission estimates
E. All of the above

5.2. Answers

Answer 1 (lime production)

The correct answer is (C).

The amount of CO_2 from coke combustion should be reported as combustion emissions under the energy sector. Also, the scum at the end of the process contains limestone but also organic substances and minerals; this mixture is used as fertilizer and you should ensure that these CO_2 emissions are reported in the relevant agriculture category.

Answer 2 (cement and glass)

The correct answer is (B).

Since from the paragraph of the review report it is not clear which methodologies are applied by the Party for the first period of the time series (tier 1 or tier 2) you can't conclude on the advice to give to the Party. However, it is always good drafting to suggest a method to improve time-series consistency rather than simply writing a factual sentence. For instance, if the Party uses a tier 1 or a tier 2 approach for the first years of the time series, it is unlikely that it can collect data on carbonates used in the processes. One approach would be to develop a time series based on the relationship observed between the two methods during the years when both can be used. The time series is then constructed by assuming that there is a consistent relationship between the results of the previously used and new method. The emission or removal estimates for those years when the new method cannot be used directly are developed by proportionally adjusting the previously developed estimates, based on the relationship observed. The use of an average EF, based on plant data, back to previous years of the time series can be proposed to the Party only after examining the time series and discussing the appropriateness of this approach with the Party. You should always take into account the Party acknowledgement on the process (i.e. if the same ratio of carbonates contents in the product can be assumed along the period).

Answer 3

The correct answer is (F).

As a reviewer, you should always analyse the emission trend of EFs. The most sensible action to take is to ask the Party whether it has information on the types of glass produced every year in the time series (and not a total figure of glass production). If these data are available (national statistics often distinguish glass production by type (e.g float, container)), you can ask the Party to apply an average EF to each type of glass, based on the 2006–2014 data; in this case a tier 2 would be applied for the first years of the time series followed by the use of plant-specific data considering the effect of different carbonate contents of raw materials used for different glass types.

For cement production, you would accept the use of AD on raw material consumption and the use of IPCC default EFs since they are based on common formula weights and CO_2 ratios per carbonate species. You could also compare these factors with country-specific parameters and/or EFs derived by plant data available for those last years but no major differences are expected.

Answer 4

The correct answer is (E).

AD and CO_2 emissions associated with use of limestone, dolomite and soda ash for 1990–1991 are reported as "NO" and there is incoherence in the information reported (extrapolation is mentioned in the text but data are missing in the NID table and in the CRT). Evidence from the NID suggests that these activities occurred for the years reported as "NO". So the Party should ensure completeness by providing information on the missing AD and CO_2 emission estimates.

6. Key points to remember

- where site-specific raw materials data are used, please check carefully for completeness, including that all sources of carbonate and fuels are accounted for (not just the limestone).
- Check the consistency of the time series. If technologies and practices in the industry have not changed much EFs derived from recent data may be appropriate for historical years, or a splicing method may be used consistent with the 2006 IPCC Guidelines. There may be cases where practices or technologies have changed, and the Party may document that the use of two different methods does result in the most appropriate emissions factors. However, the TERT may assess this justification.
- Check quantities of carbonates consumed in the processes.
- Where IEFs vary, check whether this could be due to variations in shares of different carbonates used over time: lime and magnesium oxide contents may vary in the different periods.

Lesson 4: Chemical industry

1. Introduction and objectives of the lesson

1.1. Lesson outline

This lesson is organized into six sections and helps you focus on what best complements your prior knowledge of the topic:

1. Introduction and objectives of the lesson
2. Category overview and methodological information
3. Review approach
4. Practical exercises
5. Self-check quiz
6. Key points to remember

1.2. Categories in chemical industry

The categories considered in this lesson and their codes in the CRTs are as follows:

- 2.B Chemical industry;
- 2.B.1 Ammonia production;
- 2.B.2 Nitric acid production;
- 2.B.3 Adipic acid production;
- 2.B.4 Caprolactam, glyoxylic acid production;
- 2.B.5 Carbide production;
- 2.B.6 Titanium dioxide production;
- 2.B.7 Soda ash production;
- 2.B.8 Petrochemical and carbon black production:
    - 2.B.8.a Methanol;
    - 2.B.8.b Ethylene;
    - 2.B.8.c Ethylene dichloride and vinyl chloride monomer;
    - 2.B.8.d Ethylene oxide;
    - 2.B.8.e Acrylonitrile;
    - 2.B.8.f Carbon black;
    - 2.B.8.g Other;
- 2.B.9 Fluorochemical production: HFC-23 emissions from HFC-22 production; and emissions from production of other fluorinated compounds.

This list of categories is consistent with the set of CRTs. Any of these categories could be a key category for a Party and, as such, should be placed relatively high up on your list of priorities when reviewing it. You should refer to the 2006 IPCC Guidelines (vol. 3, chap. 3) for the methodologies to estimate emissions from these categories. Some of the main problems you may encounter when reviewing emissions from these categories are also discussed in this lesson.

The expected time needed to complete lesson 4 depends on the level of your knowledge of GHG inventories for the IPPU sector under the ETF and the 2006 IPCC Guidelines:

- For readers with experience: 15–30 minutes
- For readers with less experience: 25–50 minutes

1.3. 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 chemical industry;
- Identify whether a Party's reporting for chemical industry is consistent with the requirements of the MPGs;
- Draft key review recommendations to Parties in relation to emissions from chemical industry.

1.4. CO_2 capture

CO_2 capture technologies are particularly relevant in the chemical industry, so there is a possibility of deducting the quota of CO_2 captured in higher-tier estimation methods.

Any methodology taking into account CO_2 capture should consider that CO_2 emissions captured in the process may be both combustion and process related. In cases where combustion and process emissions are to be reported separately (e.g. in the petrochemical industry), inventory compilers should ensure that quantities of CO_2 are not double counted. In these cases, the total amount of CO_2 captured should preferably be reported in the corresponding energy combustion and IPPU categories in proportion to the amounts of CO_2 generated in these categories. The default assumption is that there is no CCS taking place. For additional information on CCS, refer to section 1.2.2 of volume 3 of the 2006 IPCC Guidelines, and for more details on CO_2 capture and CO_2 storage, see section 2.3.4 of volume 2 of the 2006 IPCC Guidelines.

Chemical industry in the 2019 Refinement to the 2006 IPCC Guidelines

In the 2019 Refinement to the 2006 IPCC Guidelines, changes and updates occurred to some subcategories within chemical industry, namely nitric acid production and fluorochemical production, as described in specific sections below. Note the addition of the new category "hydrogen production", which is discussed extensively and includes guidance on definitions, double counting, completeness and cross-cutting allocation. No further changes occurred to the other subcategories within chemical industry.

2. Category overview and methodological information

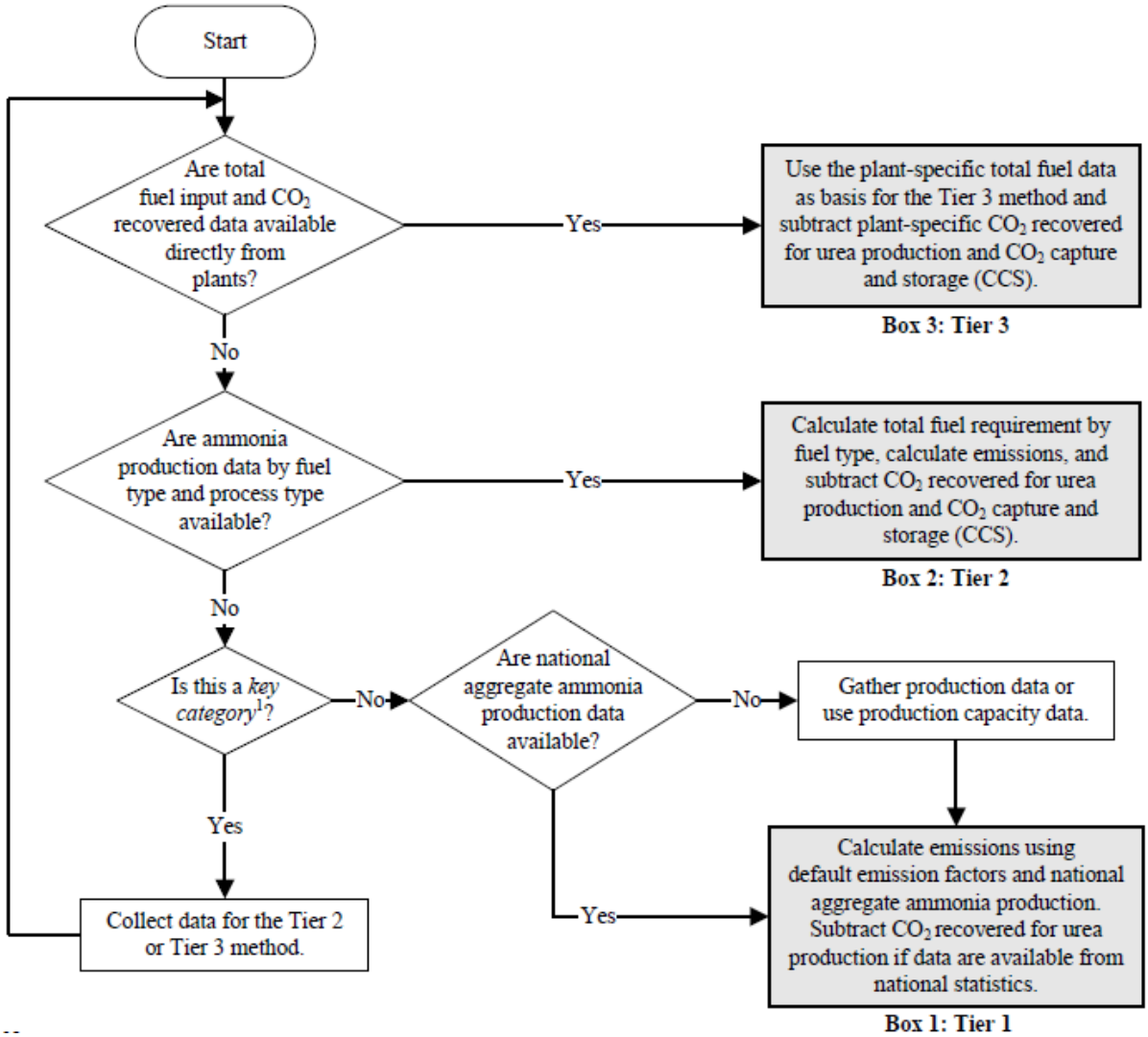
2.1. Ammonia production (category 2.B.1)

General reference

General information is given in the 2006 IPCC Guidelines (vol.3, chap.3, section 3.2) and default EFs by production processes are provided in table 3.1 of the same chapter.

Choice of tier

The IPCC decision tree for choosing the estimation method is shown in figure 4-1.



J. Figure 4-1. 2006 IPCC Guidelines decision tree for estimation of CO_2 emissions from ammonia production

There are three different methodological tiers specified in the 2006 IPCC Guidelines to estimate CO_2 process emissions from ammonia (NH_3) production. Emissions are estimated from the total fuel requirement, or values derived from estimates of the total fuel requirement, used in the production of ammonia. AD to estimate emissions should preferably be consumption of natural gas and/or other fossil fuels used both as feedstock and as for energy purposes. Only if feedstock consumption is not available, data on ammonia production should be used.

Priorities and potential key issues to consider during a review

Information necessary to reproduce the emission calculations should be reported by the Party, including information on fuel requirements and ammonia production (e.g. even if a tier 3 method is applied, where ammonia production is not directly used in the calculations). It should be recognized that this type of information may be confidential, particularly where there are only few companies operating, so it may be important to work with the Party during the review, taking into account concerns about confidentiality (paras. 31(e), 47 and 164 of the MPGs).

Plants using hydrogen rather than natural gas to produce ammonia do not release CO_2 emission from the synthesis process.

If CO_2 from ammonia production is recovered for subsequent use and excluded from the reporting in this category, the products and the purposes for which the CO_2 is used should be clearly explained in the NID. For example, if the captured CO_2 is used in urea production, Parties should provide an overview in the NID of where CO_2 emissions from significant uses of urea are reported.

Potential for double counting

In the 2006 IPCC Guidelines, no distinction is made between fuel and feedstock emissions, with all emissions from ammonia production being accounted for in the IPPU sector. This approach might cause problems in the energy sector (e.g. when ammonia production is integrated with the production of other chemicals).

To ensure that double counting does not occur, fuel consumption in ammonia production should not be included in the energy sector, so the total quantities of oil or gas used (fuel plus feedstock) in ammonia production must be subtracted from the quantity reported under energy use. You should coordinate with the energy sector experts to ensure that Parties have prepared their accounting for non-energy use of fossil fuel feedstock properly (i.e. that there is no double counting or omissions).

As a check, you could verify whether natural gas used as feedstock in the ammonia production plants and the amount of fuel used is included in the national energy balances (or in energy statistics) under the non-energy final consumption sector; noting that this will depend on country-specific circumstances.

CO_2 recovery

Where CO_2 is captured, this quantity should be deducted from the accounted emissions in a higher-tier emissions calculation. The treatment of CO_2 recovery depends on the type of use (CCS, urea, industrial gas).

For CO_2 recovered for subsequent use in urea production, estimations may be carried out from the quantity of urea produced by multiplying urea production by 44/60 (i.e. the stoichiometric ratio of CO_2 to urea). When such a deduction is made, it is good practice to ensure that emissions from urea use are

included elsewhere in the inventory (please see box 3.2 in the 2006 IPCC Guidelines, vol.3, chap.3, section 3.2.2.3).

In particular, emissions from urea use as fertilizer should be included in the agriculture sector (CRT 3.G–J). Another use of urea is as a reducing agent in selective catalytic reduction of NO_X in exhaust gases originating from diesel or gasoline direct injection engines; the 2006 IPCC Guidelines (vol. 2, chap. 3), outline that emissions from urea use should be accounted for in the energy sector. However, when reviewing the energy sector, reviewers should note that in CRT 1A(a)s4, there is a note (13) which says that "Emissions from the use of urea as a catalyst are to be reported under category 2.D.3". In addition, emissions from the use of urea for NO_X abatement in power plants should be reported under the IPPU sector, category 2.D.3, Use of urea (see note (10) of CRT 2(I).A-H).

The CO_2 recovered from industrial gas applications (e.g. freezing) should not be accounted for separately, as it is a relatively low-volume short-term use, and it is assumed that all industrial gaseous carbon will be emitted to the atmosphere in the producing country.

As other uses of CO_2 recovered from ammonia production may occur (e.g. precipitated carbonates, some types of fuel additives, other feedstock uses similar to urea, technical gases, including CO_2), you should check to see if the Party presents, in its NID, the amount of CO_2 emissions (specifying the part of CO_2 recovered not reported elsewhere and not reported under the energy sector as recovered and stored). As a reviewer, you should ensure that the Party is only accounting for the recovery of CO_2 from ammonia production that is accounted for elsewhere in the inventory or exported from the country. If the Party cannot identify the uses of the recovered CO_2, and consequently where emissions from the use of the urea are reported (or if the Party cannot demonstrate that the urea is exported), then the Party should not subtract these emissions from ammonia production.

2.2. Nitric acid production, adipic acid production, caprolactam, glyoxal and glyoxylic acid production

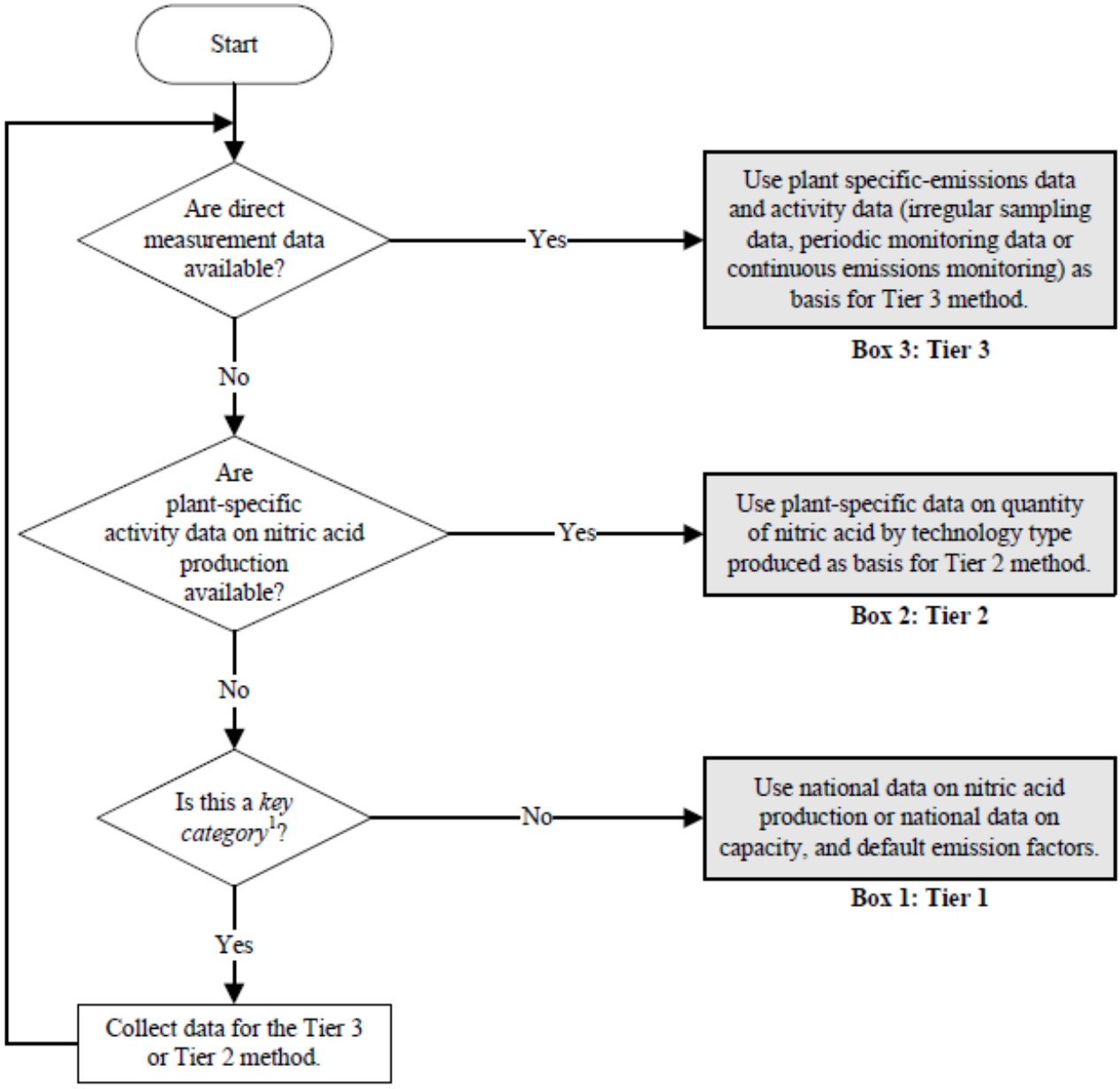
Although related to different production processes, these categories can be treated as a group because the methods for calculating N_2O emissions are similar and issues regarding abatement technologies and efficiency in terms of emission reduction are also similar. As a result, you will find that descriptions of the methods for calculating emissions, as well as discussion on priorities and potential key issues, only refer to the nitric acid production processes.

General reference

For each of the other categories, you can refer to the section on nitric acid production processes and to the 2006 IPCC Guidelines (vol.3, chap.3, section 3.3).

Choice of tier

There are three methodological tiers available in the 2006 IPCC Guidelines for estimating N_2O emissions from nitric production (see fig. 4-2).



K. Figure 4-2. 2006 IPCC Guidelines decision tree for estimation of CO_2 emissions from nitric acid production

Emissions of N_2O depend on the amount generated in the production process in question and the amount destroyed in any subsequent abatement process.

General reference

The 2006 IPCC Guidelines provide default EFs for nitric acid production by production process and associated uncertainties (see table 3.3 in the 2006 IPCC Guidelines, vol. 3, chap. 3).

Priorities and potential key issues to consider during a review

Abatement

Nitric acid manufacture may be a significant source of atmospheric N_2O, if not abated, and is the main source of N_2O emissions in the chemical industry.

A number of technologies for N_2O reduction during nitric acid manufacture have been developed since 2000, including a tail gas process where both N_2O and NO_X emissions can be simultaneously reduced (requiring the addition of ammonia to the tail gas); a process-gas option involving direct catalytic decomposition right after the platinum gauzes; and a full-scale catalyst decomposition option. So you may expect a sharp decrease in emissions in the years since around 2005 in many countries. However, Parties should have information to demonstrate the types and utilization of emission control technologies (i.e. destruction).

Completeness

National-level statistics can underestimate nitric acid production by 30–50 per cent, possibly because nitric acid production can be integrated into larger facilities and therefore the nitric acid produced as an intermediate product is not included. It is good practice to account for these sources by methods such as identifying them through national registries of NO_X emissions, which is another unintended by-product of nitric acid production. If national level production data are not available, Parties may estimate production using production capacity and assuming a capacity utilization factor of 80 per cent.

Confidentiality

Consider that a Party may keep some information confidential in case there are only one or two producers in the country; you can evaluate which kind of information to ask for while maintaining the confidentiality of the data provided and considering the results of the previous review, if abatement technologies and EFs have already been checked in depth.

Nitric acid production in the 2019 Refinement to the 2006 IPCC Guidelines

In the 2019 Refinement to the 2006 IPCC Guidelines, improvements were made to nitric acid production, particularly within the chapter dealing with the choice of EFs, and the improvements involved all tier 1, tier 2 and tier 3 methods to different extents. Specifically, production process categories (e.g. to include dual-pressure processes – see new table 3.3A) were updated as well as corresponding default EFs for the tier 2 method (table 3.3).

2.3. Carbide production (SiC and CaC_2) (category 2.B.5)

GHG emissions are associated with the production of silicon carbide and calcium carbide.

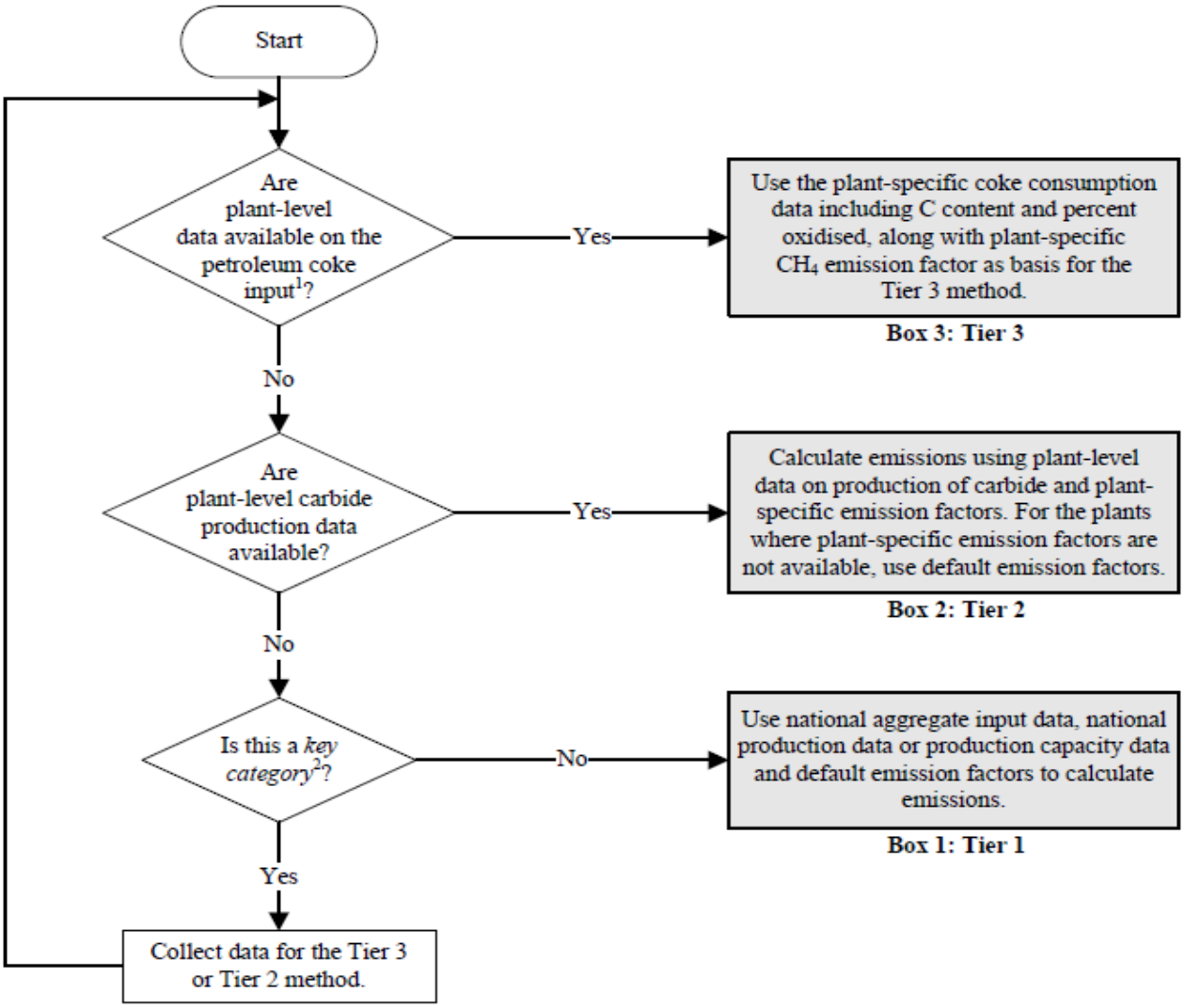
General reference

2006 IPCC Guidelines, volume 3, chapter 3, section 3.6.

Choice of tier

There are three different methodological tiers available in the 2006 IPCC Guidelines for estimating emissions from SiC and CaC_2 production. The choice of method depends on the availability of data at the national level.

GHG emissions from SiC production refer both to CO_2 and CH_4, while only CO_2 emissions occur from the production of CaC_2. The IPCC decision tree for choosing the estimation method to follow is shown in figure 4-3.



L. Figure 4-3. 2006 IPCC Guidelines decision tree for estimation of CO_2 and CH_4 emissions from carbide production

Priorities and potential key issues to consider during a review

The following issues need to be taken into account when reviewing emissions from this category.

For silicon carbide:

- Petroleum coke used in the production of SiC should be subtracted from the energy sector as a non-energy use of petroleum coke;
- More carbon is needed in the SiC production process than calculated from a stoichiometric reaction, the excess carbon is converted to CO_2 and released, and should be accounted for as a process by-product emission.

For CaC_2:

- Emissions occurring from the first step of the CaC_2 production process, lime production, should be reported under the lime production category;
- During the production of CaC_2, CO is produced as an intermediate product and is often used as fuel in the production process. CO_2 emissions from the use of CO should be reported under this category and not under the energy sector;
- CO_2 emissions from the reduction step and use of product (to produce acetylene, C_2H_2 for welding applications only) should be reported as emissions from CaC_2 production;
- Only those emissions from the reaction of lime with petroleum coke and use of the CaC_2 to produce $C_2H_2$for welding applications should be reported as emissions from CaC_2 production (please see box 3.5 of the 2006 IPCC Guidelines, vol. 3, chap. 3, section 3.6).

The inventory expert should consider the import and export of CaC_2 used to produce C_2H_2 for welding operations. The reviewer should check that emissions from the use of CaC_2 that is **exported** by the Party are not estimated in that Party's inventory, but that emissions from the use of CaC_2 **imported** for C_2H_2 production **for use in welding** operations are estimated, for all tiers. Reviewers may encourage provision of a CaC_2 balance to ensure appropriate accounting of the use of CaC_2 for C_2H_2 manufacture.

Note that, for the tier 2 and tier 3 methods, the 2006 IPCC Guidelines indicate that "where acetylene is produced from CaC_2 at another location and the quantity of CaC_2 used for this purpose is not known, it is good practice to document this fact". Reviewers should remember that "completeness" is a principle of inventory reporting, so if a Party is unable to track the use of CaC_2 for C_2H_2 production for use in welding, then you should recommend that the Party estimate these emissions.

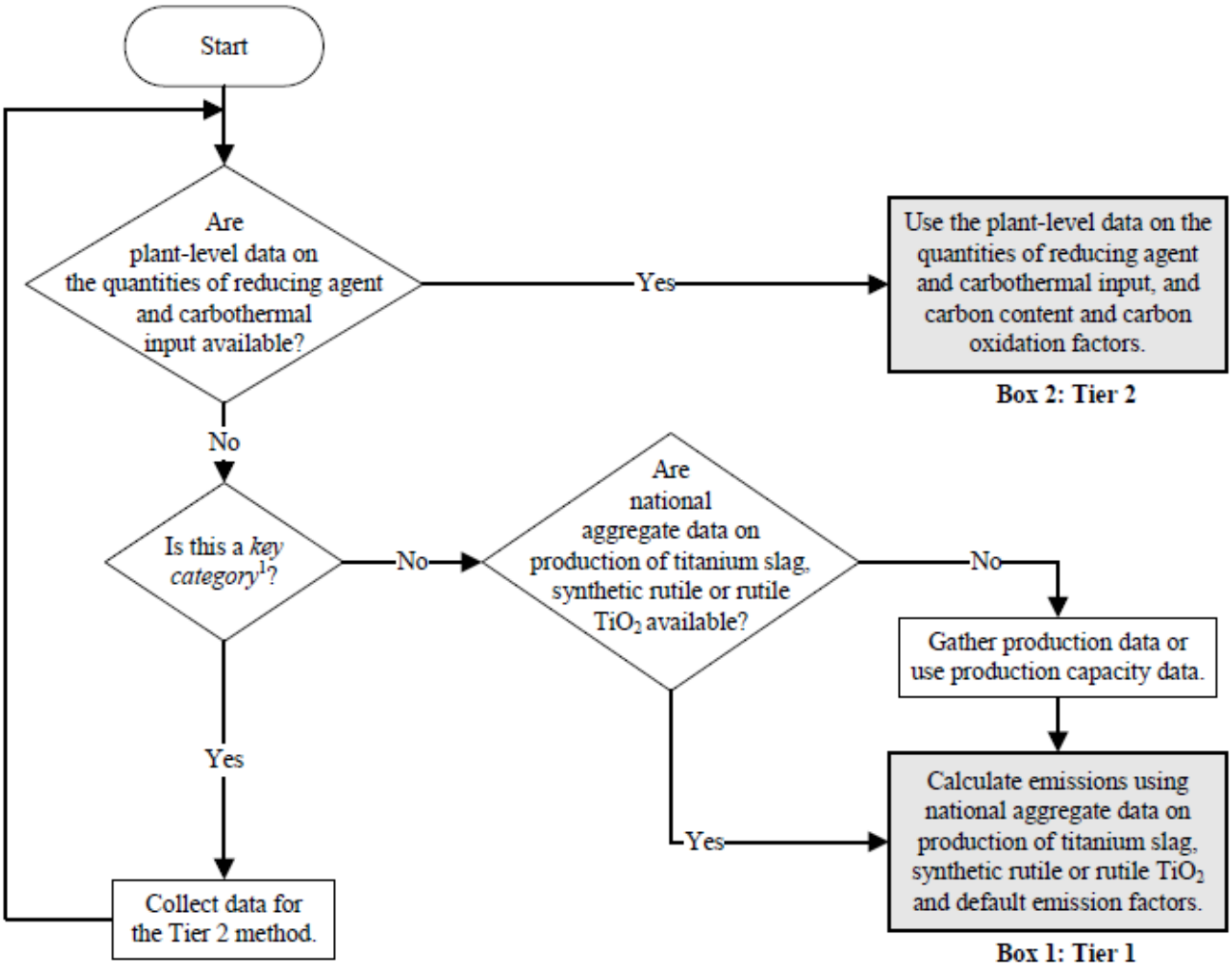
2.4. Titanium dioxide production (category 2.B.6)

General reference

2006 IPCC Guidelines, volume 3, chapter 3, section 3.7.

Choice of tier

There are two different methodological tiers available in the 2006 IPCC Guidelines for estimating process CO_2 emissions from TiO_2 production. Methods proposed in the guidelines are classified according to the extent of the plant-level data available (see fig. 4-4).



M. Figure 4-4. 2006 IPCC Guidelines decision tree for estimation of CO_2 emissions from TiO_2 production

Priorities and potential key issues to consider during a review

Completeness

You should verify the complete coverage for TiO_2 production, accounting for all emissions from all sources including titanium slag, synthetic rutile and rutile TiO_2.

Double counting

In order to avoid double counting, the quantities of electrode carbon, coal used as a reductant and petroleum coke used in the chloride route process must be subtracted from the quantity reported under energy and non-energy use in the energy sector (see 2006 IPCC Guidelines, vol. 3, chap. 3, box 3.6).

2.5. Soda ash production (category 2.B.7)

Emissions of CO_2 from the production of soda ash (Na_2CO_3) vary substantially with the manufacturing process. Four different processes may be used commercially to produce soda ash.

- Three of these processes are referred to as **natural processes** because they use natural sodium carbonate-bearing deposits (mainly trona);
- The fourth, the Solvay process, is classified as a **synthetic process**. Calcium carbonate (limestone) is used as a source of CO_2 in the Solvay process.

General reference

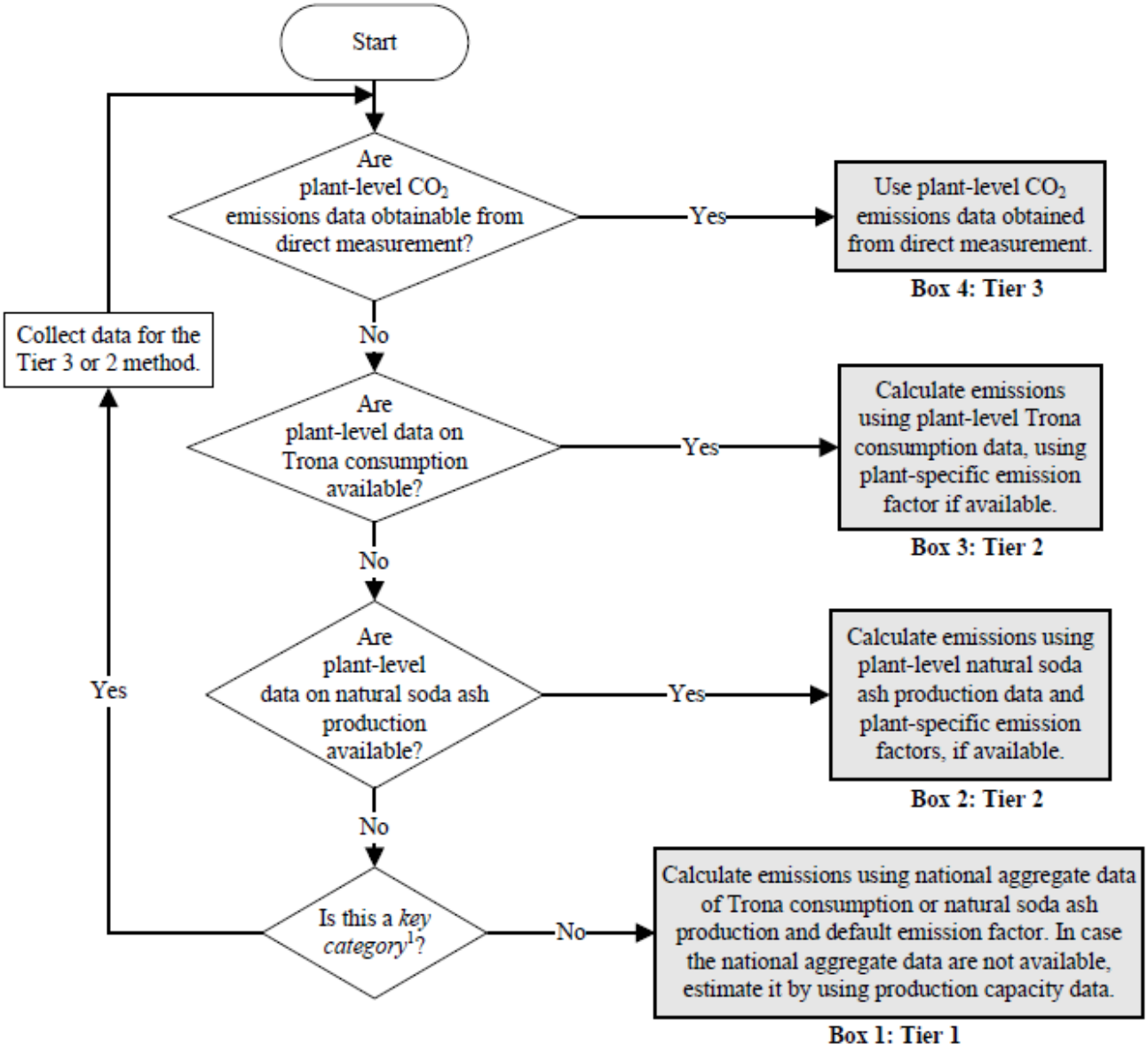
2006 IPCC Guidelines, volume 3, chapter 3, section 3.8.

Choice of tier

There are three different methodological tiers available in the 2006 IPCC Guidelines for estimating emissions from **natural** soda ash production. The choice of method for estimating emissions depends on national circumstances. Emissions can be estimated using an output-based approach (emissions per unit of soda ash produced) or an input-based approach (emissions per unit of trona). Figure 4-5 shows the decision tree.

In the case of soda ash production by the Solvay process, the estimation of CO_2 emissions from a stand-alone soda ash plant should be based on an overall balance of CO_2 for the whole chemical process. A simplified version of the balance may be used assuming that the CO_2 emissions result from the stoichiometric oxidation of the coke carbon.

CO_2 emissions are result from the use of soda ash, and these emissions are accounted for as a source under the relevant industry using the product, as discussed in the 2006 IPCC Guidelines (vol. 3, chap. 2 Mineral industry emissions).



N. Figure 4-5. 2006 IPCC Guidelines decision tree for estimation of CO_2 emissions from soda ash production

2.6. Petrochemical and carbon black production (category 2.B.8)

Overview

The petrochemical industry uses fossil fuels (e.g. natural gas) or petroleum refinery products (e.g. naphtha) as feedstocks. The 2006 IPCC Guidelines (vol. 3, chap. 3, section 3.9) provide guidance for estimating CO_2 and CH_4 emissions from the production of methanol, ethylene and propylene (in steam crackers), ethylene dichloride, ethylene oxide and acrylonitrile. There are a number of other

petrochemical processes that emit small amounts of GHGs for which specific guidance is not provided in the IPCC guidelines (e.g. styrene production); however, there are opportunities to report emissions from these categories in the CRT.

Guidelines are also provided for carbon black. Carbon black is not considered to be a petrochemical, but the carbon black production process uses petrochemical feedstock.

General reference

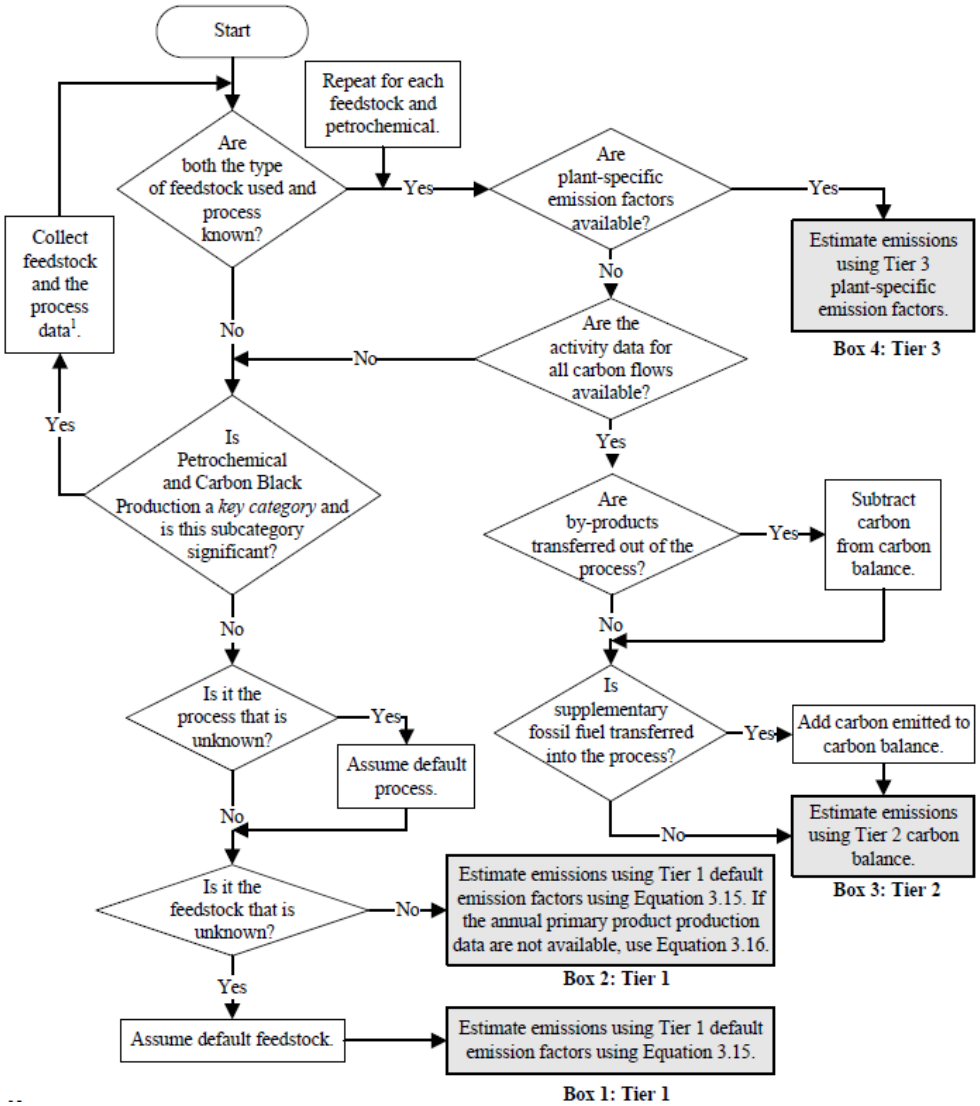
2006 IPCC Guidelines: volume 3 (IPPU), section 3.9, chapter 3.

Default EFs are provided in the 2006 IPCC Guidelines for CO_2 and CH_4 for each petrochemical process (see vol. 3, tables 3.12, 3.14, 3.17, 3.20, 3.22–3.23 for CO_2; and tables 3.16, 3.19, 3.21 and 3.24 CH_4).

Choice of tier

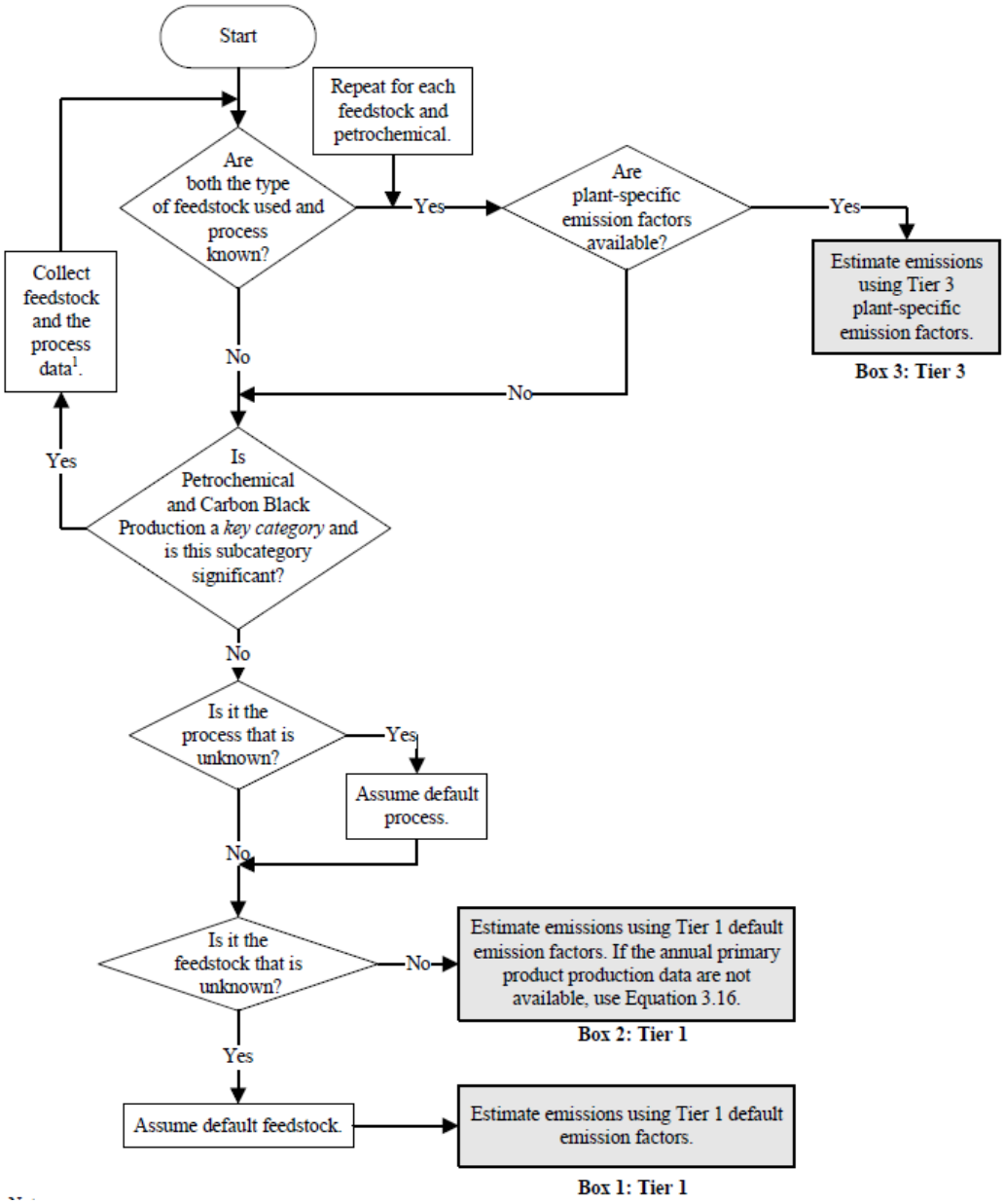
There are three methodological tiers available in the 2006 IPCC Guidelines for estimating CO_2 and CH_4 emissions, which should be applied for each petrochemical product produced (see figs. 4-6–4-7).

Guidelines for CO_2 estimation



O. Figure 4-6. 2006 IPCC Guidelines decision tree for estimation of CO_2 emissions from the petrochemical industry and carbon black industry

Guidelines for CH_4 estimation



P. Figure 4-7. 2006 IPCC Guidelines decision tree for estimation of CH_4 emissions from the petrochemical industry and carbon black industry

Priorities and potential key issues to consider during a review

Completeness

Where the production process exists in a Party, the categories will likely be minor contributors to emissions. However, complete inventory submissions will address them all. Make sure that Parties are correctly using all notation keys (i.e. "NE" and "NO"; see paragraphs 31(b) and 32 in the MPGs) in their CRTs and that they have documented their reasoning in their NID.

Potential under- or overestimation

The issue of potential underestimation of AD in these categories is relevant because we are considering intermediate products that may be converted directly in other chemicals or for which production may occur in integrated plants. For instance, production data for ethylene oxide may not be complete because the ethylene oxide may be converted directly to ethylene glycol, or into other products (e.g. amines and ethers), in integrated plants. The same applies for ethylene dichloride, which may be converted directly to vinyl chloride monomer in an integrated ethylene dichloride/vinyl chloride monomer plant, not excluding that there could also be some other industries that use ethylene dichloride in their production processes. So, even the use of a surrogate product as AD for other petrochemicals may underestimate their actual production level.

Potential overestimation of emissions may also occur. This could be the case for carbon black production, when national production statistics also incorporate amounts of product from biogenic sources, such as animal black and bone black.

Potential for double counting

Within the petrochemical industry and carbon black industry, primary fossil fuels (natural gas, petroleum and coal) are used for non-fuel purposes in the production of petrochemicals and carbon black. The use of these primary fossil fuels may involve combustion of part of the hydrocarbon content for heat raising and the production of secondary fuels (i.e. off-gases). Attention should be paid to emissions from the combustion of off-gases generated by petrochemical production processes, which should be attributed to the IPPU sector category that produces them and reported as industrial emissions. However, if any portion of the off-gases generated by the specific IPPU category is transferred out of the process for combustion elsewhere, the corresponding emissions are to be reported as fuel combustion in the appropriate energy sector category. As a reviewer, you should determine if the Party has transparently documented and accounted for the flow of fuels in the appropriate sector.

Also note that the national energy statistics may account for total combustion of fossil fuels (including natural gas, oil and coal) and also secondary fuels (such as industrial process off-gases) for energy production. If this is the case, emissions from petrochemical processes should be subtracted from the calculated emissions in the energy sector to avoid double counting. This is particularly relevant for ethylene and methanol, where primary fuel (e.g. natural gas, ethane and propane) feedstock consumption may be reported in national energy statistics.

In addition, there is a potential for double counting emissions from petrochemical and carbon black plants because these plants produce CH_4 and non-CH_4 hydrocarbon by-products that may be burned for energy recovery, and such energy recovery may be reported in national energy statistics under "other" fuels or some similar categorization.

In this case, CH_4 in petrochemicals should be considered as "recovered" and CO_2, CH_4 and N_2O emissions from the recovered gas should be accounted for in the energy sector.

The following section on CO_2 capture could be relevant to better understand the issue of potential double counting from recovered emissions.

CO_2 capture

If CO_2 capture technology is installed and used at a plant, it is good practice to deduct the CO_2 captured in a higher-tier emission calculation. You should consider that CO_2 emissions captured in the process may be both combustion and process related. In cases where combustion and process emissions are to be reported separately, inventory compilers should ensure that the same quantities of CO_2 are not double counted. The total amount of CO_2 captured should preferably be reported in the corresponding energy combustion and IPPU categories in proportion to the amounts of CO_2 generated in these categories.

Petrochemical processes may utilize CO_2 captured elsewhere as a feedstock, and CO_2 may also be captured from petrochemical processes. For example, some methanol plants may utilize by-product CO_2 captured from other industrial processes as a feedstock for methanol production. This may create potential double counting issues, and so the CO_2 captured should not be reported as CO_2 emissions from the process from which the CO_2 is captured. For additional information on CCS, refer to section 1.2.2 of volume 3 of the 2006 IPCC Guidelines, and for more details on CO_2 capture and CO_2 storage, see section 2.3.4 of volume 2 (Energy) of the 2006 IPCC Guidelines.

For ethylene production, specifically, there is a simplification of the methodology that provides for an estimation of the secondary products, in case these data are not available, by applying default EFs (see table 3.25 and equation 3.18 of the 2006 IPCC Guidelines, vol. 3, chap. 3). However, you should note that these default factors lead to a double counting with the energy sector (consumption of residual gases). In general, the application of the tier 2 method (i.e. carbon balance) could lead to double counting of emissions, because steam crackers can be integrated in a refinery or part of a petrochemical site, and it would not be easy to move the relevant emissions from the energy sector to the IPPU sector in accordance with the national energy statistics (because steam cracking is not the main process in a refinery).

2.7. Fluorochemical production (category 2.B.9)

There are two subcategories under fluorochemical production:

- HFC-23 emissions from HCFC-22 production;
- F-gas emissions from production of other fluorinated compounds.

General reference

2006 IPCC Guidelines, volume 3, chapter 3, section 3.10.

Note: The methodology described in section 3.10.1 of the 2006 IPCC Guidelines (vol. 3, chap. 3) refers specifically to HFC-23. The methodology for F-gas emissions of fluorinated by-products in general and "fugitive" emissions is covered in section 3.10.2 of the same chapter.

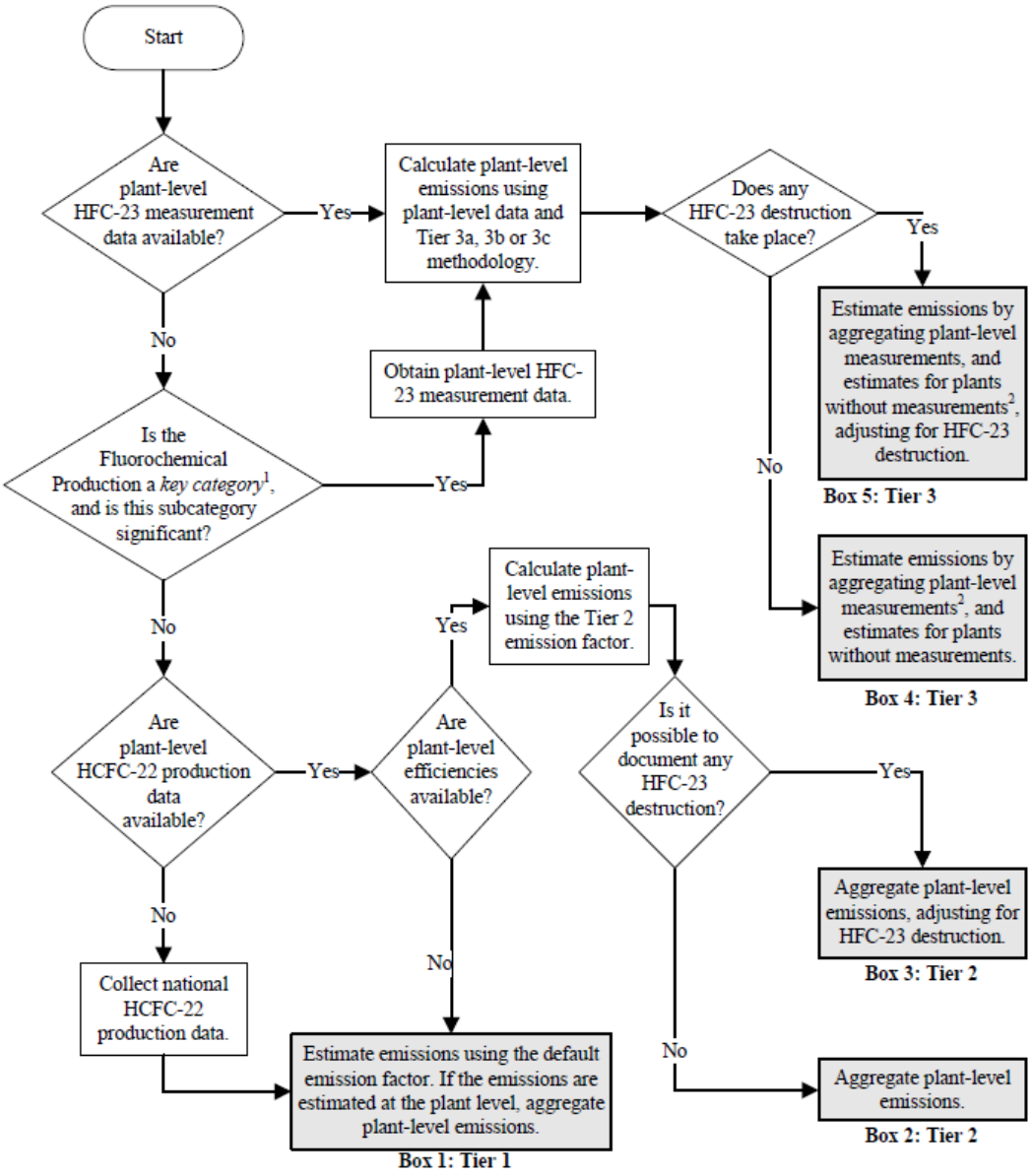
Trifluoromethane (HFC-23 or CHF_3) is generated as a by-product during the manufacture of chlorodifluoromethane (HCFC-22 or $CHClF_2$). Chemicals such as HFC-23 (and other HFCs, PFCs and SF_6)

are not significantly removed by aqueous (acidic, neutral or alkaline) scrubbing processes, and will be released into the atmosphere.

Choice of tier

The 2006 IPCC Guidelines provide three methodological tiers for estimating emissions from fluorochemical production. Unlike with many other categories, if this category is a key category, and emissions from the specific fluorochemical produced are considered a significant subcategory, then it is good practice to use a tier 3 method (see fig. 4-8 for the decision tree).

Note: For each *key category* the inventory compiler should determine if certain subcategories are particularly *significant*. Usually, for this purpose, the subcategories should be ranked according to their contribution to the aggregate *key category*. Those subcategories that contribute together more than 60 per cent to the *key category* should be treated as particularly *significant* (2006 IPCC Guidelines, vol.1, chap.4, page 4.8).



Q. Figure 4-8. 2006 IPCC Guidelines decision tree for estimation of HFC-23 emissions from HCFC-22 production

Priorities and potential key issues to consider during a review

There are a small number of plants producing HCFC-22 globally, and thus you should expect Parties to report either an emission estimate or "NO" in their CRTs.

Abatement

Procedures to abate emissions include destruction of HFC-23 in a number of facilities; in this case, emissions occur only when the destruction facility is not in operation. No abatement methods should be assumed when applying a tier 1 method, unless the tier 1 method is applied at the plant level and abatement has been verified by process records.

Confidentiality

Parties will often face issues of confidentiality with data from chemical production facilities because a limited number of companies and production facilities for HFCs exist across the world. However, if applying higher-tier methods, the reporting of HFC-23 emissions would not disclose the production data of HCFC-22, whereas the application of the tier 1 method would.

Fluorochemical production in the 2019 Refinement to the 2006 IPCC Guidelines

In the 2019 Refinement to the 2006 IPCC Guidelines, several revisions were made to the methodologies for fluorochemical production including on the choice of methods, EFs and AD. In particular, updates occurred to clarify the full range of emissions and their sources at fluorochemical production plants. Moreover, default EFs for the tier 1 method were updated, as well as the tier 3 method to include emissions from equipment leaks and to provide more detail for estimating emissions from process vents. Many equations were added and some decision trees (for HFC-23 emissions and other emissions from production of fluorinated compounds) were updated.

F-gas emissions from production of other fluorinated compounds

Emissions of a chemical occur during its production and distribution or as a by-product during the production of a related chemical (e.g. CF_4 from the production of CFC-11 and -12 or of SF_6 from the production of uranium hexafluoride in the nuclear fuel cycle). There may also be emissions of the chemical that is being produced (i.e. fugitive emissions).

Both by-product and fugitive emissions are calculated in the same way.

General reference

2006 IPCC Guidelines, volume 3, chapter 3, section 3.10.

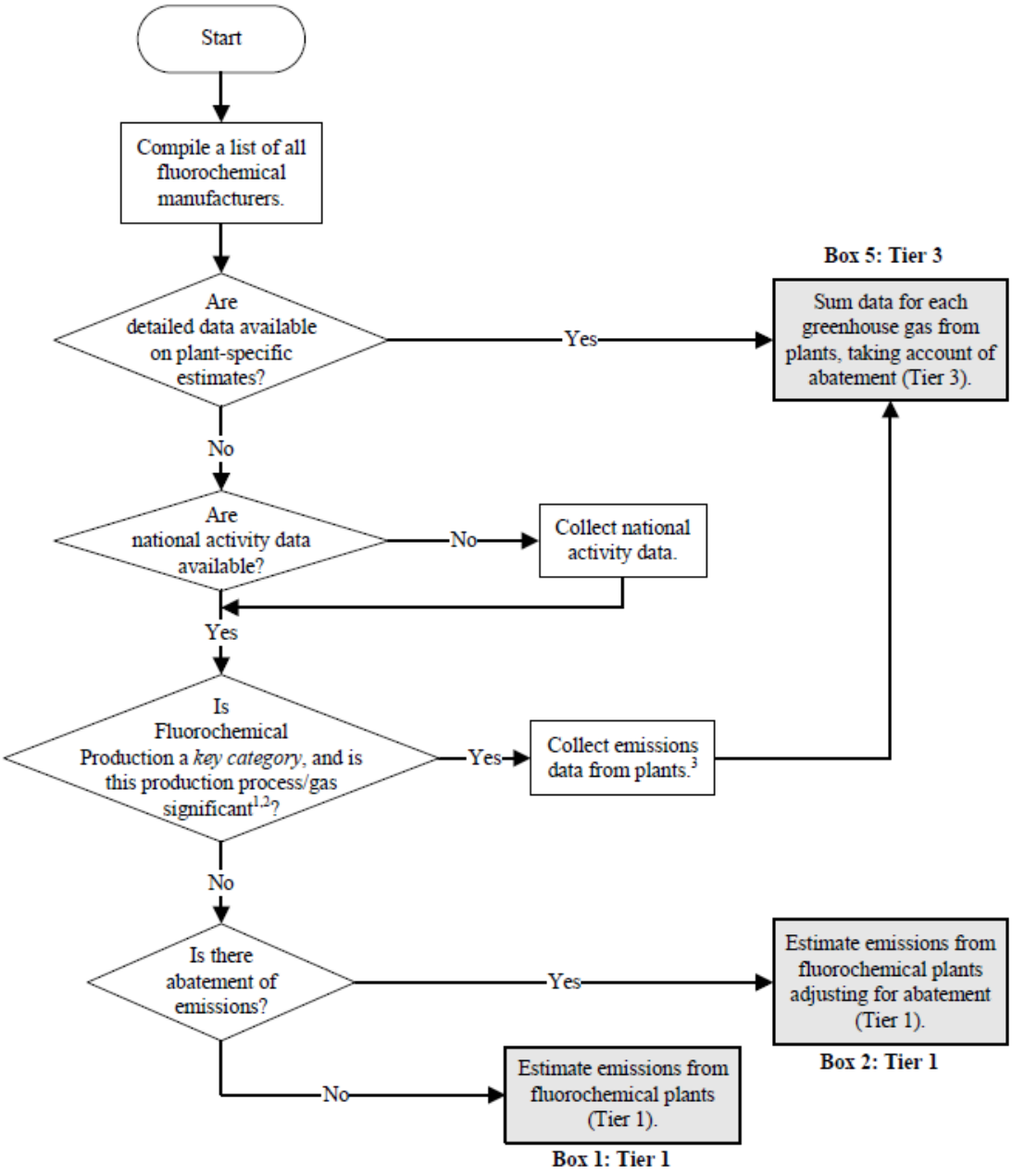
Note: The methodology for emissions of fluorinated by-products in general and 'fugitive' emissions is covered in section 3.10.2 of the 2006 IPCC Guidelines (vol. 3, chap. 10).

Choice of tier

The 2006 IPCC Guidelines specify two methodological tiers that can be applied: tier 1 and tier 3. Unlike with many other categories, if this category is a key category, and emissions from the subset of

chemicals produced are considered a significant subcategory, then it is good practice to use a tier 3 method.

The IPCC decision tree for choosing the estimation method is shown in figure 4-9.



R. Figure 4-9. 2006 IPCC Guidelines decision tree for estimation of F-gas emissions (fugitive and by-product) from production processes

Priorities and potential key issues to consider during a review

Each process has a different spectrum of F-gas emissions, in terms of both chemical nature and quantities, so it is essential that the Party identifies the existence of potentially emissive manufacturing plants in the country.

However, in general, the components that are lost during production of a particular fluorochemical have radiative forcing properties similar to those of the desired fluorochemical; so for sources that are not significant, fugitive and by-product emissions can be considered to be the same.

Also note that recycling of used gas may be carried out by the producers of new gas or by other recycling firms. Emissions may occur during handling and purification of old gas and handling of recycled gas. As specific EFs for these processes are not available in the guidelines, attention should be paid to check whether values different from the default factors are used.

When using a tier 1 method, problems of confidentiality arising from reporting specific component data can be circumvented by providing a single number for total national emissions of each HFC, PFC and SF_6.

3. Review approach

3.1. Overview

In the following section you will find some examples of potential findings you may be faced with during a review and recommendations you may describe in the relevant tables of the annual review report.

We will consider two cases: in the first you have to fill in a table where recommendations from the previous cycles of reviews are listed; in the second you will need to look for new findings and compile a table in consideration of your own assessment.

- In the table below, you will find some recommendations from the previous reviews. You are asked to indicate if the issue is resolved, not resolved or addressing considering what the Party has reported in its most recent submission (NID/CRT). The type of issue is indicated as Adherence to the MPGs, Completeness, etc..
- For the new findings, some indications are given so that you will be able to conclude on some issues and give recommendations to the Party. Here you may also indicate the type of issue you have found.

Case 1 (verifying implementation of previous recommendations)

Let's consider the following example.

Status of implementation of issues raised in the previous review report of Party K

ID#	Issue classification	Recommendation made in previous review report	TERT assessment and rationale
IPPU			
I.4	2.B.1 Ammonia production – CO_2 (I.9, 2019) (I.9, 2018) Accuracy	Review the CO_2 emissions from ammonia production by considering imports, exports and production of urea.	*Note to the reviewer*: To assess this issue, please read the section of a Party's NID on Ammonia production. We will then conclude whether this issue is resolved or not resolved, explaining the reasons.
I.5	2.B.2 Nitric acid production – N_2O (I.21, 2019) Transparency	Provide more transparent information on the EFs used for nitric acid production in the NID, including how EFs provided in the NID are used for the estimation of emissions, and the years and number of plants for which they are used.	*Note to the reviewer*: To assess this issue, please read the section of the Party's NID on nitric acid. We will have all the material to make our conclusion on the issue.

Issue I.1: Party's NID, section on Ammonia production

CO_2 emissions from ammonia production is a key category for both the level and the trend assessment (tier 1, excluding and including LULUCF). CO_2 emissions from ammonia production are estimated using a tier 3 methodology. The Party has used equation 3.3 of the 2006 IPCC Guidelines (vol. 3, chap. 3 p.3.13) to estimate the CO_2 emissions.

Total CO_2 emissions are calculated on the basis of natural gas consumption (energy and non-energy use). CO_2 emissions resulting from the use of urea as a fertilizer, which are included in the agriculture sector, and the annual amount of CO_2 used for the production of urea exported are subtracted from CO_2 emissions derived from ammonia production. No import of urea occurs in the country. Figures are reported in the table below.

Year	Natural gas consumption [kt]	CO_2 emissions [kt]	The amount of CO_2 resulting from the use of urea as a fertilizer [kt]	The annual amount of CO_2 used for the production of exported urea [kt]
1990	2 707.96	6 033.02	117.30	–
1995	2 101.40	4 677.85	115.68	–
2000	1 943.01	3 262.93	53.93	1,123.48
…	…	…	…	…
2020	510.63	1,006.16	67.24	94.51

Issue.I.2: Party's NID, section on Nitric acid production

Tier 2 and tier 3 methods were used for estimating N_2O emissions from nitric acid production; mainly tier 2, where plant-level production values were applied to technology-level EFs:

- Tier 2 method: use of facility-specific (combined from multiple nitric acid plants at the same facility) or plant-specific production data and production technology-specific EFs that are provided by plant technology vendors or national technology-specific average values when plant-specific EFs were not available;
- Tier 3 method: use of plant-specific production data and plant-specific EFs or continuous emissions monitoring system data when these were available from companies.

The tier 2 method was applied to all six high-pressure plants with NSCR abatement technologies currently in operation in the country for almost all years. Tier 3 plant-specific EFs were also applied to five plants for certain years: two high-pressure plants with NSCR abatement from 1990–2004, one high-pressure plant with NSCR abatement for 2004, one dual-pressure "Type 1" plant from 2008 onward and one high-pressure SCR plant from 2012 onwards. It should be noted that in order to ensure that confidential plant- or facility-specific production data is fully protected, it is not possible to specifically associate EFs with the plants.

The applicability of the EFs is indicated in the table below.

Table A6.2–3 N_2O Emission Factors for Nitric Acid and Adipic Acid Production

Category	Process Description[a]	N_2O Emission Factor (kg/t)
Nitric Acid Production	Dual-pressure plants with extended absorption "Type 2"	12[b]
	High-pressure plants with non-selective catalytic reduction	0.66[b]

(Source: Personal communication from national fertilizer institute.)

Reporting findings

Now let's try to compile the table with the information we have checked.

ID#	Issue classification	Recommendation made in previous review report	TERT assessment and rationale
IPPU			
I.1	2.B.1 Ammonia production – CO_2 (I.9, 2019) (I.9, 2018) Accuracy	Review the CO_2 emissions from ammonia production by considering imports, exports and production of urea.	Resolved. CO_2 emissions from ammonia production take into account urea production, imports and exports. The CO_2 flux of both urea production used in agriculture and urea exported was discounted.
I.2	2.B.2 Nitric acid production – N_2O (I.21, 2019) Transparency	Provide more transparent information on the EFs used for nitric acid production in the NID, including how EFs provided in the NID are used for the estimation of emissions, and the years and number of plants for which they are used	Addressing. The Party provided information on the EFs used for specific nitric acid production technology types in the NIR and CRT 2(I).A-H. The Party stated in the NID that a tier 2 method was applied for all currently operating plants for almost all years. However, the specific years, number of plants and the EFs used were not presented in the NID. During the review, the TERT suggested that one way to improve transparency without disclosing confidential data could be reporting for certain years/time periods the total number of plants corresponding to each of the average technology-specific EFs. During the review the Party replied that it would consider this approach, although confidentiality rules could hinder its implementation.

Case 2 (new findings)

We will now look for new findings in a Party's submission.

Let's check a Party's NID for category 2.B.8 Petrochemical and carbon black production by reading the following extract and tables from the Party's NID:

Petrochemical and carbon black production (2.B.8)

The manufacture of organic chemicals results in process emissions of NMVOC. Other gases such as CO_2, CH_4, N_2O, NO_X and CO may also be generated depending on the manufacturing process.

Complete time series of emissions of CH_4 and NMVOCs are included in the inventory for methanol, butadiene, carbon black, ethyl benzene, ethylene, ethylene oxide, formaldehyde, HDPE, LDPE, LLDPE, propylene, polypropylene, polystyrene, styrene, polyvinyl chloride and styrene butadiene rubber. Disaggregated production and emissions data for these sources are confidential. Emission estimates are aggregated at the polymers and other chemicals source category level.

Subsector	CO_2 (kg/tonne)	CH_4 (kg/tonne)
Acetylene [a]	3 384 kg CO_2 per tonne C_2H_2 used	
Butadiene		
Carbon black		0.11
Ethyl benzene		
Ethylene		0.03
Ethylene oxide		
Formaldehyde		
HDPE		
LDPE and LLDPE		
Methanol [b]		0.002
Propylene		
Polypropylene		
Polystyrene [b]		
Styrene [b]		4
Styrene butadiene rubber		1.5
Polyvinyl chloride		8.5

Please also check the following table, CRT 2(I).A-H:

TABLE 2(I).A-H SECTORAL BACKGROUND DATA FOR INDUSTRIAL PROCESSES AND PRODUCT USE — Year

Emissions of CO_2, CH_4 and N_2O — Submission

(Sheet 1 of 1) — Country

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	ACTIVITY DATA		IMPLIED EMISSION FACTORS [2]			EMISSIONS [3]			Recovery/Capture [4] [5]			
	Production/Consumption quantity		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2 fossil	CO_2 biogenic [6]	CH_4	N_2O
	Description [1]	(kt)	(t/t)			(kt)			(kt)			
2.B. Chemical industry						2820.77	0.43	7.48	302.94	NO	NO	NO
2.B.1. Ammonia production [7]	Production	1576.05	1.43	NO	NO	1953.38	NO	NO	302.94	NO	NO	NO
2.B.2. Nitric acid production	Production	1699.33			0.004			7.48				NO
2.B.3. Adipic acid production	Production	NO	NO		NO	NO		NO	NO	NO		NO
2.B.4. Caprolactam, glyoxal and glyoxylic acid production						NO		NO	NO	NO		NO
2.B.4.a. Caprolactam	NA	NO				NO		NO	NO	NO		NO
2.B.4.b. Glyoxal	NA	NO				NO		NO	NO	NO		NO
2.B.4.c. Glyoxylic acid	NA	NO				NO		NO	NO	NO		NO
2.B.5. Carbide production	Production	C	C	C		3.66	0.43		NO	NO	NO	
2.B.5.a. Silicon carbide		NO	NO	NO		NO	NO		NO	NO	NO	
2.B.5.b. Calcium carbide	NA	C	C	NO		3.66	0.43		NO	NO	NO	
2.B.6. Titanium dioxide production	Production	C	C			848.13			NO	NO		
2.B.7. Soda ash production	Production	C	C			IE			NO	NO		
2.B.8. Petrochemical and carbon black production						NO,IE,NA	NO,IE,NA		NO	NO	NO	
2.B.8.a. Methanol	Production	C				IE	IE		NO	NO	NO	
2.B.8.b. Ethylene	Production	C				NO	IE		NO	NO	NO	
2.B.8.c. Ethylene dichloride and vinyl chloride monomer		NO				NO	NO		NO	NO	NO	
2.B.8.d. Ethylene oxide	Production	C				NA	NA		NO	NO	NO	
2.B.8.e. Acrylonitrile		NO				NO	NO		NO	NO	NO	
2.B.8.f. Carbon black	Production	C				NO	IE		NO	NO	NO	
2.B.8.g. Other [8]						NO	NO		NO	NO	NO	
Drop-down list:												
2.B.8.g.i. Styrene		NO				NO	NO		NO	NO	NO	
2.B.8.g.ii. Other *(please specify)*						NO	NO		NO	NO	NO	
		NO				NO	NO		NO	NO	NO	
2.B.10. Other						15.61	NO	NO	NO	NO	NO	NO
Drop-down list:												
2.B.10.a. Hydrogen production		NO				NO	NO	NO	NO	NO	NO	NO
2.B.10.b. Other *(please specify)*						15.61	NO	NO	NO	NO	NO	NO
Confidential chemical industry emissions	Production	C				15.6105739	NO	NO	NO	NO	NO	NO

Nature of the finding

The finding may be related to the estimation of CO_2 emissions from ethylene oxide.

We would ask the Party a preliminary question, with a brief description of the finding. For instance, you could ask for additional clarification on the following:

- The Party reports AD for ethylene oxide production as "C" for the entire time series and CO_2 emissions as "NA" in CRT 2(I).A-H. The 2006 IPCCC Guidelines (vol. 3, chap. 3, table 3.20) provide default CO_2 EFs for this category.
- Can the Party explain whether these emissions were estimated?

Let's suppose that the Party replies that CO_2 emissions captured and supplied from the only ethylene oxide plant in the country are used in the food and drink industry where a specific EF is used, whereas CO_2 emissions are reported in category 2.B.10.

Translating the finding into an issue

What did the finding identify?

- It is not clear whether the Party estimates CO_2 emissions from ethylene oxide production or if the emissions are included in some other category.

Why is it a problem?

- The issue may relate to the accuracy/comparability of emission estimates.

What is an ideal situation?

- The Party reports CO_2 emissions under the relevant category.

What is the recommendation of the TERT?

- Report CO_2 emissions separately in category 2.B.8 or, if this is not possible, report them as "IE" and explain in the NID where they are reported.

Nature of the issue

Comparability (assuming that the Party confirmed during the review that the emissions are included in the inventory: if they were missing, it would be an accuracy issue).

Reporting the finding

Now, let's report our finding in the review report.

Additional findings made during the individual review of the submission of Party K

ID#	Finding classification	Description of the finding with recommendation or encouragement	Is finding an issue/problem?
IPPU			
I.6	2.B.8 Petrochemical and carbon black production – CO_2	The Party reports AD for ethylene oxide production as "C" for the entire time series and CO_2 emissions as "NA" in CRT 2(I).A-H. The 2006 IPCCC Guidelines (vol. 3, chap. 3, table 3.20) provide default CO_2 EFs for this. During the review the Party explained that CO_2 emissions were reported in category 2.B.10, whereas CO_2 captured and supplied from the only ethylene oxide plant in the country is used in the food and drink industry. The TERT recommends that the Party report CO_2 emissions from ethylene oxide production separately in category 2.B.8 or, if this is not possible, report them as "IE" in the CRT and explain, in the NID, where they are reported.	Yes. Comparability

4. Practical exercises

4.1. Exercise 1 (ammonia production)

CO_2 from ammonia production in the CRT is reported as "emissions" and "recovered" for subsequent use.

Please also check the following CRT:

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	ACTIVITY DATA		IMPLIED EMISSION FACTORS [2]			EMISSIONS [3]			Recovery/Capture [4] [5]			
	Production/Consumption quantity		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2 fossil	CO_2 biogenic [6]	CH_4	N_2O
	Description [1]	(kt)	(t/t)			(kt)			(kt)			
2.B. Chemical industry												
2.B.1. Ammonia production [7]	Production	468.80	1.97		NO	566.79	NE	NA	354.85	NO	NO	NO
2.B.2. Nitric acid production	Production	322.19			0.00			0.33				NO
2.B.3. Adipic acid production	Production	NO	NO		NO	NO		NO	NO	NO		NO
2.B.4. Caprolactam, glyoxal and glyoxylic acid production						NO		NO	NO	NO		NO

In the table, note 7 specifies the following:

To ensure that double counting does not occur, fuel consumption (e.g. natural gas) in ammonia production should not be included in the energy sector. Should CO_2 from ammonia production be recovered for subsequent use and be excluded from the reporting in category 2.B.1, the products and the purposes for which the CO_2 is used should be clearly explained in the NID for the most recent inventory year. The related CO_2 emissions from these products and significant uses shall be reported in the relevant source categories in the inventory if these emissions occur within the borders of the Party concerned. Parties shall provide an overview in the NID in which other source categories of the GHG inventory CO_2 emissions from significant uses of urea are reported.

The Party describes in its NID (section 4.3.1, Methodological issues) the following:

Methodology

Natural gas is used as both feedstock and fuel in ammonia production and GHG emissions from both uses have been calculated. Since natural gas used in ammonia production is included in the energy balance under "non-energy use" category, double counting does not occur (with the energy sector).

The tier 3 method is used to estimate CO_2 emissions. The basis for the calculation is plant-specific total fuel data. The quantity for subsequent use in the production of urea and applied to soil is substracted from the total quantity of CO_2 generated to derive CO_2 emitted.

Questions

- What step would you take as a reviewer?
- What are the most important questions you would ask with regard to recovery of CO_2 emissions from ammonia production?

Select one:

A. You would ask for information on the use of urea other than in application to soils to be reported under agriculture

B. You would concentrate on possible use of urea in SCR systems in diesel engines (in vehicles) to be reported under IPPU

Answer

The correct answer is (A).

The correct action is to ask the Party for information on potential uses of urea other than in soils.

Note. If urea is used in SCR systems in diesel engines (in vehicles) or in SCR in industrial combustion, for instance power plants, emissions should be reported in the IPPU sector (category 2.D.3).

One possible way to approach the issue would be the following:

Prepare

The TERT should first assess the Party's submission to ensure that this information is not provided.

Assess (through communication with the Party)

You should ask the Party to provide information on these other uses of urea. The ideal situation is that the Party either provides information that shows that these activities did not occur or provides AD and related CO_2 emission estimates.

Assuming that the response by the Party is that uses of urea other than application to soils will be explored, what would be your recommendation to the Party?

Draft

You may recommend that the Party explore further uses of urea other than application to soils and, if they exist, to estimate those emissions. Alternatively, if the Party cannot estimate those emissions you may recommend that the Party revise the estimation method considering different amounts of CO_2 recovered.

This issue may be considered an issue of completeness. This is a possible case of emission estimates being missing: other countries report the use of urea in SCR in diesel engines and applied to industrial combustion.

4.2. Exercise 2 (calcium carbide)

A Party estimates CO_2 emissions from CaC_2 production including emissions from the decomposition of $CaCO_3$ and the use of reductant and emissions from the use of non-exported carbide product.

The Party applies a tier 2 method with EFs provided by plant operators.

The information in the table below is reported in the NID and CRT.

Calcium carbide production			
Year	CaC_2 production	IEF CO_2	CO_2 emissions
	(kt)	(t/t)	(Gg)
1990	10.00	2.88	28.80
1995	50.00	1.78	89.00
	73.50	1.84	135.24
	…	…	…
2020	100.48	1.49	149.72

Question 1

What additional information would you ask the Party to provide in order to let you compare figures with other countries?

Select one:

A. The type of reductant used in the process
B. The amount of reductant used in the process
C. The plant-specific EFs
D. The amount of CaC_2 imported
E. All of the above

Answer 1

The correct answer is (E).

The information on the type and amount of reductant is very important to verify the plant-specific EF. Since emissions are already provided by the Party it is important to check the range of EFs to make a comparison among countries. You should also check whether the amount of CaC_2 imported has been considered, since the 2006 IPCC Guidelines also provide a default EF for estimating emissions from the use of product.

Question 2

Next, consider a situation where the range of EFs is comparable with those of other countries and the Party replies that the amount of CaC_2 imported has probably not been considered in the estimation process.

The Party informed the TERT that petroleum coke is used as a reductant in CaC_2 production. Consider the following CRT for the energy sector.

As a reviewer, would you have any questions for the Party regarding its estimation of emissions from CaC_2 production after reviewing this table?

Feedstocks, reductants and other non-energy use of fuels — Submission

(Sheet 1 of 1) — Country

FUEL TYPE			ACTIVITY DATA AND RELATED INFORMATION	IMPLIED EMISSION FACTOR	CARBON EXCLUDED FROM REFERENCE APPROACH		IMPLIED CARBON EXCLUDED FRACTION	REPORTED CO_2 EMISSIONS[1]	
			Fuel quantity for NEU	Carbon emission factor	Carbon excluded	CO_2 excluded	Carbon fraction excluded from reference approach[2]	CO_2 emissions from the NEU reported in the inventory	Reported under: Select category(ies) from the category tree[3]
			(TJ)	(t C/TJ)	((kt) C)	((kt) CO_2)	(%)	((kt) CO_2)	
Liquid fossil fossil	Primary fuel	Crude oil							
		Orimulsion							
		Natural gas liquids	9,045.82	15.57	140.84	516.40	1		
	Secondary fuels	Gasoline							
		Jet kerosene							
		Other kerosene[4]							
		Shale oil							
		Gas/diesel oil[4]	464.27	19.86	9.22	33.81	1		
		Residual fuel oil							
		Liquefied petroleum gases (LPG)[4]	NO	NO	NO	NO	NO		
		Ethane[4]							
		Naphtha[4]	23,900.00	19.99	477.76	1,751.79	1		
		Bitumen							
		Lubricants[1]	1,849.50						
		Petroleum coke[5]	NO	NO	NO	NO	NO		
		Refinery feedstocks	NO	NO	NO	NO	NO		
		Other oil[6]	NO	NO	NO	NO	NO		
Other liquid fossil									

Select one:

A. No, the reporting by the Party is consistent with that reported in the IPPU sector for CaC_2
B. Yes

Answer 2

The correct answer is (B).

The non-energy use of petroleum coke in CRT 1.A(d) is reported using "NO", despite its use as a reductant in carbide production. You would first ask a question to the Party as to why it is reporting "NO" when it has indicated use of petroleum coke as a reductant for CaC_2 production. One possible way to approach the issue would be the following:

Prepare

The TERT should first assess the Party's submission on CO_2 emissions from CaC_2 production including emissions from the decomposition of $CaCO_3$ and the use of reductant and emissions from the use of non-exported carbide product as well as the amount of CaC_2 imported.

Assess (through communication with the Party)

Since emissions are already provided by the Party it is important to check the range of EFs to make a comparison among countries. Note that the 2006 IPCC Guidelines provide also a default EF for estimating emissions from the use of product. You should also check whether the amount of CaC2 imported.

Assume that, during the review, the Party informed the TERT that petroleum coke is used as a reductant in CaC_2 production.

Draft

You would recommend that the Party check whether imports of CaC_2 occur in the country and, if they do occur, to consider this amount in the estimation process.

You would also recommend that the Party improve the accuracy of the information in the CRT, removing the “NO” and adding information on the type and amount of reductant used in the process. In addition, you would recommend that the Party explain any recalculation and reallocation of emissions in its next NID.

5. Self-check quiz

5.1. Questions

Question 1 (ammonia)

A Party estimates CO_2 emissions from ammonia production by applying a tier 3 method with the availability of plant-specific data on the amount of natural gas consumption used to produce ammonia, and its composition for the entire time series.

The formula to calculate emissions is the following:

Emissions (kg) = (Consumption of gas (m^3) * C content of gas (kg/m^3) * 44/12 * oxidation factor) – recovery for urea production

where the carbon content of natural gas for the Party is plant specific.

The Party assumes a default oxidation factor of 1 and assumes zero recovery of CO_2 for urea production. IEFs, derived by dividing CO_2 emissions by the amount of ammonia produced, vary between 1,24 and 1.45 t CO_2/t ammonia produced along the time series.

You would compare the range of these factors with the IPCC default values reported in the following table.

TABLE 3.1
DEFAULT TOTAL FUEL REQUIREMENTS (FUEL PLUS FEEDSTOCK) AND EMISSION FACTORS FOR AMMONIA PRODUCTION (PER TONNE NH_3)

Production Process	Total fuel requirement (GJ(NCV)/tonne NH_3) ± Uncertainty (%)	Carbon content factor [CCF][1] (kg/GJ)	Carbon oxidation factor [COF][1] (fraction)	CO_2 emission factor (tonnes CO_2 /tonne NH_3)
Modern plants – Europe Conventional reforming – natural gas	30.2 (± 6%)	15.3	1	1.694
Excess air reforming – natural gas	29.7 (± 6%)	15.3	1	1.666
Autothermal reforming – natural gas	30.2 (± 6%)	15.3	1	1.694
Partial oxidation	36.0 (± 6%)	21.0	1	2.772
Derived from European average values for specific energy consumption (Mix of modern and older plants) Average value – natural gas	37.5 (± 7%)	15.3	1	2.104
Average value – partial oxidation	42.5 (± 7%)	21.0	1	3.273

NCV – Net Calorific Value.

[1]. Values from Energy, Vol. 2, Chapter.1, Tables 1.3 and 1.4..

Source: Adapted from EFMA (2000b; p.21); de Beer, Phylipsen and Bates (2001; p.21); for modern plants default factors can be derived using C content based on natural gas (dry basis) and partial oxidation default factors can be derived using C content based on residual fuel oil.

What other information would you consider most important to ask the Party to provide in order to improve the transparency of the information already provided?

Select one:

A. The data management information for natural gas use at the plant, the specific carbon content of natural gas and the category-specific quality checks against national energy statistics
B. Reference conditions for the natural gas compositional analysis and also the sampling frequency
C. The EF on an energy basis to further improve comparability against EFs for other categories and other Parties

Question 2 (nitric acid)

Consider the following paragraph.

Nitric acid production. The value of the N_2O EF (0.001 t/t) is low compared with values reported by most Parties and lower than the IPCC default values (0.002–0.009 t/t). The Party noted that its EF was taken from a study based on information from the only nitric acid producer in the country that regularly measures its N_2O emissions.

What would NOT be useful for the TERT to review in more detail in order to address the comparatively low EF?

Select one:

A. The study upon which the EF used by the Party was based
B. The Party's emissions control (i.e. destruction) data
C. The Party's AD for completeness

Question 3 (adipic acid)

A Party estimates N_2O emissions from the only adipic acid production plant in the country using the tier 2 method, based on the default IPCC EF and plant information on abatement systems and destruction factors, which have been available since 2004. The abatement system, a thermal destruction system, became operational in 2005; the efficiency of the destruction increased over the time from 92 per cent in 2010 (continuous operating times of 320 days), to more than 98 per cent in 2015 (continuous operating times of 350 days). In 2019, efficiency up to 99 per cent was achieved due to technical improvements implemented in the production process (continuous operating times of 360 days).

Which values of N_2O EFs would you expect from the process, for the year 2010, considering that for the first years of the time series the EF was equal to the default factor of 300 kg N_2O/t adipic acid?

Please consider the formula from the 2006 IPCC Guidelines:

EQUATION 3.8
N_2O EMISSIONS FROM ADIPIC ACID PRODUCTION – TIER 2

$$E_{N2O} = \sum_{i,j} \left[EF_i \bullet AAP_i \bullet \left(1 - DF_j \bullet ASUF_j\right)\right]$$

Where:

E_{N2O} = emissions of N_2O, kg

EF_i = N_2O emission factor for technology type *i*, kg N_2O/tonne adipic acid produced

AAP_i = adipic acid production from technology type *i*, tonnes

DF_j = destruction factor for abatement technology type *j*, fraction

$ASUF_j$ = abatement system utilisation factor for abatement technology type *j*, fraction

What is the IEF for 2010? Please provide your answer by filling in the cell below:

	2010
IEF (t N_2O/t adipic acid)	

Question 4 (refineries)

Consider the following statements:

> *Refineries manufacture petroleum product for fuel and for non-energy uses.*
>
> *Some fuel use in the refinery is to support manufacture of chemical products, for instance propylene, for sale.*

Which of the two sentences below is correct?

Select one:

A. The CO_2 emissions from fuel consumed by the refinery for all these activities should be reported as emissions under the energy sector
B. The CO_2 emissions from fuel consumed in the refinery to support manufacture of chemical products should be reported under the IPPU sector

Question 5 (HFC-23 emissions)

A Party estimates HFC-23 emissions as a by-product from HCFC-22 production using a tier 1 method, applying a default EF to the quantity of total national HCFC-22 production for the entire time series. In the recent years of the time series, the Party continues to estimate emissions using national-level estimates of HCFC-22 production, but has evidence of abatement techniques for HFC-23 in some, but not all, facilities.

Can the Party apply this information to reduce its emissions?

Select one

A. Yes, the Party can subtract the amount of destroyed HFC-23 from national estimates where the abatement system has been verified
B. No, the Party cannot use a tier 1 method and apply the reduction for abatement technologies when emissions are estimated only at the national, and not plant, level

5.2. Answers

Answer 1 (ammonia)

The correct answer is (A).

In this case, it is important to know the carbon content of the natural gas over time applied by the Party, and understand the use of natural gas as feedstock in the ammonia production process. It can also be checked if the amount of fuel used is included in the energy balance under the non-energy final consumption or non-energy use.

Answer 2 (nitric acid)

The correct answer is (C).

The completeness of the AD will generally affect both the AD and the emission estimate but not affect the IEF. Emission controls, on the other hand, may have a large impact on the value of an IEF, particularly for nitric acid. Furthermore, the IPCC default EF for nitric acid does not include any emission controls. Since emissions from nitric acid production may show a sudden reduction from one year to another, depending on the time (and operating time) of implementation of the technology, emission controls are just as important for the emission estimate as the basic AD and the EF used.

Answer 3 (adipic acid)

The correct answer is 0.06 t N_2O/t adipic acid

In 2010:

IEF = 300 kg N_2O/t adipic acid * 1– (0.92 (320/365))

IEF = 300 kg N_2O/t adipic acid * 0.19

IEF = 58.03 kg N_2O/t adipic acid

IEF = 0.06 t N_2O/t adipic acid

Answer 4 (refineries)

The correct answer is (B).

The 2006 IPCC Guidelines state that primary fossil fuels (natural gas, petroleum, coal) are used for non-fuel purposes in the production of petrochemicals and carbon black. The use of these primary fossil fuels may involve combustion of part of the hydrocarbon content for heat raising and the production of secondary fuels (i.e. off-gases). Combustion emissions from fuels obtained from feedstocks should be allocated to the source category in the IPPU sector. However, where the fuels are not used within the source category but are transferred out of the process for combustion elsewhere (e.g. for district heating purposes) the emissions should be reported in the appropriate energy sector source category (2006 IPCC Guidelines, vol. 3, chap. 3, section 3.9.4.2).

Refineries manufacture petroleum product for fuel and for non-energy uses and in doing so produce hydrogen and other gases, intermediate products and basic chemicals. The CO_2 emissions from fuel consumed by the refinery for this activity are reported under the energy sector. This principle is maintained in the IPCC guidelines, even when some fuel use in a refinery is to support manufacture of chemicals for sale (e.g. propylene or aromatics) (2006 IPCC Guidelines, vol. 3, chap. 1, section 1.3.3).

Answer 5 (HFC-23 emissions)

The correct answer is (B).

When using a tier 1 method applied **to national-level** production, it is assumed that there is no information on plant data so the use of abatement technologies is not permitted in the calculation formula. If applying the tier 1 method **to individual plants**, a Party may subtract emissions from those plants if abatement has been verified by process records. However, normally, if plant-level data are available, a higher tier method should be possible.

6. Key points to remember

- CO_2 capture technologies are particularly relevant in the chemical industry, so there is a possibility of deducting the quota of CO_2 captured in higher-tier estimation methods.
- Any methodology taking into account CO_2 capture should consider that CO_2 emissions captured in the process may be both combustion and process related.
- If CO_2 from ammonia production is recovered for subsequent use and excluded from the reporting in this category, the products and the purposes for which the CO_2 is used should be clearly explained in the NID.
- Nitric acid may be a significant source of atmospheric N_2O, if not abated, and the major source of N_2O emissions in the chemical industry. A number of technologies for N_2O reduction during nitric acid manufacture have been developed in recent years, so you may expect a sharp decrease in emissions in recent years in many countries. Parties should demonstrate the types and utilization of emission control technologies (i.e. destruction).
- The issue of potential underestimation of AD in these categories is relevant, because of considering intermediate products that may be converted directly into other chemicals or for which production may occur in integrated plants.
- Parties will often face issues of confidentiality with data from chemical production facilities because a limited number of companies and production facilities for HFCs exist across the world.

Lesson 5. Metal industry

1. Introduction and objectives of the lesson

1.1. Lesson outline

This lesson is organized into six sections and helps you focus on what best complements your prior knowledge of the topic, as follows:

1. Introduction and objectives of the lesson
2. Category overview and methodological information
3. Review approach
4. Practical exercises
5. Self-check quiz
6. Key points to remember

1.2. Categories in metal industry

The categories considered in this lesson pertain to the metal industry (category 2.C metal industry in the CRT). Their codes in the CRTs are as follows:

- 2.C.1 Iron and steel production;
- 2.C.2 Ferroalloy production;
- 2.C.3 Aluminium production;
- 2.C.4 Magnesium production;
- 2.C.5 Lead production;
- 2.C.6 Zinc production.

This list of categories is consistent with the set of CRTs. Any of these categories could be a key category for a Party and, as such, should be placed relatively high up on your list of priorities when reviewing it. You should refer to the 2006 IPCC Guidelines (vol. 3, chap. 4) for the methodologies to estimate emissions from these categories. Some of the main problems you may encounter when reviewing emissions from these categories are also discussed in this lesson.

The expected time needed to complete lesson 5 depends on the level of your knowledge of GHG inventories for the IPPU sector under the ETF and the 2006 IPCC Guidelines:

- For readers with experience: 15–30 minutes
- For readers with less experience: 25–50 minutes

1.3. 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 metal industry;
- Identify whether a Party's reporting for metal industry is consistent with the requirements of the MPGs;
- Draft key review recommendations to Parties in relation to emissions from metal industry.

2. Category overview and methodological information

2.1. Overview

The following discussion covers methods for calculating emissions from metal industry. The risk of double counting of CO_2 emissions, or of their omission, is very high due to the close linkage between the energy and IPPU sectors. In fact, CO_2 emissions resulting from the role of carbon as the process reactant and as a heat source for the chemical reactions involved in the metallurgical processes are closely related in many cases.

If CO_2 capture technology is installed at a metal production facility, the CO_2 captured should be deducted in a higher-tier emissions calculation. As CO_2 emissions captured may be both combustion and process related, in cases where combustion and process emissions are to be reported separately (e.g. for iron and steel production), the compiler should ensure that the quantities of CO_2 are not double counted. The total amount of CO_2 captured should preferably be reported in the corresponding energy combustion and IPPU categories in proportion to the amounts of CO_2 generated in these categories. The default assumption is that there is no CCS taking place.

Also, the correct reporting of emissions between the energy and IPPU sectors needs particular care. For instance, in the case of blast furnace gas, if the fuel is combusted entirely within the iron and steel industry (whether for heating blast air, site power needs or for metal finishing operations), the associated emissions are reported in IPPU category 2.C.1. However, if part of the gas is removed from the metal-production facility and delivered, for example, to a nearby brick works for heat production or a main electricity producer (i.e. the gas is exported to another facility where it is used for energy purposes), then the emissions from that part of the gas are reported in the energy sector (in our example, it would be category 1.A.2.f or 1.A.1a, respectively).

For each category, a brief description of the estimation method is given with reference to the decision trees in the 2006 IPCC Guidelines, the choice of AD and EFs, how to deal with CO_2 capture, and the reporting in the CRT.

Metal production in the 2019 Refinement to the 2006 IPCC Guidelines

In the 2019 Refinement to the 2006 IPCC Guidelines, changes and updates occurred to some subcategories within metal production industry, namely iron and steel, metallurgical coke production and primary aluminium production, as described in specific sections below. Rare earths production was added as a new subcategory with extensive guidance. No further changes occurred to the other subcategories within metal production (i.e. ferroalloy production, magnesium production, lead production, zinc production).

2.2. Iron and steel production (category 2.C.1)

The production of iron and steel is an energy-intensive process, and it also generates process-related emissions of CO_2 and CH_4; N_2O emissions may also occur, but no methodology for their estimation is provided in the 2006 IPCC Guidelines.

The iron and steel industry broadly consists of:

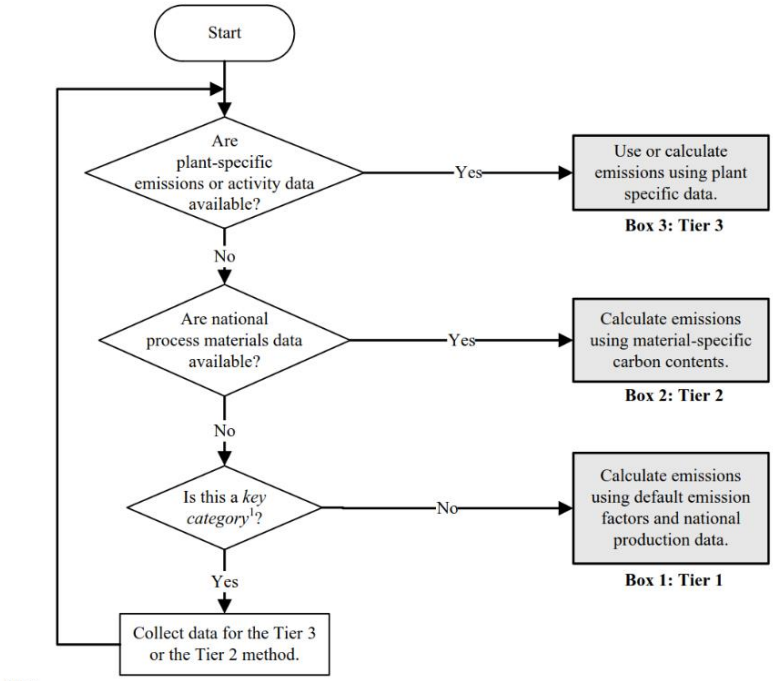
- Primary facilities that produce both iron and steel;
- Secondary steelmaking facilities;
- Iron production facilities;
- Off-site production of metallurgical coke.

The main processes for iron and steel production are metallurgical coke production, sinter production, pellet production, iron ore processing, iron making, steelmaking, steel casting and, very often, combustion of blast furnaces and coke oven gas for other purposes. These processes may occur under an "integrated" facility and typically include blast furnaces and basic oxygen furnaces, or in some cases open hearth furnaces. It is also common for parts of the production to be off site, under the responsibility of another operator such as an off-site coke production facility.

Please note here that in some countries there is no coke production and no use of blast furnaces included in the iron-production facilities. It is also possible that there is no domestic production using recycled steel scrap. As a reviewer you should read the NID carefully and pay close attention to the Party's comments in this regard.

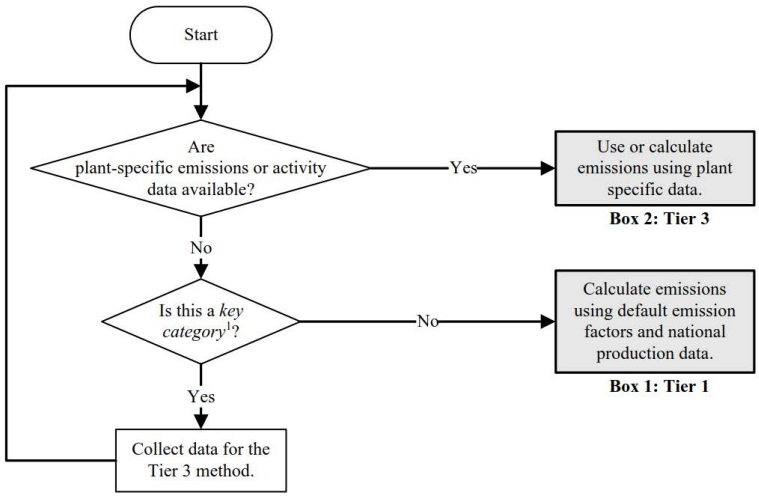
Choice of tier

The 2006 IPCC Guidelines outline three methods for estimating CO_2 emissions and two tiers for calculating CH_4 emissions from iron and steel production (please note that, for CH4, there is a tier 1 and a tier 3 method in the guidelines, but no tier 2). The IPCC decision trees for choosing the estimation method are shown in figures 5-1–5-2.



Note:
1. See Volume 1 Chapter 4, Methodological Choice and Identification of Key Categories (noting Section 4.1.2 on limited resources), for discussion of *key categories* and use of decision trees.

S. Figure 5-1. 2006 IPCC Guidelines decision tree for estimation of CO_2 emissions from iron and steel production



Note:
1. See Volume 1 Chapter 4, Methodological Choice and Identification of Key Categories (noting Section 4.1.2 on limited resources), for discussion of *key categories* and use of decision trees.

T. Figure 5-2. 2006 IPCC Guidelines decision tree for estimation of CH_4 emissions from iron and steel production

General references

Default CO_2 and CH_4 EFs are reported in the 2006 IPCC Guidelines (vol. 4, chap. 4, tables 4.1 and 4.2).

The production processes of sinter, pig iron and steel are illustrated in the 2006 IPCC Guidelines (vol. 3, chap. 4, figures 4.3–4.5),

Emissions from coke production are also illustrated in the 2006 IPCC Guidelines (vol. 3, chap. 4, figure 4.2). Although the methods for estimating emissions from metallurgical coke production are provided in the iron and steel category, these emissions should be reported in the energy sector (under category 1.A.1.c.i; see 2006 Guidelines, vol. 2, chap. 2, table 2.1).

2006 IPCC Guidelines, volume 3, chapter 4, section 4.2.

Priorities and potential key issues to consider during a review

The CRT requires separate reporting of background data for the following subcategories under 2.C.1 (iron and steel production):

- Steel;
- Pig iron;
- Direct reduced iron;
- Sinter;
- Pellet;
- Other.

More specific information (e.g. data on virgin and recycled steel production) could be provided in the documentation box of the CRT background data table, together with a reference to the relevant section of the NID, or in the NID.

Relationship to the energy sector

All carbon, including that from carbonate use, and from use in blast furnaces, direct reduced iron, basic oxygen furnaces, electric arc furnaces and open hearth furnaces should be considered as process-related emissions (2.C.1), and all carbon use in coke ovens should be reported in the energy sector (1.A.1.c.i).

The risk of double counting or omissions of emissions is very high for this category. As the primary use of carbon sources (predominantly coke, but also coal, oil, natural gas, limestone, etc.) is to produce pig iron, the CO_2 and CH_4 emissions from iron and steel production, including sinter production, are to be reported under the IPPU sector. The CO_2 and CH_4 emissions from coke production (fuel consumption and conversion losses) both on-site and off-site, from the iron and steel production facility, are to be considered as energy production and reported under the energy sector (1.A.1.c.i).

However, for integrated production and iron and steel with on-site coke production, there may be flows of by-products (e.g. coke oven gas, blast furnace gas and coke oven by-products) between the coke production facility and the iron and steel production facility, creating potential double counting issues. Carbon consumed in the form of coke oven gas or blast furnace gas at an iron and steelmaking facility and the resulting CO_2 and CH_4 emissions would be categorized under the IPPU sector; carbon consumed in the form of coke oven gas or blast furnace gas at an on-site coke production facility and the resulting CO_2 and CH_4 emissions would be categorized as energy sector emissions. Therefore it is

important that the Party shows a complete carbon balance to demonstrate transparency in its reporting. Owing to the dominant role of coke, it is important to consider the existence of coke making at a facility and define the boundary limits of a carbon balance at an iron and steelmaking facility to ensure that CO_2 emissions are not double counted.

It is important for all tiers that emissions from reducing agents and process materials (coal, coke, natural gas, etc.) are not double counted or omitted. When using a tier 1 method, total steel production by process and the amount of iron produced that is not processed into steel should be reported in the NID. When using a tier 2 method there should be a clear explanation in the NID of the linkage with the category 1.A (fuel combustion) estimate for integrated coke production emissions, to demonstrate that double counting or missing emissions have not occurred.

If part of the iron and steel derived gases are delivered off-site (e.g. for heat production or a main electricity producer), then the emissions are reported in the relevant energy subcategories.

Iron and steel and metallurgical coke production in the 2019 Refinement to the 2006 IPCC Guidelines

In the 2019 Refinement to the 2006 IPCC Guidelines, for iron and steel production the methodological guidance was updated to include improved decision trees and equations, a new tier 2 method for CH_4 emissions, new tier 3a (plant-specific carbon balance) and tier 3b (based on emission measurements) methods for CO_2 emissions, a new tier 1 method for CO_2 emissions from flaring of process gases, and new methods to estimate N_2O emissions including a tier 1 method for emissions from flaring of process gases. For metallurgical coke production, the guidance was updated to align it with the new methods presented in the energy volume for fugitive emissions, and to present new methods, such as a tier 1b simplified carbon balance method. Moreover, default EFs have been extensively updated, and the tier 2 material-specific carbon contents list has been extended and updated.

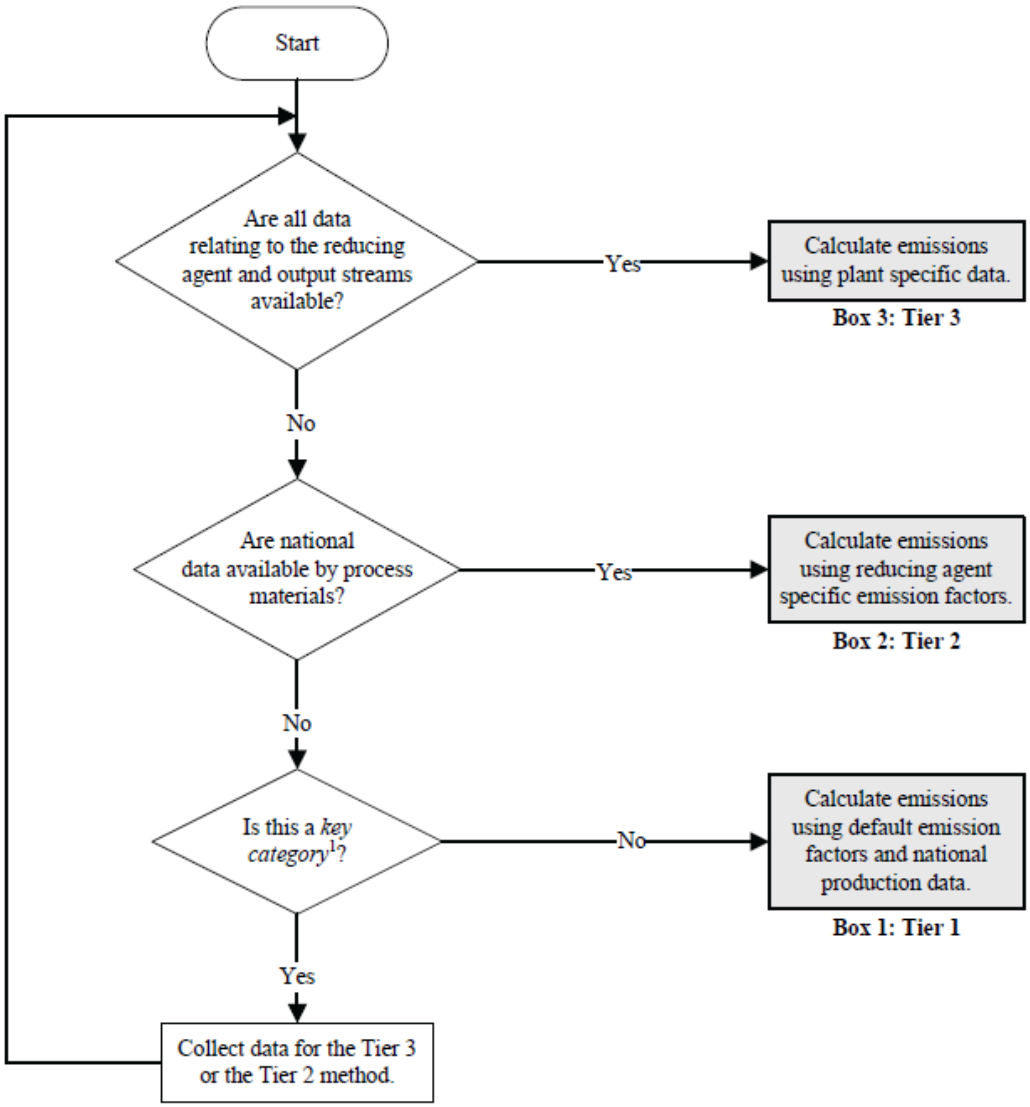
2.3. Ferroalloys production (category 2.C.2)

The 2006 IPCC Guidelines (vol. 3, chap. 3, section 4.3) include methodologies for estimating CO_2 , CH4 and N2O emissions from ferroalloys production.

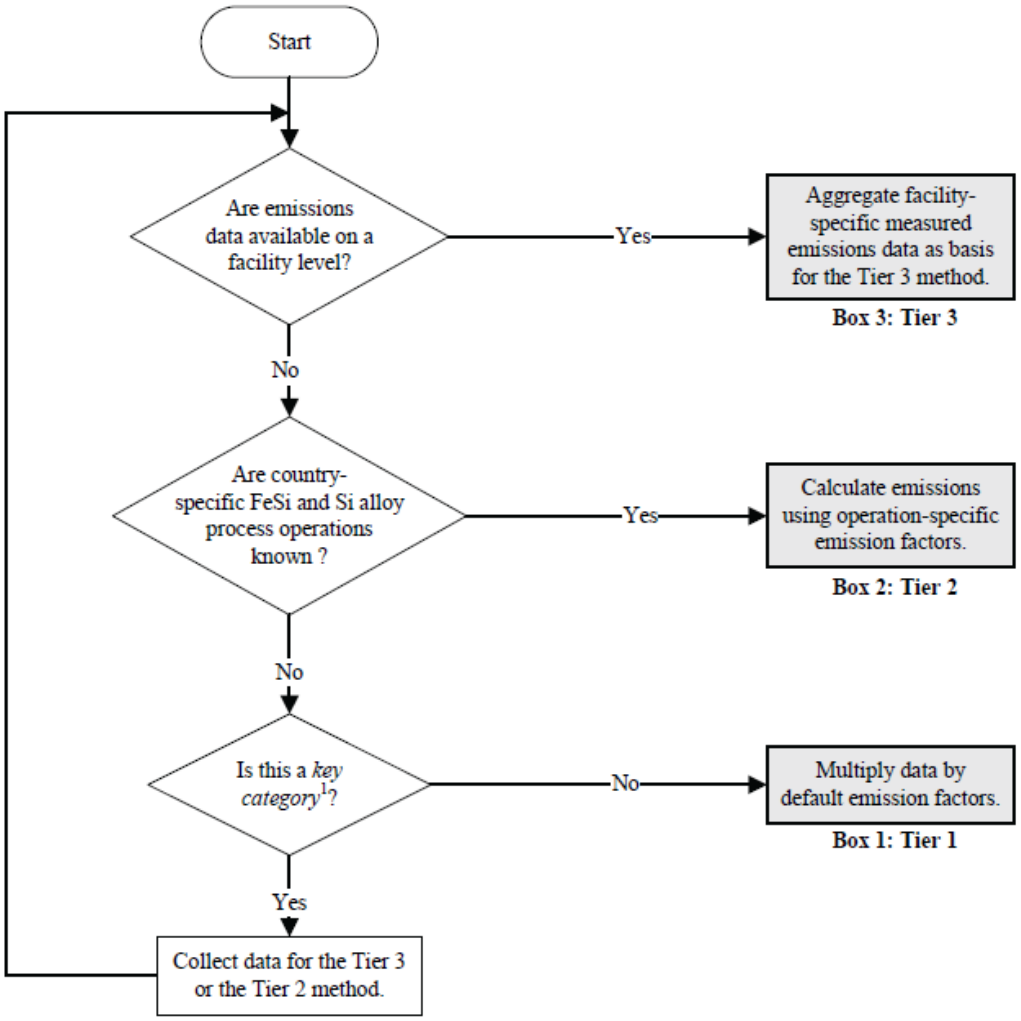
Choice of tier

The 2006 IPCC Guidelines provide three methods for estimating CO_2 and CH_4 emissions from ferroalloy production.

The choice of methods is addressed in the two decision trees (figs. 5-3 and 5-4).



U. Figure 5-3. 2006 IPCC Guidelines decision tree for estimation of CO_2 emissions from ferroalloy production



V. Figure 5-4. 2006 IPCC Guidelines decision tree for estimation of CH4 emissions from ferroalloy production

Priorities and potential key issues to consider during a review

Completeness

Carbon plays the main role as a reducing agent in many ferroalloy production processes, removing oxygen from the metal oxides and being converted into CO_2. It is sometimes aided by the use of limestone or dolomite as carbonate flux. It is important to ensure that all carbon, including that from carbonate fluxes, is included in the emission estimates.

The reducing agent in ferroalloys may also be biogenic carbon, and no CO_2 should be accounted from this reducing agent (i.e. when the carbon is biogenic). The most accurate method to estimate CO_2 emissions is to use the amount of reducing agent of fossil origin as AD and thus report this in the

sectoral background table. However, if that information is unavailable, default EFs multiplied by production volumes may be used.

Relationship to the energy sector

Keep in mind that any fossil fuel consumed not as a reducing agent in this category should be reported under the energy sector. You should coordinate with the experts on your team for the energy sector to ensure that Parties have prepared their accounting for non-energy use of fossil fuel feedstock (i.e. carbon from the consumption of coke or other reducing agents) correctly.

Double counting

As noted in section 4.3.2.4 of the 2006 IPCC Guidelines (vol. 3, chap. 4), as the primary use of carbon sources (coal, coke, limestone, dolomite, etc.) is to produce ferroalloys, the emissions are considered to be industrial process emissions and not combustion emission. It should be noted that the risk of double counting is particularly high for the tier 1 approach.

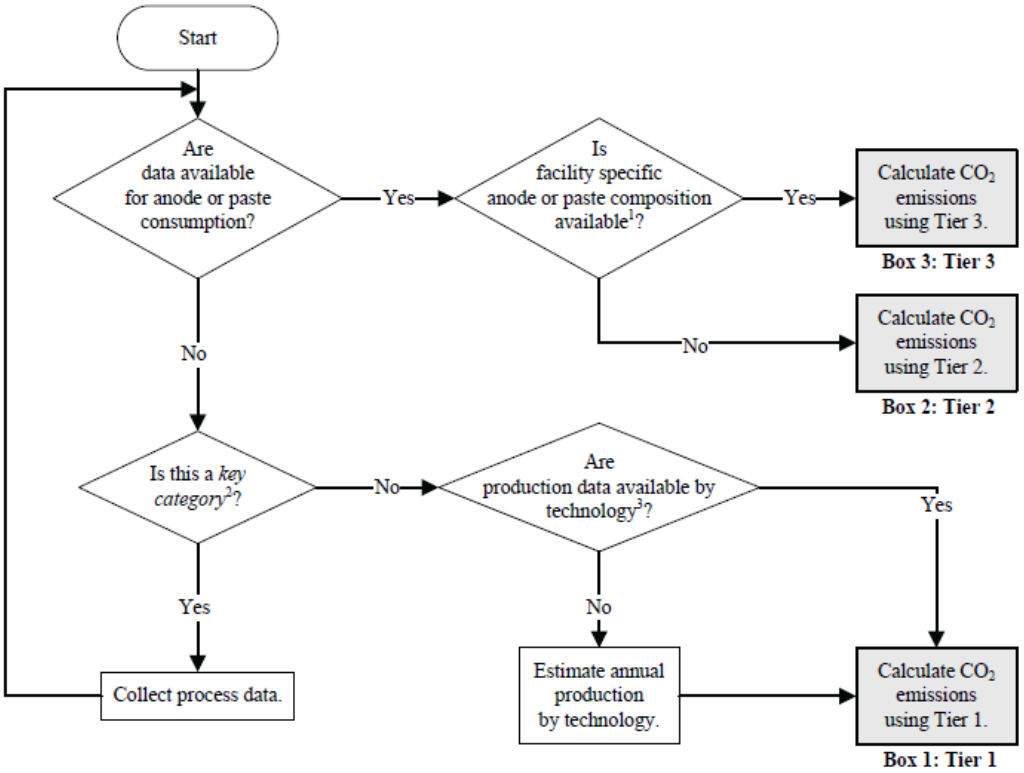
2.4. Aluminium production (category 2.C.3)

The 2006 IPCC Guidelines (vol. 3, chap. 3, section 4.4) include methodologies for estimating CO_2 and PFC emissions from primary aluminium production.

Choice of tier

CO_2 emissions

The 2006 IPCC Guidelines provide three methods for estimating CO_2 emissions from primary aluminium production. The choice of methods is illustrated in the decision tree(fig. 5-5).

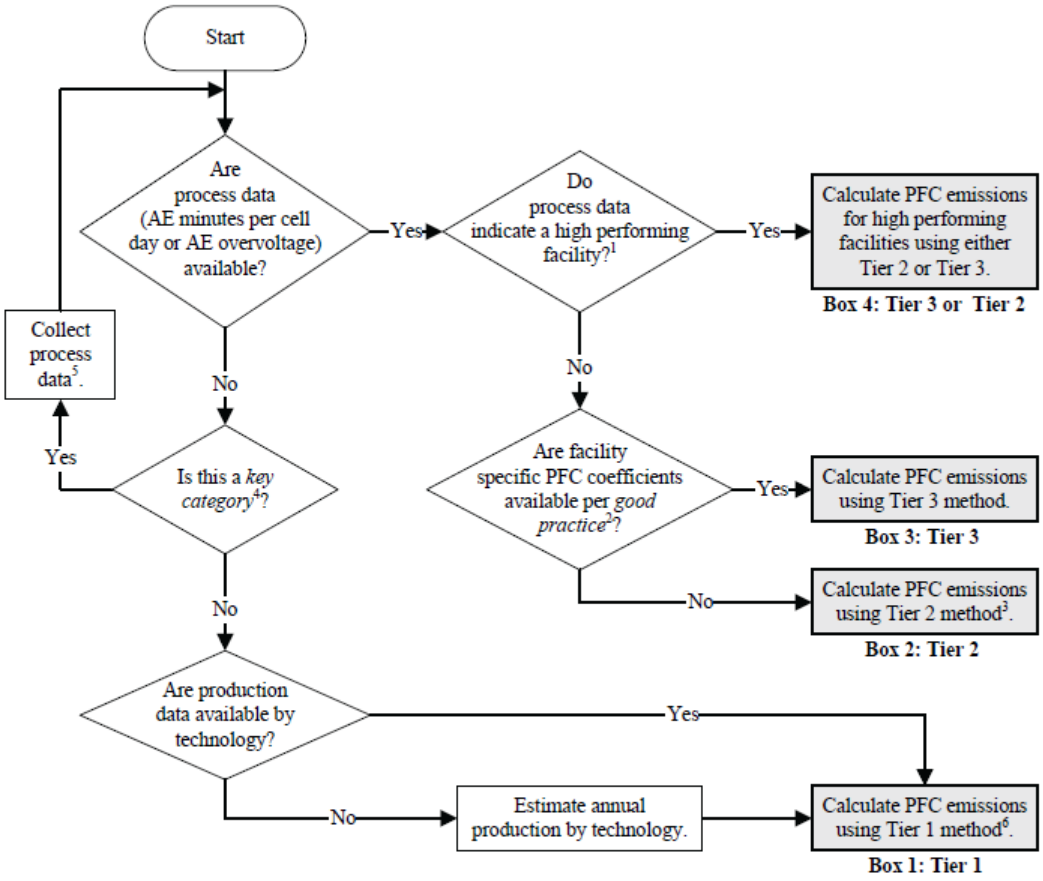


W. Figure 5-5. 2006 IPCC Guidelines decision tree for estimation of CO_2 emissions from primary aluminium production processes

All combustion-related emissions are reported in the energy sector, including those for aluminium produced using the prebake process and those from the combustion of fossil fuels used in the production of baked anodes.

Perfluorocarbon emissions

The 2006 IPCC Guidelines provide three methods for estimating PFC emissions. The decision tree (fig. 5-6) illustrates good practice in choosing the appropriate method to estimate PFC emissions.



X. Figure 5-6. 2006 IPCC Guidelines decision tree for estimation of PFC emissions from primary aluminium production processes

Priorities and potential key issues to consider during a review

Time-series consistency

The issue of consistency of the time series may be relevant. While developing a consistent time series for CO_2 emissions should not be a problem (as most facilities have historically measured anode or paste consumption), a complete time series of PFC-related AD (e.g. anode effect minutes per cell day or overvoltage) may be limited in the earlier years of the time series because PFC emissions became relevant only from 1997. For PFCs, substantial errors and discontinuities can be introduced in the time series by reverting to tier 1 methods for PFC emissions for the early years. Therefore, it would be preferable to apply splicing or surrogate data instead of a lower tier.

You should also be aware of the inter-annual changes in emissions. CO_2 emissions do not generally fluctuate by more than ±10 per cent year to year, based on the consistency of the underlying processes that produce CO_2. In contrast, inter-annual changes in emissions of PFCs per tonne of aluminium produced may change by up to ±100 per cent due to process instability, for example:

- Increases in the frequency and duration of anode effects can be the result of factors such as unanticipated power interruptions, changes in sources of alumina feed materials, cell operational problems and increases in potline amperage to increase aluminium production;
- Decreases in PFC-specific emissions can result from decreases in the frequency and duration of anode effects due to changes in the computer algorithms used in cell process control, upgrades in cell technology (e.g. the installation of point feeders), improved work practices and better control of raw materials.

Confidentiality

Reviewers can expect that much of the production and process data are considered proprietary by operators, particularly when there is only one smelter in a country, and thus Parties may have to ensure confidential data are not released.

Primary aluminium production in the 2019 Refinement to the 2006 IPCC Guidelines

In the 2019 Refinement to the 2006 IPCC Guidelines, significant changes and updates involved primarily the estimation of PFC emissions, including an update to the smelting technology classes, updated default EFs for the tier 1 method, new guidance for estimating emissions from low-voltage anode effects, updated default EFs for the existing tier 2 and tier 3 (now tier 2a and tier 3a) methods for estimating emissions from high-voltage anode effects (termed "anode effects" in the 2006 IPCC Guidelines), new tier 2b and tier 3b methods for estimating emissions from high-voltage anode effects that better account for the impact of anode effect duration, and a new tier 3DM method for facility-specific direct measurement of total PFC emissions. New guidance has also been added for estimating emissions from the production of alumina through the Bayer-Sinter and Nepheline processes.

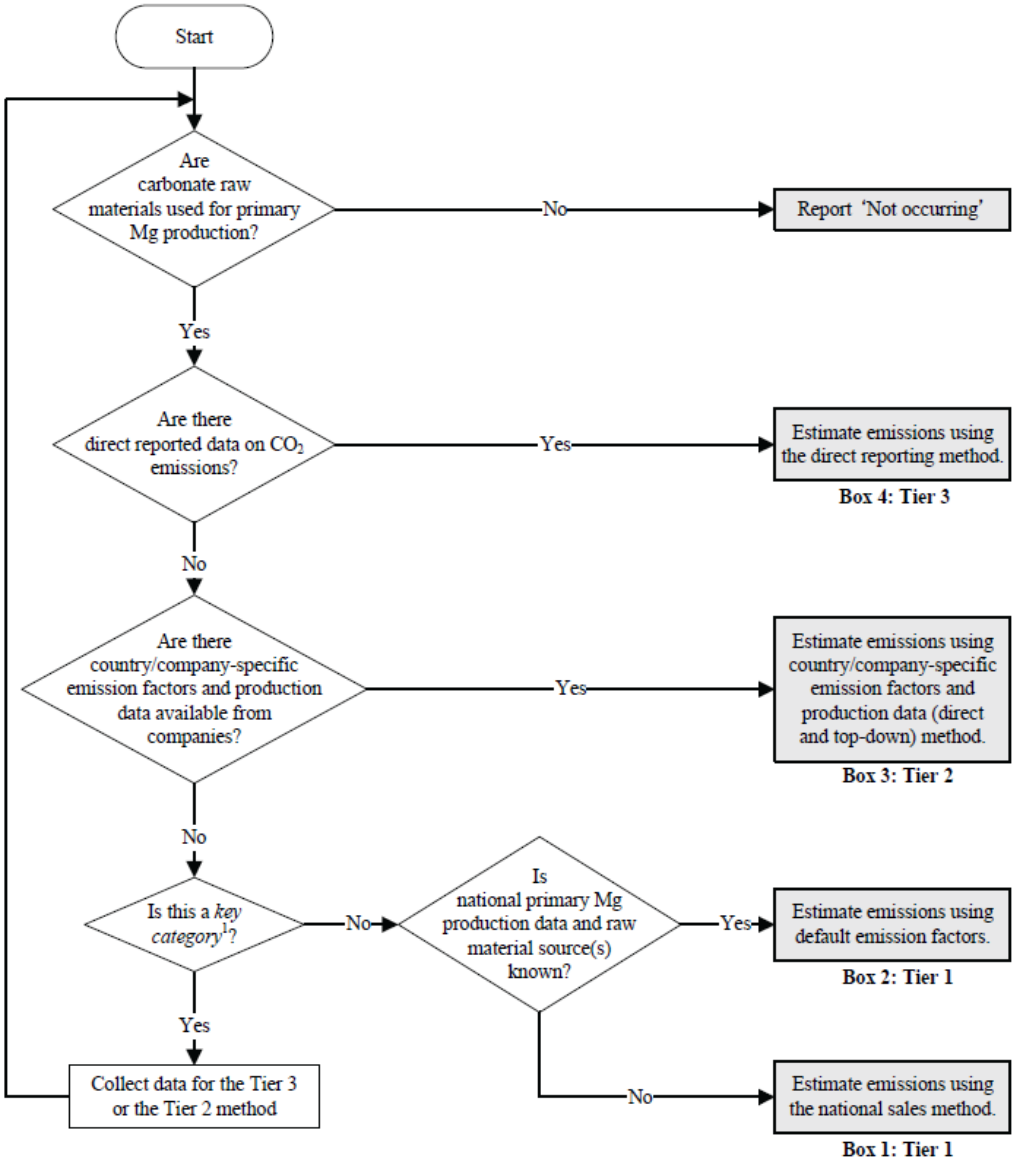
2.5. Magnesium production (category 2.C.4)

The 2006 IPCC Guidelines (vol. 3, chap. 3, section 4.5) include methodologies for estimating CO_2 and SF_6 emissions from primary magnesium production and magnesium casting.

Choice of tier

CO_2 emissions

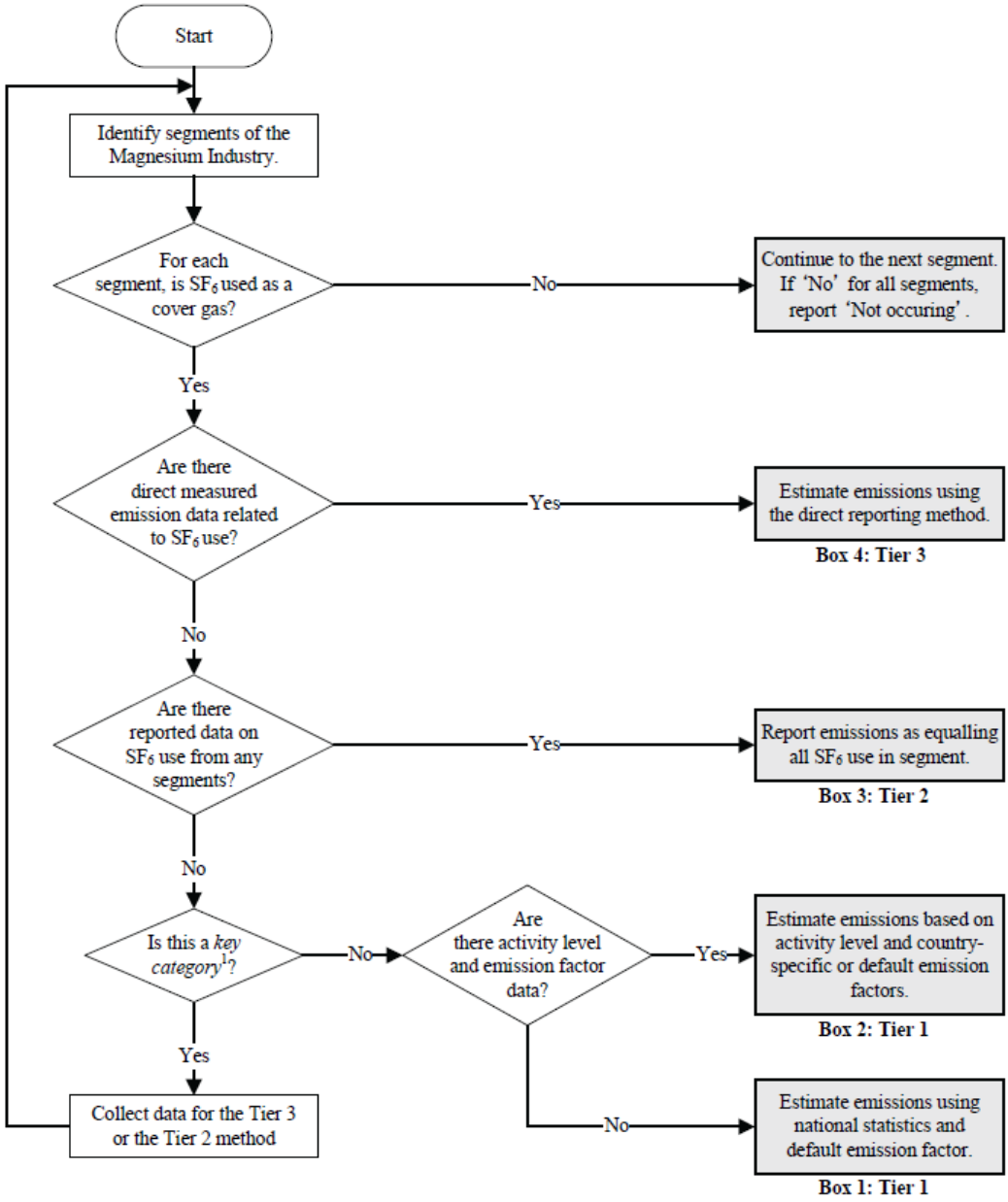
The 2006 IPCC Guidelines provide three methodological tiers for estimating CO_2 emissions from magnesium production. The IPCC decision tree for choosing the estimation method is shown in figure 5-7.



Y. Figure 5-7. 2006 IPCC Guidelines decision tree for estimation of CO_2 emissions from magnesium production

SF_6 emissions

The 2006 IPCC Guidelines provide three methodological tiers for estimating SF_6 emissions from magnesium production (fig. 5-8).



Z. Figure 5-8. 2006 IPCC Guidelines decision tree for estimation of SF_6 emissions from magnesium production

Emissions of hydrofluorocarbons and other gases during secondary magnesium production and during magnesium casting

At the time of development of the 2006 IPCC Guidelines, it was noted that other gases may be used as cover gases (e.g. HFC-134a or PFCs) but there were insufficient data available to develop default EFs for the tier 1 or tier 2 approach. However, if the GHG emissions from the use of magnesium cover gases is identified as a *key category*, the 2006 IPCC Guidelines indicate that it is *good practice* to collect direct measurements or meaningful indirect measurements of GHG emissions for all gases, as appropriate, listed in CRT 2(II) (for example, fugitive emissions of HFC134-a and emissions of PFCs as decomposition products from magnesium foundries using HFC-134a as cover gas).

Priorities and potential key issues to consider during a review

Completeness

Issues may be related to the availability of data from casting operations. While only a few countries produce primary magnesium, and data on primary magnesium production should be readily available from the Party or from international data reports, casting operations are likely to take place in most countries. However, data from casting operations, which often tend to be small facilities, are generally more difficult to obtain. Reviewers should ensure that Parties have considered the existence of these smaller casting operations as opposed to just assuming that they do not occur.

Double counting

You should also consider whether double counting is occurring by considering emissions reported by the Party from calcination of magnesium carbonate raw materials during primary magnesium production and those emissions associated with calcining limestone, dolomite and other carbonaceous minerals (see section “Other process uses of carbonates” in this course). All emissions associated with the calcination of carbonates for primary magnesium production should be reported as GHG emissions from magnesium production.

2.6. Lead production (category 2.C.5), zinc production (2.C.6) and other metals (2.C.7)

This section includes a discussion of all non-ferrous metals except aluminium and magnesium (e.g. lead and zinc) when the production processes involve the use of carbon as a reducing agent. Some ores may contain carbon themselves, or are not reduced with carbon.

A description is provided for lead production and the same considerations may apply to the zinc and other non-ferrous metals production.

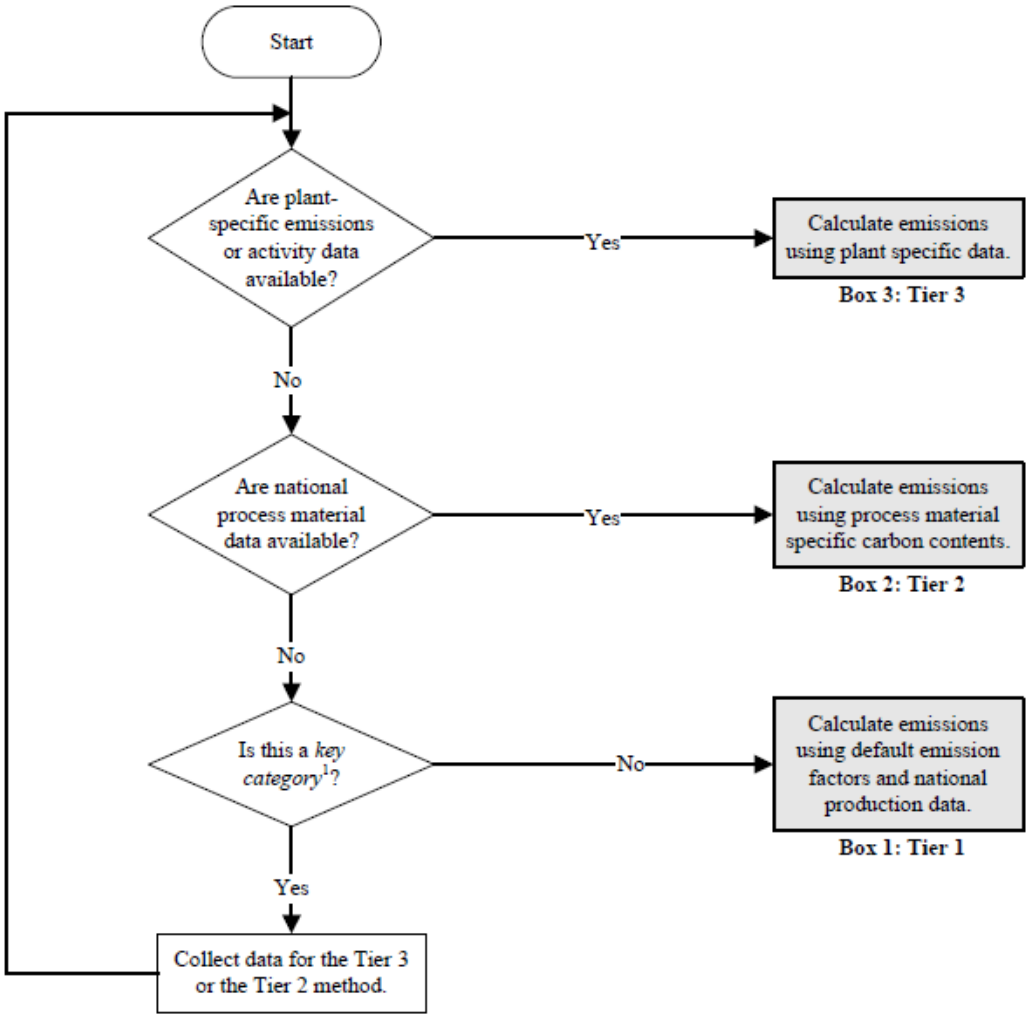
General reference

2006 IPCC Guidelines, volume 3, chapter 3, section 3.8.

Choice of tier

The 2006 IPCC Guidelines provide three methodological tiers for estimating CO_2 emissions from lead production.

The IPCC decision tree for choosing the estimation method is shown in figure 5-9.



AA. Figure 5-9. 2006 IPCC Guidelines decision tree for estimating CO_2 emissions from lead production

Priorities and potential key issues to consider during a review

Double counting

For all the methods used, there is a potential risk of double counting. You should coordinate with the energy expert to ensure that emissions from reducing agents and process materials (coal, coke, natural gas, etc.) are not double counted or omitted.

3. Review approach

3.1. Overview

In the following section you will find some examples of potential findings you may face during a review and recommendations appropriate to these findings you would describe in the relevant tables of the annual review report.

We will consider two cases: in the first you have to fill in a table where recommendations from the previous cycles of reviews are listed; in the second you will need to look for new findings and compile a table in consideration of your own assessment.

- In the table below, you will find some recommendations from the previous reviews. You are asked to indicate if the issue is resolved/not resolved or addressing considering what the Party has reported in its most recent submission (NID/CRT). The type of issue is indicated as one of the TACCC principles (transparency, accuracy…) or Adherence to the MPGs.
- For the new findings, some indications are given so that you will be able to conclude on some issues and give recommendations to the Party. Please also indicate the type of issue you have found.

Case 1 (verifying implementation of previous recommendations)

Let's consider an example in the table below.

Status of implementation of issues raised in the previous review report of Party K

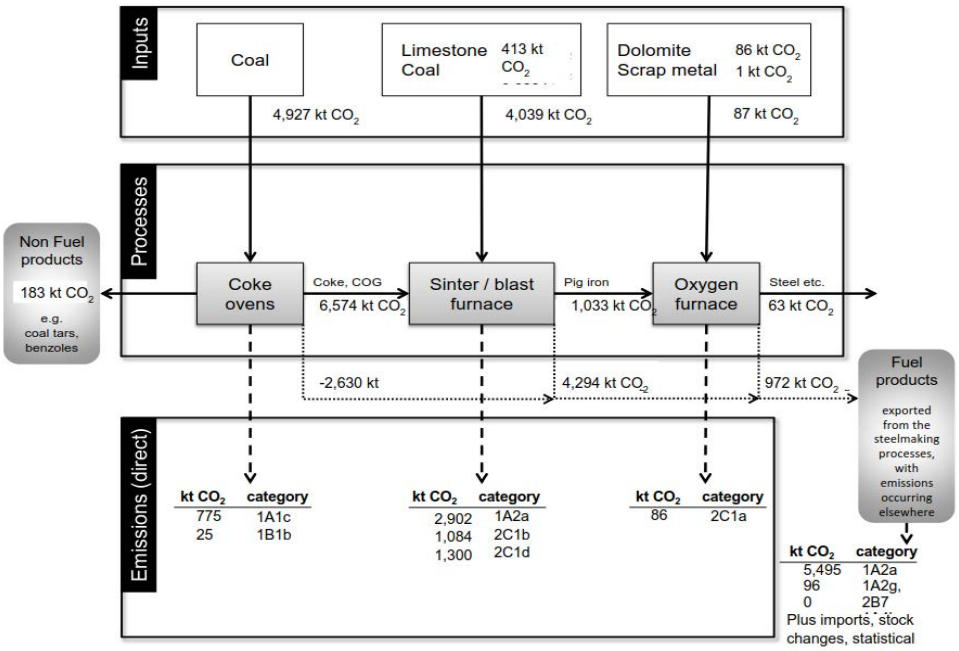
ID#	Issue classification	Recommendation made in previous review report	TERT assessment and rationale
IPPU			
I.7	2.C.1 Iron and steel production – CO_2 (I.18, 2019) Transparency	Update figure 3.1 in the NID to clarify the subcategories under which CO_2 emissions from sintering, blast furnaces and oxygen furnaces are reported.	*Note to the reviewer*: To assess the issue, review the Party's carbon balance. In the Party's NID, figure 3.1, check whether CO_2 emissions from sintering, blast furnaces and oxygen furnaces are transparently described and correctly reported in the scheme. Then you cross-check the values to see if they are correctly reported in the relevant CRT. All categories are to be fully listed and reference to the CRT is to be made. We will have all the material to make our conclusion on the issue.
I.8	2.C.4 Magnesium production – SF_6 (I.28, 2019) Accuracy	Carry out the planned improvement to recalculate SF_6 emissions using data from companies for 2010 onward to increase the accuracy of estimated SF_6 emissions from magnesium casting and that the Party explain the recalculation in the NID.	*Note to the reviewer*: To assess this issue, please read the section of the Party's NID on magnesium production and check whether all the necessary information is there. We will have all the material to make our conclusion on the issue.

Issue I.1: Party's NID, section on Iron and steel and coke manufacture

Extract from the Party's NID:

The carbon balance model used is shown in a simplified form in Figure 3.1, with inputs and outputs of carbon (expressed as CO_2) given for the year 2017 as an example. Note that there is one negative value in the diagram because the figures take into account imports, exports and stock changes. For some years, the energy balance statistics do not have sufficient coke oven coke to account for all known uses and so the GHG inventory has to deviate from the energy balance statistics by assuming a higher demand for this fuel.

Figure 3.1 Carbon balance model for 2017[a]



[a] Other adjustments includes statistical differences (+21 kt CO_2), imports (-2898 kt CO_2), exports (0 kt CO_2), stock changes (+18 kt CO_2), fugitive emissions from coke ovens reported as methane (16 kt CO_2), adjustments for natural gas added to coke oven gas (-27 kt CO_2), carbon stored in dusts (+11 kt CO_2), and deviations from DUKES (-96 kt CO_2)

Please also check the following CRT:

TABLE 2(I).A-H SECTORAL BACKGROUND DATA FOR INDUSTRIAL PROCESSES AND PRODUCT USE — Year

Emissions of CO_2, CH_4 and N_2O — Submission

(Sheet 1 of 1) — Country

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	ACTIVITY DATA		IMPLIED EMISSION FACTORS [2]			EMISSIONS [3]			Recovery/Capture [4] [5]			
	Production/Consumption quantity		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2 fossil	CO_2 biogenic [6]	CH_4	N_2O
	Description [1]	(kt)	(t/t)			(kt)			(kt)			
2.C. Metal industry						2572.86	0.43					
2.C.1. Iron and steel production						2501.24	0.43					
2.C.1.a. Steel	Steel produced	7493.756208	0.02	0.00		117.85	0.01		NO	NO	NO	
2.C.1.b. Pig iron	Pig iron production	5997	0.18	0.00		1083.66	0.00		NO	NO	NO	
2.C.1.c. Direct reduced iron		NO	NO	NO		NO	NO		NO	NO	NO	
2.C.1.d. Sinter	Sinter production	C	C	C		1299.73	0.41		NO	NO	NO	
2.C.1.e. Pellet		NO	NO	NO		NO	NO		NO	NO	NO	
2.C.1.f. Other *(please specify)*		NO	NO	NO		NO	NO					
		NO	NO	NO		NO	NO		NO	NO	NO	
2.C.2. Ferroalloys production		NO	NO	NO		NO	NO		NO	NO	NO	
2.C.3. Aluminium production	Primary aluminium production	46.51	1.54	NO		71.62	NO		NO	NO	NO	
2.C.4. Magnesium production		NO	NO			NO			NO	NO		
2.C.5. Lead production		NO				NO			NO	NO		
2.C.6. Zinc production		NO				NO			NO	NO		
2.C.7. Rare earths production		NO				NO			NO	NO		
2.C.8. Other (*please specify*)												
		NO				NO			NO	NO		

Issue I.2: Party's NID, section on Magnesium production

Extract from the Party's NID:

SF_6 emission estimates for 2010 to 2018 were recalculated for magnesium casting due to updates in gross output data and inclusion of updated SF_6 use data provided by the operating magnesium casting facilities. The changes were between –0.29 kt and +13 kt.

For 2014 to 2019, SF_6 use data was provided by four out of five operating magnesium casting facilities through a voluntary data collection. Where SF_6 use data was not available for a facility during the years 2010 to 2019, SF_6 emissions were estimated based on provincial gross output data. More specifically, a ratio of "gross output for a year with no facility-specific SF_6 use data" to "gross output for the most recent year for which the facility provided SF_6 use data" was calculated. SF_6 emissions (for the years with no SF_6 use data) were then estimated by multiplying the ratio by the most recent facility-specific SF_6 emission value.

The technique applied to estimate emissions from magnesium casting for 1990–2004, 2008–2009 and 2010–2019 (for certain facilities) is considered to be of tier 2 type. For 2005–2007 and 2010–2019 (for certain facilities) for which facility reported data was available, the emission estimation method is of tier 3 type.

Now let's try to verify the implementation of previous recommendations using the information we have found.

ID#	Issue classification	Recommendation made in previous review report	TERT assessment and rationale
IPPU			
I.1	2.C.1 Iron and steel production – CO_2 (I.18, 2019) Transparency	Update figure 3.1 in the NID to clarify the subcategories under which CO_2 emissions from sintering, blast furnaces and oxygen furnaces are reported.	Resolved. Figure 3.1 "Carbon balance model for 2017" of the NID was correctly updated to reflect that CO_2 emissions from sinter production are reported under category 2.C.1.d, CO_2 emissions from pig iron production in blast furnaces under category 2.C.1.b, and CO_2 emissions from steel production in oxygen furnaces under category 2.C.1.a (in table 2(I).A-H of the CRT).
I.2	2.C.4 Magnesium production – SF_6 (I.28, 2019) Accuracy	Carry out the planned improvement to recalculate SF_6 emissions using data from companies for 2010 onward to increase the accuracy of estimated SF_6 emissions from magnesium casting and that the Party explain the recalculation in the NID.	Resolved. The Party reports in its NID that emission estimates for 2010–2018 were recalculated for magnesium casting due to updates in gross output data and inclusion of updated SF_6 use data provided by the operating magnesium casting facilities. For 2014–2019, SF_6 use data were provided by four out of five operating magnesium casting facilities through voluntary data collection, and these data were used to estimate SF_6 use in cases where SF_6 use data were not available for a facility during 2010–2019. More specifically, the NID explains that a ratio of "provincial gross output for a year with no facility-specific SF_6 use data" to "provincial gross output for the most recent year for which the facility provided SF_6 use data" was calculated, and that SF_6 emissions for the years with no SF_6 use data were then estimated by multiplying the ratio by the most recent facility-specific SF_6 emission value.

Case 2 (new findings)

We will now look for new findings in a Party's submission.

Let's check a Party's NID for the categories lead and zinc production (categories 2.C.5 and 2.C.6) by reading the following extract and tables from the Party's NID:

Emissions from lead and zinc production occur in our country due to the use of reductants in the sintering or smelting processes. Currently, CO_2 emissions are reported under category 2.D.3, non-energy products from fuels and solvent use, since disaggregation is not possible at this time. Future improvements include identifying the type of production processes in the country and disaggregating emissions, if possible, based on the type of reductant used in lead and zinc production.

Please also check the following table, CRT 2(I).A-H:

TABLE 2(I).A-H SECTORAL BACKGROUND DATA FOR INDUSTRIAL PROCESSES AND PRODUCT USE													Year
Emissions of CO_2, CH_4 and N_2O													Submission
(Sheet 1 of 1)													Country
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	ACTIVITY DATA		IMPLIED EMISSION FACTORS (2)			EMISSIONS (3)			Recovery/Capture (4) (5)			
	Production/Consumption quantity		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2 fossil	CO_2 biogenic (6)	CH_4	N_2O
	Description (1)	(kt)	(t/t)			(kt)			(kt)			
2.C. Metal industry						12997.29	0.08		NO	NO	NO	
2.C.1. Iron and steel production						8260.70	0.08		NO	NO	NO	
2.C.1.a. Steel	Steel produced in EAF and BOF	12961.00	0.08	NO,IE		1045.01	IE		NO	NO	NO	
2.C.1.b. Pig iron	Pig iron production	7813.00	0.92	0.00		7215.69	0.08		NO	NO	NO	
2.C.1.c. Direct reduced i	Direct Reduced Iron production	IE	NO,IE	NO,IE		IE	IE		NO	NO	NO	
2.C.1.d. Sinter	(please specify)	IE	NO,IE	NO,IE		IE	IE		NO	NO	NO	
2.C.1.e. Pellet	(please specify)	IE	NO,IE	NO,IE		IE	IE		NO	NO	NO	
2.C.1.f. Other *(please specify)*		NO	NO	NO		NO	NO		NO	NO	NO	
	Limestone use	NO	NO	NO		NO	NO		NO	NO	NO	
2.C.2. Ferroalloys production	ferroalloy reductant-use	IE	NO	NO		IE	IE		NO	NO	NO	
2.C.3. Aluminium production	Aluminium production	2466.57	1.54	NO		4736.59	NO		NO	NO	NO	
2.C.4. Magnesium production	Mg Production	NA	NO			NA			NO	NO		
2.C.5. Lead production	(please specify)	IE				IE			NO	NO		
2.C.6. Zinc production	(please specify)	IE				IE			NO	NO		
2.C.7. Rare earths production		NO				NO			NO	NO		
2.C.8. Other (*please specify*)		NO				NO			NO	NO		
		NO				NO			NO	NO		

Note to the table: "IE" is used because disaggregated data currently not available.

Questions

In evaluating the data provided by the Party you should consider the following questions, for which we have provided examples of adequate responses.

What did the finding identify?

- Emission estimates are not included in the appropriate category.

Why is it a problem?

- The issue may relate to the comparability of emission estimates.

What is an ideal situation?

- Reallocate the emissions to report in the appropriate category.

What is the recommendation by the TERT?

- Report in the next submission whether further steps to reallocate emissions are planned.

Nature of the finding

The Party reports emissions from lead production under category 2.D.3 other (non-energy products from fuels and solvent use) instead of under category 2.C.6.

We would ask the Party a preliminary question, with a brief description of the finding, for instance:

- In its NID, the Party reported that the use of reductants cannot be disaggregated. Can the Party provide the TERT with a description of lead production in the country? Does the Party plan to further investigate the issue?

Let's suppose that the Party provides supporting information, explaining the production process of lead and why there is a lack of data to disaggregate the emissions.

Translating the finding into an issue

What did the finding identify?

- Emission estimates are not reported in the appropriate category.

Why is it a problem?

- The issue may relate to the comparability of the CRT or the lack of information in the NIR that explains why disaggregation is not possible.

What is an ideal situation?

- The Party provided supporting information explaining the production process of lead and why the lack of disaggregated data results in aggegated reporting of emissions.

What is the recommendation of the TERT?

- Report whether further steps to reallocate emissions are planned.
- Improve transparency by including in the NID more information on the lead production process and the data available to estimate the emissions.

Nature of the issue

Transparency

Reporting the findings

Now, let's report our finding in the review report, noting that during the review the Party explained that the lack of disaggregated data resulted in aggegated reporting of emissions (i.e. information is missing in the NID) and that the emissions are not reported in the appropriate category.

ID#	Finding classification	Description of the finding with recommendation or encouragement	Is finding an issue/problem?
I.9	2.C.5 Lead production – CO_2	The Party reports CO_2 emissions from lead production under category 2.D.3 other (non-energy products from fuels and solvent use) instead of under 2.C.6. In its NID, the Party reported that the use of reductants cannot be disaggregated. During the review the Party provided supporting information explaining the production process of lead and why there is a lack of information to disaggregate. The TERT recommends that the Party explain in the NID that the lack of data resulted in the aggregation of emissions. The TERT also recommends that the Party report whether further steps to reallocate emissions are planned.	Yes. Transparency

4. Practical exercises

4.1. Exercise 1 (iron and steel production)

A Party provides, in its NID, the following description of the method applied for calculating emissions from the iron and steel category.

The category "Iron and steel production" includes the following processes: steel production (2.C.1.1), pig iron production (2.C.1.2), sinter production (2.C.1.3) and steel production in electric arc furnaces (2.C.1.5). CO_2 emissions from sinter production are allocated in the energy sector, iron and steel production (1.A.2.a), whereas CO_2 emissions from coke production are allocated in the steel production category (2.C.1.1). The major share of CO_2 emissions derives from pig iron and steel production in blast furnaces but since it is difficult to distinguish between the two sources of production, all CO_2 emissions were included in the steel production category (2.C.1.1).

As a reviewer, how would you consider the issue?

Select one:

A. The reporting of emissions by the Party is not in line with the 2006 IPCC Guidelines, and you would recommend that the Party report all CO_2 emissions under the IPPU sector
B. The reporting of emissions by the Party is not in line with the 2006 IPCC Guidelines, and you would recommend that the Party report CO_2 emissions from sinter production under the IPPU sector
C. The reporting of emissions by the Party is not in line with the 2006 IPCC Guidelines, and you would recommend that the Party report CO_2 emissions from coke production in the energy sector
D. Both B and C

Answer

The correct answer is (D).

According to the 2006 IPCC Guidelines, since the primary use of carbon sources (predominantly coke, but also coal, oil natural gas, limestone etc.) is to produce pig iron, the CO_2 and CH_4 emissions from iron and steel production including sinter production are considered industrial process emissions and should be reported as such (under the IPPU sector). The CO_2 and CH_4 emissions from coke production (both fuel consumption and conversion losses) are categorized as energy production and should be reported as such (under the energy sector).

Where the plant is an integrated production and iron and steel with onsite coke production, there may be flows of by-products (e.g. coke oven gas, blast furnace gas, coke oven by-products) between the coke production facility and the iron and steel production facility, creating potential double counting issues. Carbon consumed in the from of coke oven gas at an iron and steelmaking facility and the resulting CO2 and CH4 emissions would be categorized as IPPU emissions and reported as such. This is important because all emissions from coke consumed as reductant in the iron and steel production is accounted under the IPPU sector.

Prepare

The TERT should first assess the Party's submission to assess the information provided.

Assess (through communication with the Party)

You should ask the Party if there are plans to reallocate emissions in the appropriate category/sector as specified in the 2006 IPCC Guidelines, following which CO_2 emissions from iron and steel production including sinter production should be reported under the IPPU sector and the CO_2 emissions from coke production (both fuel consumption and conversion losses) under the energy sector.

Assuming that the response by the Party is that at the moment the reallocation of emissions is not possible due to the lack of disaggregated information provided by the industry, what would be your recommendation to the Party?

Draft

You would recommend that the Party further explore the possibility and reallocate CO_2 emissions from sinter production under the IPPU sector and CO_2 emissions from coke production under the energy sector.

This issue may be considered an issue of comparability. This is a possible case where it is difficult for a Party to correctly allocate the emissions as indicated by the CRT and the 2006 IPCC Guidelines, and any other assumption may not reflect the real situation (this is the reason why it is fundamental to have a carbon balance).

4.2. Exercise 2 (aluminium production)

A Party provides, in its NID, the following description of the method applied for calculating emissions from aluminium production. Please note that CO_2 emissions from aluminium production has been identified as a key category for the Party and the Party is a developing country.

CO_2 emissions from aluminium production have been estimated applying the tier 1 approach on the basis of AD provided by the industrial association and default EF reported by the 2006 IPCC Guidelines for the prebaked anode process. The EF has been assumed equal to 1.7 t CO_2/t primary aluminium production for all the years of the time series.

PFC emissions have not been calculated owing to lack of information on specific technology of the aluminium production process.

Question

How would you consider the issue?

Select one:

A. The Party has to use a tier 2 method for estimating CO_2 emissions unless it has mentioned specific national circumstances
B. The Party may use a tier 1 method for estimating CO_2 emissions on account of flexibility in the light of its capacity
C. The Party has to use a tier 1 method for estimating PFC emissions on account of flexibility in the light of its capacity
D. Both B and C

Answer

The correct answer is (A).

The Party should use a higher-tier method for estimating emissions from a key category unless it has mentioned specific national circumstances that retain this application but not applying for flexibility. The Party may decide not to estimate PFC emissions from aluminium production, asking for flexibility in the light of its capacity.

Question

What additional information would you ask the Party to provide in order to have a clear picture of CO_2 and PFC emissions?

Select one:

A. Can the Party collect some more information to estimate CO_2 emissions using a tier 2 method?
B. Can the Party collect some information to estimate PFC emissions using a tier 1 method?
C. Both A and B

Answer

The correct answer is (C).

All the questions could be relevant. The application of a tier 2 method requires additional information collected from the industry and, finally, the Party may decide to also estimate PFC emissions from aluminium production in future submissions, so the TERT may ask for some information.

One possible way to approach the issue would be the following:

Prepare

The TERT should first assess the Party's submission on CO_2 and PFC emissions from aluminium production, and assess the use of flexibility in the light of the Party's capacity.

Assess (through communication with the Party)

You should also check whether the Party has additional information to use a tier 2 method for estimating CO_2 emissions, for example, on components such as electrolysis emissions from prebake anode, pitch volatile matter oxidation from pitch coking, bake furnace packing material.

And you could ask if the Party has additional information on cell type to use the tier 1 method for estimating PFC emissions from the category.

Draft

You would recommend the Party to collect information from the industry and estimate CO_2 emissions using a tier 2 method. The issue may be considered an issue of accuracy.

As the category is relevant for the Party's inventory (it was identified as key for CO_2 emissions), you would encourage the Party to estimate PFC emissions using a tier 1 method.

4.3. Exercise 3 (lead and zinc production)

Category 2.C.5 – Lead production

For the Party, primary lead production is limited to a single site, which produced zinc and lead from imported ore concentrates until it closed in 2003. Emissions are reported under category 2.C.6 and so this process is described in the following section.

Category 2.C.6 – Zinc production

Zinc was produced in the Party until early 2003, using the imperial smelting process at a smelter operated by the zinc industry. The site processed imported ore concentrates, and had a capacity to produce approximately 150,000 t zinc, as well as 65,000 t lead. The imperial smelting process involves the use of a blast furnace to reduce zinc and lead oxides to the metal using coke as a reductant. Limestone could also be added to act as a slag-forming agent. The operators report data on total CO_2 emissions from the process.

It is also noted that zinc production is a key category according to the trend assessment.

Due to the site closures and resultant sector contribution to the Party inventory trend, and because a tier 1 method is used, the Party has recently reviewed this sector and included some additional sources using the best currently available data. Unfortunately, as the only sites in this sector have been closed for a number of years it is highly unlikely that new data will be found to derive a better estimate.

Question

How would you consider the issue?

Select one:

A. You would ask if the Party has information on the quantities of the limestone used on site for the production process
B. You would ask the Party to collect some more information to estimate CO_2 emissions using a tier 2 method
C. All of the above

Answer

The correct answer is (A).

The Party reports that the operator-reported CO_2 emissions are totals only, so a question should be asked to understand if the emissions source may be split between limestone, coke and other fuel.

The Party has already described problems with collecting data referring to previous years, so considering that the category is a key category and we are dealing with emissions from an activity that ceased some years ago we could skip question B. One possible way to approach the issue would be the following:

Prepare

The TERT should first assess the Party's submission, especifically all the information reported on the estimations for this category.

Assess (through communication with the Party)

You should check whether the Party can collect additional information to estimate CO_2 emissions splitting by source (coke, other fuels and limestone) and report emissions from fuel combustion on site and process-related emissions.

Draft

You would recommend that the Party collect information from the industry and estimate CO_2 emissions splitting by source (coke, other fuels and limestone). If this is not possible you would recommend that the Party include a detailed description in its NID on these processes and how the completeness of the fuel- and process-related emissions is ensured.

The issue may be considered an issue of completeness (if it is clear that not all sources are accounted for) or transparency (if emissions are correctly estimated but detailed information is not reported in the NID).

5. Self-check quiz

5.1. Questions

Question 1 (iron and steel)

Metallurgical coke can be produced either at the iron and steel facility (on site) or at separate facilities (off site). Which of the following statement is correct?

Select one:

A. Both CO_2 and CH_4 emissions from metallurgical coke production are to be reported in the energy sector
B. Both CO_2 and CH_4 emissions from metallurgical coke production are to be reported in the IPPU sector
C. If the production occurs on site, all emissions should be reported in the IPPU sector
D. If the production occurs off site, all emissions should be reported in the energy sector

Question 2

Where should emissions from limestone and dolomite consumption in the iron and steel industry be reported?

Select one:

A. In the energy sector, under 1.A.2.a. Iron and steel (manufacturing industries and construction)
B. In the IPPU sector, under 2.A.4 Other process uses of carbonates
C. In the IPPU sector, under 2.C.1 Iron and steel production

Question 3

PFC emissions occur from primary aluminium production. Different parameters are needed to estimate PFC emissions from this process according to the tier used. Which of the following parameters is not used in the estimation process?

Select one:

A. Cell technology type
B. Metal production
C. Slope coefficient
D. Anode effect minutes per cell day data or accurate overvoltage data for all cell types
E. None of the above

Question 4

When estimating CO_2 emissions from ferroalloys production, you should be alert for:

Select one:

A. The correct reporting considering the primary use of carbon sources (coal, coke) in the production process
B. The risk of double counting or omission in either the industrial processes or the energy sector
C. The carbon content of the reducing agents used in the production process
D. All of the above

Question 5

Which emissions result from primary aluminium production?

Select one:

A. PFC emissions, which may result from anode effects
B. CO_2 emissions, deriving from the consumption of carbon anodes
C. Both A and B

5.2. Answers

Answer 1

The correct answer is (A).

Metallurgical coke is primarily used in the blast furnace to make iron. Coke oven gas is a by-product of the manufacture of metallurgical coke for the production of iron and steel. Metallurgical coke is produced either at the iron and steel facility (on site) or at separate facilities (off site); the production is considered to be an energy use of fossil fuel, and as a result emissions should always be reported in category 1.A.1c.i of the energy sector.

Answer 2

The correct answer is (C).

CO_2 emissions from the use of carbonates in the iron and steel industry should be reported under process emissions from the iron and steel industry in the IPPU sector. This is a change from the previous IPCC guidelines (the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*), which required emissions from carbonate used to be reported under limestone and dolomite use. In the 2006 IPCC Guidelines, emissions from limestone, dolomite and other carbonates are reported in the category where they are consumed. Emissive uses of carbonates not included elsewhere are reported under category 2.A.D.

Answer 3

The correct answer is (E).

Except for tier 1, the other two methods for estimating emissions, tier 2 and tier 3, are related to the process control in use but they are both based on the relationship between anode effect and performance (i.e. the slope and overvoltage coefficient equations). All parameters are used in one or more of the estimation methods.

Answer 4

The correct answer is (D).

The estimation of CO_2 emissions from ferroalloys production makes primary use of carbon sources and it is important to attribute these emissions to the production process and not consider them as combusted.

Furthermore, the carbon content of the reducing agents used in the production process is relevant for the application of higher-tier methods.

Answer 5

The correct answer is (C).

CO_2 emissions occur from the consumption of carbon anodes in the reaction to convert aluminium oxide to aluminium metal, whereas PFC emissions may be derived during an anode effect condition where an insufficient amount of alumina is dissolved in the electrolyte, causing voltage elevated above the normal operating range

6. Key points to remember

- The correct reporting of emissions between the energy and IPPU sectors needs particular care, especially to use the appropriate allocation and to avoid double counting and omissions of emissions.
- In the case of blast furnace gas, if the fuel is combusted entirely within the iron and steel industry (whether for heating blast air, site power needs or for metal finishing operations), the associated emissions are reported in IPPU category 2.C.1. If part of the gas is delivered to a nearby brick works for heat production or a main electricity producer, then the emissions are reported in category 1.A.2.f or 1.A.1a.
- All carbon, including that from carbonate use, used in blast furnaces, direct reduced iron, basic oxygen furnaces, electric arc furnaces and open hearth furnaces should be considered as process-related (2.C.1) emissions, and all carbon used in the coke oven should be reported in the energy sector (1A1c.i).
- Any fossil fuel consumed not as a reducing agent in this category should be reported under the energy sector.

Lesson 6. Non-energy products from fuels and solvent use

1. Introduction and objectives of the lesson

1.1. Lesson outline

This lesson is organized into six sections and helps you focus on what best complements your prior knowledge of the topic.

1. Introduction and objectives of the lesson
2. Category overview and methodological information
3. Review approach
4. Practical exercises
5. Self-check quiz
6. Key points to remember

1.2. Categories in non-energy products from fuels and solvent use

The categories considered in this lesson pertain to non-energy product from fuels and solvent use, and their codes in the CRTs are as follows:

- 2.D Non-energy product from fuels and solvent use;
- 2.D.1 Lubricant use;
- 2.D.2 Paraffin wax use;
- 2.D.3 Other (bitumen/asphalt, solvents and any others).

This list of categories is consistent with the set of CRTs. Any of these categories could be a key category for a Party and, as such, should be placed relatively high up on your list of priorities when reviewing it. You should refer to the 2006 IPCC Guidelines (vol. 3, chap. 5) for the methodologies to estimate emissions from these categories. Some of the main problems you may encounter when reviewing emissions from these categories are discussed in this lesson.

The expected time needed to complete lesson 6 depends on the level of your knowledge of GHG inventories for the IPPU sector under the ETF and the 2006 IPCC Guidelines:

- For readers with experience: 15–30 minutes
- For readers with less experience: 25–50 minutes

1.3. 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 non-energy products from fuels and solvent use;
- Identify whether a Party's reporting for the non-energy products from fuels and solvent use is consistent with the requirements of the MPGs;
- Draft key review recommendations to Parties in relation to emissions from non-energy products from fuels and solvent use.

2. Category overview and methodological information

2.1. Overview

This category covers the estimation of CO_2 emissions from the use of fossil fuels as a product for primary purposes other than (1) combustion for energy purposes and (2) use as feedstock or reducing agent. (Remember that emissions from (1) should be reported in the energy sector and emissions from (2) should be reported in the IPPU sector but under chemical industry or metal industry.) The non-energy products comprise lubricants, paraffin waxes and other, specifically bitumen/asphalt and solvents. Emissions from the disposal of the products after their use (i.e. the combustion of waste oils such as used lubricants) are to be estimated and reported in the waste sector when incinerated without energy recovery or in the energy sector when energy recovery takes place.

Emissions (CO_2 but also CH_4 and N_2O) arise from disposal of the products after first use.

Generally, the basic formula for calculating CO_2 emissions includes an EF composed of two factors: a carbon content factor and a factor that represents the fraction of fossil fuel carbon that is oxidized during use, for example, actual co-combustion of the fraction of lubricants that slips into the combustion chamber of an engine.

CH_4 and N_2O emissions from the activities in this section are expected to be minor or to not occur, so no method for their estimation is provided in the 2006 IPCC Guidelines.

A method has been introduced for checking the completeness of CO_2 emission estimates from non-energy uses, which checks that non-energy use/feedstock requirements of processes included in the inventory are in balance with the non-energy use/feedstock supply as recorded in the national energy statistics (see 2006 IPCC Guidelines, vol. 3 (IPPU), chap. 1, section 1.4).

The rest of the lesson will provide a brief description of the estimation method with reference to the decision trees in the 2006 IPCC Guidelines, the choice of AD and EFs, and the reporting in the CRTs.

General reference

2006 IPCC Guidelines, volume 3, chapter 5.

2.2. Lubricant use (category 2.D.1)

Lubricants are mostly used in industrial and transportation applications. Lubricants are produced either at refineries through separation of crude oil or at petrochemical facilities. Motor oils, industrial oils and greases are examples of lubricants.

The use of lubricants in engines is primarily for their lubricating properties, and associated emissions are considered as non-combustion emissions to be reported in the IPPU sector. The only exception to this rule is emissions from the combustion of lubricants mixed with other fuels in two-stroke engines, which should be reported in the energy sector.

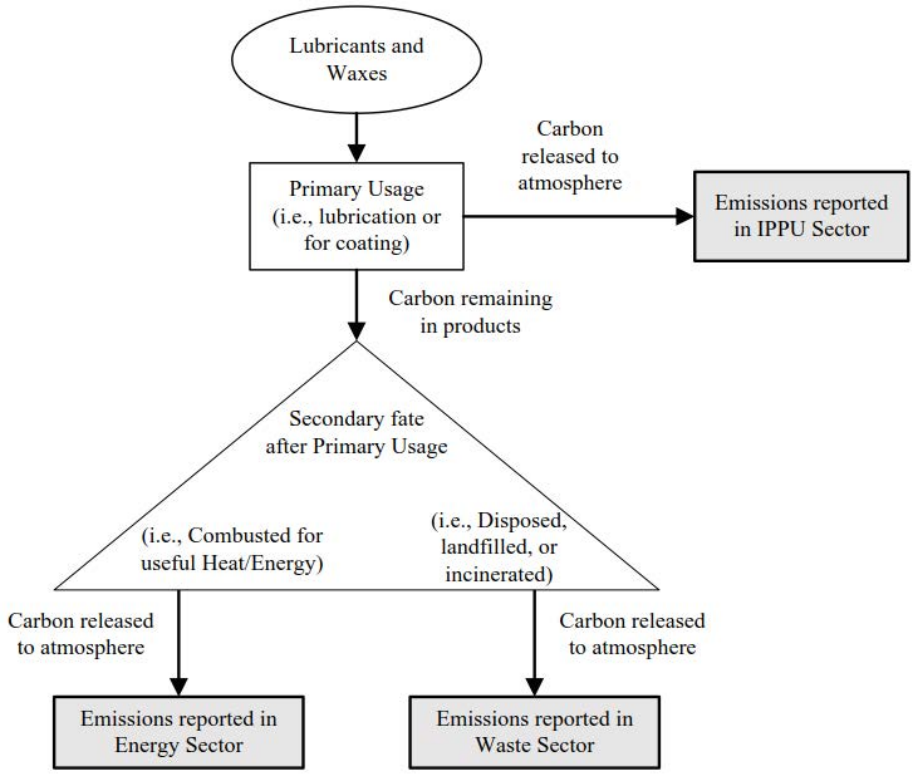
It is difficult to determine the proportion of lubricant consumed in machinery and in vehicles that is actually combusted (and thus directly results in CO_2 emissions) and the proportion that is not fully oxidized and that results firstly in NMVOC and CO emissions (except for the use in 2-stroke engines, which is excluded here). For this reason, when calculating CO_2 emissions the total amount of lubricants lost during their use is assumed to be fully combusted and these emissions are directly reported as CO_2 emissions.

General reference

2006 IPCC Guidelines, volume 3, chapter 5, section 5.2.

Choice of tier

The 2006 IPCC Guidelines provide two methodological tiers for estimating CO_2 emissions from lubricant use. Both have a similar approach (emissions = AD x EF) so the choice of tier depends on the availability of the amount of lubricant as a total (tier 1) or disaggregated by different types (tier 2) and the association of the relevant factor, namely oxidized during use (see fig. 6-1). The default oxidized during use factor is four times smaller for greases than for lubricating oils, so using the tier 2 method will mainly capture the impact of using actual fractions of oils and greases in the emission calculation. Please note that it is considered *good practice* to use the tier 2 method when this category has been identified as a *key category*.



BB. Figure 6-1. Sectoral allocation of emissions from lubricants and waxes

Priorities and potential key issues to consider during a review

As it is difficult to determine the fraction of lubricant combusted and the fraction not fully oxidized (which results in NMVOCs and CO emissions), it is assumed that the total amount of lubricant lost during use is fully combusted and reported as CO_2 emissions.

Emissions from the disposal of used lubricants are reported in the waste sector or in the energy sector. Waste combusted with energy recovery should be reported under the energy sector, while waste disposed of in landfills or incinerated as waste is to be reported under the waste sector.

For emissions not related to the non-combustion usage of lubricants, you should cross-check the appropriate allocations in the energy and waste sectors (oxidation from post-use combustion or degradation after disposal).

2.3. Paraffin wax use (category 2.D.2)

Paraffin waxes are used in a number of different applications, including candles, corrugated boxes, paper coating, board sizing, food production, wax polishes and surfactants. Emissions mainly occur when the waxes are combusted,that is, during use, such as when burning candles, or in their disposal (e.g. incinerated for energy recovery purposes (and reported in the energy sector) or combusted as waste (and reported in the waste sector)).

As when assessing the reporting on lubricants, you should cross-check that any emissions from paraffin waxes that are produced due to energy recovery are correctly allocated and reported in the energy sector and that emissons from degradation after disposal are reported under the waste sector.

Two methods for estimating CO_2 emissions are provided in the 2006 IPCC Guidelines depending on the availability of the amount of waxes as a total or by different types and the association of the relevant oxidized during use factors.

General reference

2006 IPCC Guidelines, volume 3, chapter 5, section 5.3.

2.4. Other (bitumen/asphalt, solvents and any others) (category 2.D.3)

Direct GHG emissions from these sources are negligible, but these categories can be a major source of NMVOC emissions that are later oxidized to CO_2 in the atmosphere. Please note that CO_2 emissions from the use of urea as abatement systems are to be reported under 2.D.3 Other and specified in "other".

General reference

2006 IPCC Guidelines, volume 3, chapter 5, section 5.4 for asphalt production and use, and section 5.5. for solvent use.

Indirect CO_2 emissions

Indirect emissions originate from the atmospheric oxidation of CH_4, CO and NMVOCs. Reporting indirect CO_2 emissions is not mandatory: a Party may choose to estimate indirect CO_2 emissions from the oxidation of NMVOCs. If a Party elects to report indirect CO_2 emissions, national totals should be presented with and without indirect CO_2 emissions.

The conversion of NMVOC emissions into CO_2 emissions may be carried out considering a fossil carbon content value equal to 60 per cent as indicated in the 2006 IPCC Guidelines (vol. 3, chap. 5, section 5.5.4).

3. Review approach

3.1. Overview

In the following section you will find some examples of potential findings you may encounter during a review and recommendations you may describe in the relevant tables of the annual review report.

We will consider two cases: in the first you have to fill in a table where recommendations from the previous cycles of reviews are listed; in the second you will need to look for new findings and compile a table in consideration of your own evaluation.

- In the table below, you will find some recommendations from the previous reviews. You are asked to indicate if the issue is resolved/not resolved or addressing after considering what the Party has reported in its most recent submission (NID/CRT). The type of issue is indicated as Adherence to the MPGs, Completeness, etc.;
- For the new findings, indications are given so that you will be able to conclude on some issues and give recommendations to the Party. Here you may also indicate the type of issue you have

found. Please note that each finding can only be classified as one issue type (e.g. "transparency" or "accuracy", but not "accuracy and transparency").

Case 1 (verifying implementation of previous recommendations)

Let's consider an example in the table below.

Status of implementation of issues raised in the previous report of Party K

ID#	Issue classification	Recommendation made in previous review report	TERT assessment and rationale
IPPU			
I.1	2.D.1 Lubricant use – CO_2 (I.21, 2019) Accuracy	Report emissions from combusted lubricant use from two-stroke engines under category 1.A.3.b (road transportation) under the energy sector.	*Note to the reviewer*: To assess this issue, please read the Party's submission below. We will have all the material to make our conclusion on the issue.

Issue I.1: Party's NID, section on non-energy products from fuels and solvent use

Extract from the Party's NID:

Methodology: Lubricant use

Lubricants, together with bitumen and solvents, are non-fuel products of crude oil, which are included in the energy statistics. It is assumed that 60 per cent of lubricants are not oxidized during engine operation, i.e. not actually combusted (personal communication). Therefore, consumption and greases in the energy statistics are reduced by 60 per cent before emissions are estimated. AD are currently not available to determine the quantity of lubricants consumed in 2-stroke engines. Accordingly, all emissions from lubricant use are accounted for in the IPPU sector.

Planned improvement

All AD, methodologies and EFs are kept under review. Particular focus will be on the investigation of AD to enable the reallocation of emissions from lubricant use in 2-stroke engines to the energy sector.

Now let's try to verifying the implementation of the previous recommendations based on the information we have gathered.

Issue classification	Recommendation made in previous review report	TERT assessment and rationale
2.D.1 Lubricant use – CO_2 (I.21, 2019) Accuracy	Report emissions from lubricant use from two-stroke engines under category 1.A.3.b (road transportation) under the energy sector.	Addressing. The Party reported that because it has no AD for lubricant use in two-stroke engines it could not estimate and reallocate emissions in the energy sector; therefore all emissions are included in category 2.D.1. In its planned improvement the Party stated that particular focus will be on the investigation of AD to enable the reallocation of emissions.

Case 2 (new findings)

Issue I.1

We will now look for new findings in a Party's submission. Let's check a Party's NID for category 2.D Non-energy products from fuels and solvent use by reading the following extract and tables from the Party's NID:

Non-energy products from fuels and solvent use (2D)

Source category description: CO_2 emissions from the use of urea in selective catalytic reduction vehicles (CRT category 2.D.3).

The 2006 IPCC Guidelines recommends that equation 3.2.2 (vol. 2) be used for estimating emissions from the use of urea-based additives in catalytic converters. For estimating emissions from this source, road transportation AD must be considered. More specifically, vehicle population, fuel consumption ratios and kilometre accumulation rates are used to determine the amount of diesel consumed by these vehicles and consequently the volume of urea-based diesel exhaust fluid additive consumed by their SCR catalyst. To determine the portion of the fleet employing this technology (technology penetration ratio), vehicle certification and regulatory data is used to identify the vehicles equipped with SCR. A dosing rate representing 2 per cent of the diesel consumption has been employed as it is the midpoint of the range suggested in the 2006 IPCC Guidelines. Additionally, the default additive purity of 32.5 per cent was corroborated.

Please also check the following table, CRT 2(I).A-H:

TABLE 2(I).A-H SECTORAL BACKGROUND DATA FOR INDUSTRIAL PROCESSES AND PRODUCT USE													Year
Emissions of CO_2, CH_4 and N_2O													Submission
(Sheet 1 of 1)													Country
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	ACTIVITY DATA		IMPLIED EMISSION FACTORS (2)			EMISSIONS (3)			Recovery/Capture (4) (5)			
	Production/Consumption quantity		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2 fossil	CO_2 biogenic (6)	CH_4	N_2O
	Description (1)	(kt)	(t/t)			(kt)			(kt)			
2.D. Non-energy products from fuels and solvent use						354.37	NO,IE	NO,NE,IE	NO	NO	NO	NO
2.D.1. Lubricant use	Lubricants used	420.30	0.63	NO	NO	266.56	IE	IE	NO	NO	NO	NO
2.D.2. Paraffin wax use	Petroleum waxes	40.45	0.60	NO	NO	24.22	NO	NO	NO	NO	NO	NO
2.D.3. Other *(please specify)* (9),(10)						63.59	NO	NO,NE	NO	NO	NO	NO
Drop-down list:												
2.D.3.a.i. Solvent use		NA	NO,NE	NO	NO,NE	NE	NO	NE	NO	NO	NO	NO
2.D.3.a.ii. Road paving with asphalt		NA	NO,NE	NO	NO,NE	NE	NO	NE	NO	NO	NO	NO
2.D.3.a.iii. Asphalt roofing		NA	NO,NE	NO	NO,NE	NE	NO	NE	NO	NO	NO	NO
2.D.3.a.iv. Other *(please specify)*						63.59	NO	NO	NO	NO	NO	NO
Urea fuel additive	Urea use	266.80	0.24	NO	NO	63.59	NO	NO	NO	NO	NO	NO

Questions

What did the finding identify?

- Emission estimates from use of urea (other than in SCR) are not reported.

Why is it a problem?

- The issue may relate to the completeness of emission estimates.

What is an ideal situation?

- The Party reports on the other uses of urea or confirms that uses of urea (other than in SCR) do not occur.

What is the recommendation of the TERT?

- Improve transparency by including in the NID more information on other uses of urea (other than in SCR).
- Estimate the emissions from other uses of urea.

Nature of the finding

The Party reports emissions from use of urea in SCR systems in diesel engines (in vehicles).

The TERT notes that SCR can be also applied to industrial combustion, for instance power plants.

We would ask the Party a preliminary question, with a brief description of the finding, for instance:

- The Party reports emissions from the use of urea in SCR systems in diesel engines (in vehicles). The TERT notes that other Parties state that SCR can also be applied to industrial combustion, for instance in power plants, and also report these emissions. Can the Party provide information on this potential other use of urea?

Let's suppose that the Party replies that it will further explore the issue.

Translating the finding into an issue

What did the finding identify?

- CO_2 emissions associated with potential uses of urea.

Why is it a problem?

- Other countries also report the use of urea in SCR applied to industrial combustion.
- This is a possible case of emission estimates that are missing.

What is an ideal situation?

- The Party provides information that either shows that these activities did not occur or alternatively provides AD and related CO_2 emission estimates.

What is the recommendation of the TERT?

- Ensure completeness by providing information on the missing AD and CO_2 emission estimates.

Nature of the issue

Completeness

Issue I.2: Party's NID, section on Non-energy products from fuels and solvent use

A Party reports indirect CO_2 emissions from the atmospheric oxidation of NMVOCs and includes those CO_2 emissions under category 2.D.3 Non-energy products from fuels and solvent use. However, in CRT 6 the Party reports indirect CO_2 as "NO"; and in CRTs 10s1 and 10s2 the total CO_2 equivalent emissions, including indirect CO_2 both with and without land use, land-use change and forestry as "NA".

Extract from the Party's NID and CRT 6:

The conversion of NMVOC emissions into CO_2 emissions has been carried out considering the carbon content value of 85 per cent as indicated by the European Environmental Agency (EEA, 1997).

TABLE 6 CROSS-SECTORAL REPORT: Indirect emissions of N_2O and CO_2

Year

Submission

Country

GREENHOUSE GAS EMISSIONS AND REMOVALS	SOURCE EMISSIONS					INDIRECT EMISSIONS	
	CH_4	CO	NMVOC	NO_X	NH_3	CO_2 [1]	N_2O [2]
	(kt)					(kt)	
Total	1 813	4 264	966	722	21	NO	4
1. Energy	314	2 544	398	647	12	NO	3
2. Industrial processes and product use	2	72	391	5	0.4	NO	0.03
3. Agriculture [3]	788	12	135	53		NO	NA
4. LULUCF [3]	59	1 590	62	15		NO	0.1
5. Waste	651	46	11	2	8	NO	0.1
6. Other (please specify)	NO	NO	NO	NO	NO	NO	NO

[1] Parties may report indirect CO_2 from the atmospheric oxidation of CH_4, CO and NMVOCs , according to decision 18/CMA.1, annex, para. 52.
[2] Parties may report indirect emissions of N_2O from sources other than agriculture and LULUCF, according to decision 18/CMA.1, annex, para. 52.
[3] Indirect emissions of N_2O resulting from ammonia emissions are covered in the sectoral tables for agriculture and LULUCF. In this table, only indirect N_2O emissions resulting from NO_x emissions are to be included.

Questions

Let's proceed by answering the following questions:

What did the finding identify?

- Indirect CO_2 emissions from solvent use.

Why is it a problem?

- The issue may relate to adherence to the MPGs. According to paragraph 52 of the MPGs, for Parties that decide to report indirect CO_2 the national totals shall be presented with and without indirect CO_2.

What is an ideal situation?

- The Party reports the totals with and without indirect CO_2 emissions.

What is the recommendation of the TERT?

- Report national totals with and without indirect CO_2 emissions in CRT 6.

Nature of the finding

The Party does not report national totals with and without indirect CO_2 emissions.

Translating the finding into an issue

What did the finding identify?

- National totals are not reported with and without indirect CO_2.

Why is it a problem?

- The MPGs (paragraph 52) request Parties to report national totals with and without indirect CO_2.

What is an ideal situation?

- The Party reports its national figures with and without indirect CO_2 emissions in CRT 6.

What is the recommendation of the TERT?

The TERT recommends that the Party report national totals with and without indirect CO_2 emissions separately in the relevant CRT.

Nature of the issue

Adherence to decision 18/CMA.1

Reporting the findings

Now, let's report our two findings.

ID#	Finding classification	Description of the finding with recommendation or encouragement	Is finding an issue/problem?
I.1	2.D.3 Other (non-energy products from fuels and solvent use) – CO_2	The Party reports emissions from the use of urea in SCR systems in diesel engines (in vehicles). During the review the TERT asked the Party about potential other uses of urea, for instance for SCR applied to industrial combustion. The Party replied that it will explore the issue in the next submission. The TERT recommends that the Party ensure completeness by providing information on the potentially missing AD and CO_2 emission estimates. If these emissions from other use of urea do not occurr the TERT recommends that the Party describe this in the NID.	Yes. Completeness
I.2	2.D.3 Other (non-energy products from fuels and	The Party reports indirect CO_2 emissions from the atmospheric oxidation of NMVOCs and includes the emission estimates in category 2.D.3 Non-energy products from fuels and solvent use. However, the Party does not report national totals with and without indirect CO_2 emissions in its CRTs.	Yes. Adherence to decision 18/CMA.1

ID#	Finding classification	Description of the finding with recommendation or encouragement	Is finding an issue/problem?
	solvent use) – indirect CO_2	The TERT recommends that the Party report national totals with and without indirect CO_2 emissions separately in the relevant CRT.	

4. Practical exercises

4.1. Exercise 1 (CH_4 and N_2O)

A Party reports CH_4 and N_2O emissions in category 2.D.3 Non-energy products from fuels and solvent use in CRT 2(I).A-Hs2 as "IE". According to CRT 9, CH_4 and N_2O emissions from this category are reported in category 2.B.8. However, no N_2O or CH_4 emissions are reported in the category 2.B.8.

How would you consider the issue?

Select one:

A. The reporting of emissions by the Party is not in line with the 2006 IPCC Guidelines, and you would recommend that the Party report all emissions under the appropriate category
B. You would ask the Party where these emissions originate from
C. Both A and B

Answer

The correct answer is (C).

Default EFs for CH_4 and N_2O from category 2.D.3 are not specified in the 2006 IPCC Guidelines, so no emissions are expected for these two gases. Therefore the TERT may ask for further information on this reporting. Supposing that these emissions occur, the TERT may also ask the Party to report them under the appropriate category. One possible way to approach the issue would be the following:

Prepare

The TTERT should first assess the Party's submission to assess the information provided.

Assess (through communication with the Party)

You should ask the Party for informaton on the source of these emissions because EFs for CH_4 and N_2O are not specified in the 2006 IPCC Guidelines. If these emissions occur, you would ask the Party to report them under the appropriate category.

Assuming that the response by the Party is that no CH_4 or N_2O emissions occur from the category and the notation key was only related to CO_2 emissions, what would be your recommendation to the Party?

Draft

If these emissions actually do not occur, you may recommend that the Party use "NO" instead of "IE" for CH_4 and N_2O in the corresponding CRT and correct the description in the NID.

This issue may be considered an issue of transparency.

5. Self-check quiz

5.1. Questions

Question 1

In which sector should emissions resulting from the “first use” of lubricants be reported, assuming that the country's energy balance does not indicate a non-energy use of products?

Please select the right answer:

A. Always in the energy sector when data on lubricants are reported in the national energy balance
B. In the respective sector where they are used
C. Always in the IPPU sector
D. None of the above

Question 2

The methods for calculating CO_2 emissions from non-energy product uses (e.g. lubricants, paraffin, waxes) follow a basic formula, in which the EF is composed of:

Select one:

A. A carbon content factor
B. A factor that represents the fraction of fossil fuel carbon that is oxidized during use
C. Both A and B

Question 3

Would the incorrect allocation of emissions from two-stroke engines in the IPPU sector instead of in the energy sector affect the accuracy of emission estimates?

Select one:

A. No, it is only a problem of allocation
B. Yes, it will also affect the accuracy

Question 4

A Party estimates indirect CO_2 emissions from solvent use and reports them in category 2.D.3 “other”. However, the CRT reports emission totals only without indirect emissions (while those with indirect CO_2 emissions are reported as “NA”).

GREENHOUSE GAS EMISSIONS	Base year[(1)]	1990	1995	2000	2005	2010	2015	2020
	CO_2 equivalent (kt)							
CO_2 emissions without net CO_2 from LULUCF	438008.80	438008.80	448332.91	468442.09	500005.68	433688.02	360088.18	348085.03
CO_2 emissions with net CO_2 from LULUCF	432346.81	432346.81	423476.30	446119.84	463962.94	390974.94	315883.95	311175.62
CH_4 emissions without CH_4 from LULUCF	48247.49	48247.49	50325.84	50766.14	48328.31	46980.03	43883.60	43032.65
CH_4 emissions with CH_4 from	49428.97	49428.97	50606.40	51449.28	48609.16	47289.31	44150.69	43203.16
N_2O emissions without N_2O fr	26036.24	26036.24	27578.52	28648.16	28032.24	19078.12	17859.26	17694.85
N_2O emissions with N_2O from	26960.83	26960.83	28507.32	29383.31	28690.36	19507.30	18186.63	18167.85
HFCs	444.00	444.00	926.65	2489.03	7616.97	12052.91	15388.78	16569.74
PFCs	2906.86	2906.86	1492.31	1488.50	1939.95	1520.39	1688.33	1657.27
Unspecified mix of HFCs and	NO,NA	NO,NA	22.95	22.95	22.95	22.95	22.95	20.92
SF_6	408.35	408.35	679.72	604.31	550.00	393.79	472.25	446.43
NF_3	NA,NO	NA,NO	76.57	13.26	33.38	20.17	28.42	22.13
Total (without LULUCF)	516051.74	516051.74	529435.48	552474.43	586529.47	513756.38	439431.75	427529.02
Total (with LULUCF)	512495.82	512495.82	505788.23	531570.48	551425.71	471781.75	395821.99	391263.13
Total (without LULUCF, with indirect)	NA	NA	NA	NA	NA	NA	NA	NA
Total (with LULUCF, with indirect)	NA	NA	NA	NA	NA	NA	NA	NA

How would you consider the issue?

Select one:

A. You would recommend that the Party report indirect emissions in CRT 6 but not in the IPPU sector, and present national totals with and without indirect CO_2 emissions in CRT summary 2
B. You would encourage the Party to present national totals with and without indirect CO_2 emissions in CRT summary 2

5.2. Answers

Answer 1

The correct answer is (D).

Since we are talking here of lubricants as non-energy products, emissions deriving from their use should be generally reported under the IPPU sector. However, when lubricants are used in two-strokes engines, emissions should be reported under the energy sector (transport) because in this case the lubricant is intentionally mixed with another fuel and co-combusted in the engine. In all other cases, emissions should be reported in the IPPU sector.

However, if the specification in the energy balance of these products (lubricants) is under non-energy use the Party may report all the emissions under the IPPU sector.

Answer 2

The correct answer is (C).

The basic formula for calculating CO_2 emissions is:

EQUATION 5.1
BASIC FORMULA FOR CALCULATING CO_2 EMISSIONS FROM NON-ENERGY PRODUCT USES

$$CO_2\ Emissions = \sum_i \left(NEU_i \bullet CC_i \bullet ODU_i\right) \bullet 44/12$$

Where:

CO_2 Emissions = CO_2 emissions from non-energy product uses, tonne CO_2

NEU_i = non-energy use of fuel *i*, TJ

CC_i = specific carbon content of fuel *i*, tonne C/TJ (=kg C/GJ)

ODU_i = ODU factor for fuel *i*, fraction

44/12 = mass ratio of CO_2/C

Answer 3

The correct answer is (B).

The reporting of emissions in the IPPU sector instead of in the energy sector would also affect the accuracy because CH_4 and N_2O emissions may occur. Not reporting CO_2 emissions in the energy sector would probably imply that CH_4 and N_2O emissions from two-stroke engines are not estimated and reported in the inventory.

Answer 4

The correct answer is (A).

If a Party decides to estimate indirect CO_2 emissions, national totals should be presented with and without indirect emissions.

National totals for each relevant assessment, for instance of key categories or uncertainty, should be those including indirect emissions.

6. Key points to remember

- Assess the completeness of CO_2 emission estimates from non-energy uses, checking that non-energy use/feedstock requirements of processes included in the inventory are in balance with the non-energy use/feedstock supply as recorded in the national energy statistics.
- The use of lubricants in engines is primarily for their lubricating properties, and associated emissions are to be reported in the IPPU sector. However, emissions from the combustion of lubricants mixed with other fuels in two-stroke engines should be reported in the energy sector and reporting them in IPPU will probably underestimate CH_4 and N_2O emissions (because they are not estimated in the IPPU section, only in the energy sector).

Lesson 7. Electronics industry

1. Introduction and objectives of the lesson

1.1. Lesson outline

This lesson is organized into six sections and helps you focus on what best complements your prior knowledge of the topic:

1. Introduction and objectives of the lesson
2. Category overview and methodological information
3. Review approach
4. Practical exercises
5. Self-check quiz
6. Key points to remember

1.2. Categories in electronics industry (2.E)

The categories considered in this lesson pertain to the electronics industry (category 2.E in the CRT). Their codes in the CRTs are as follows:

- 2.E.1 Integrated circuit or semiconductors;
- 2.E.2 TFT-FPDs manufacturing;
- 2.E.3 Photovoltaic manufacturing;
- 2.E.4 Heat transfer fluids;
- 2.E.5 Other.

This list of categories is consistent with the set of CRTs. Any of these categories could be a key category for a Party and, as such, should be placed relatively high up on your list of priorities when reviewing it. You should refer to the 2006 IPCC Guidelines (vol. 3, chap. 6) for the methodologies to estimate emissions from these categories. Some of the main problems you may encounter when reviewing emissions from these categories are also discussed in this lesson.

The expected time needed to complete lesson 7 depends on the level of your knowledge of GHG inventories for the IPPU sector under the ETF and the 2006 IPCC Guidelines:

- For readers with experience: 15–30 minutes
- For readers with less experience: 25–50 minutes

1.3. 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 electronics industry;
- Identify whether a Party's reporting for electronics industry is consistent with the requirements of the MPGs;
- Draft key review recommendations to Parties in relation to emissions from the electronics industry.

2. Category overview and methodological information

2.1. Overview

Several advanced electronics manufacturing processes use FCs for plasma etching intricate patterns, cleaning reactor chambers and temperature control. The electronic industry sectors discussed in the 2006 IPCC Guidelines (vol. 3, chap. 6) include semiconductor, TFT-FPD and photovoltaic manufacturing.

The electronic industry currently emits:

- FCs that are gases at room temperature, including CF_4, C_2F_6, C_3F_8, c-C_4F_8, c-C_4F_8O, C_4F_6, C_5F_8, CHF_3, CH_2F_2, NF_3 and SF_6, and are used in two important steps of electronics manufacturing: plasma etching silicon containing materials and cleaning CVD tool chamber walls where silicon has deposited. The majority of FC emissions result from consumption of the FC precursors during the etching or the cleaning processes;
- FCs that are liquid at room temperature for temperature control (i.e. heat transfer), where emissions come from evaporative losses. In addition, liquid FCs are occasionally used for cleaning TFT-FPD panels during manufacture.

General reference

A brief description of the estimation methods covering the decision trees, the choice of AD and EFs, and the reporting in the CRT can be found in the 2006 IPCC Guidelines (vol. 3, chap. 6).

Electronics industry in the 2019 Refinement to the 2006 IPCC Guidelines

Several methodological changes were introduced in the 2019 Refinement to the 2006 IPCC Guidelines for this category. New guidance is provided on tracking gas consumption and on apportioning use to different process types. Six revised tier methods (1, 2a, 2b, 2c, 3a, 3b) are included for gaseous FCs and N_2O, compared with the four in the 2006 IPCC Guidelines.

Tier 1 default EFs for semiconductor and display manufacturing have been updated to account for technological advancements and for the use of a broader basket of F-gases and fluorinated liquids. In addition, default EFs have been introduced for the subsector microelectromechanical systems.

Other changes include updated and new tier 2 methods that account for the size of manufactured wafers in semiconductor manufacturing; a new tier 3b method for estimating emissions by developing facility-specific EFs at the stack level; new guidance on

adapting tier 2 methods to account for technological changes; new guidance for the subsector microelectromechanical systems, which is included as a new stand-alone subcategory (2.E.4); and updates to the default EFs for tier 1 and tier 2 methods, including an expanded list of input gases, by-products and fluorinated liquids.

2.2. Etching and CVD cleaning in integrated circuit or semiconductor, TFT-FPDs and photovoltaics

This topic covers etching and CVD cleaning in integrated circuit or semiconductor manufacture (CRT category 2.E.1), TFT-FPDs (CRT category 2.E.2) and photovoltaics (CRT category 2.E.3).

The semiconductor industry uses multiple long-lived FCs in plasma etching and CVD processes. The gases most commonly employed are the following:

- HFC-23;
- CF_4;
- C_2F_6;
- NF_3;
- SF_6.

Other compounds such as perfluoropropane (C_3F_8) and perfluorocyclobutane (c-C_4F_8) are also used.

Plasma etching is performed to provide pathways for conducting material to connect individual circuit components in silicon wafers.

The etching process uses plasma-generated fluorine atoms that react at the semiconductor surface according to prescribed patterns to selectively remove substrate material.

CVD chambers, used for depositing materials that will act as insulators and wires, are cleaned periodically using PFCs and other gases.

For the photovoltaic industry, the same process as in the semiconductor industry is applied; however, CVD reactor chambers to be "cleaned" from silicon deposition are much bigger (wafer surface area in photovoltaics up to 5 square metres, versus wafer surface area in semiconductors ~ 0.1 square metres).

General reference

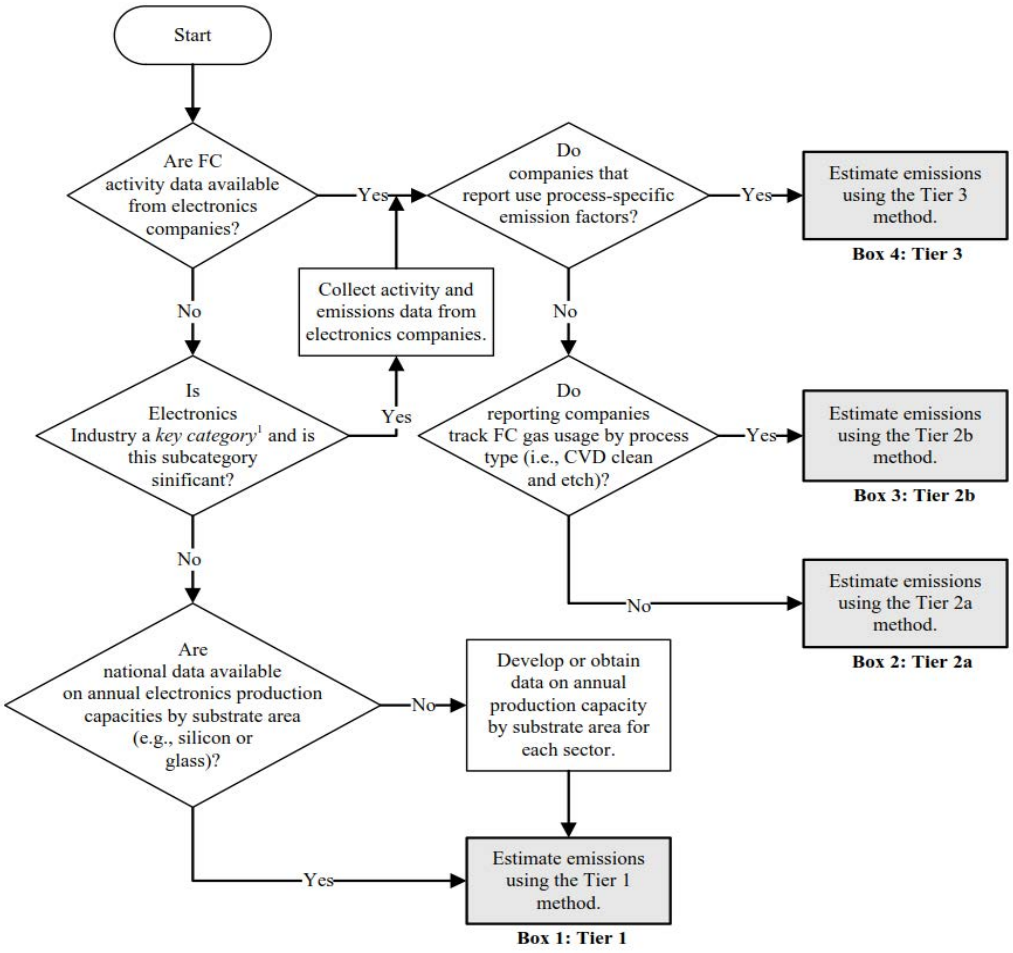
2006 IPCC Guidelines, volume 3, chapter 6, section 6.2.

Choice of tier

The 2006 IPCC Guidelines (vol. 3, chap. 6, section 6.2.1.1) provide three methodological tiers for estimating emissions from etching and CVD cleaning in semiconductor manufacturing for categories 2.E.1, 2.E.2 and 2.E.3: tier 1, tier 2 (either tier 2a or tier 2b) and tier 3.

Equations and default EFs and parameters are provided in sections 6.2.1 and 6.2.2 of the 2006 IPCC Guidelines (vol. 3, chap. 6).

The IPCC decision tree for choosing the estimation method is shown in figure 7-1.



CC. Figure 7-1. 2006 IPCC Guidelines decision tree for estimation of fluorinated compound emissions from electronics manufacturing

2.3. Heat transfer fluids in the electronics industry (category 2.E.4)

The FCs used as heat transfer fluids are liquids at room temperature and have high vapour pressures. Evaporative losses occur during cooling of certain process equipment, during testing of packaged semiconductor devices and during vapour phase reflow soldering of electronic components to circuit boards.

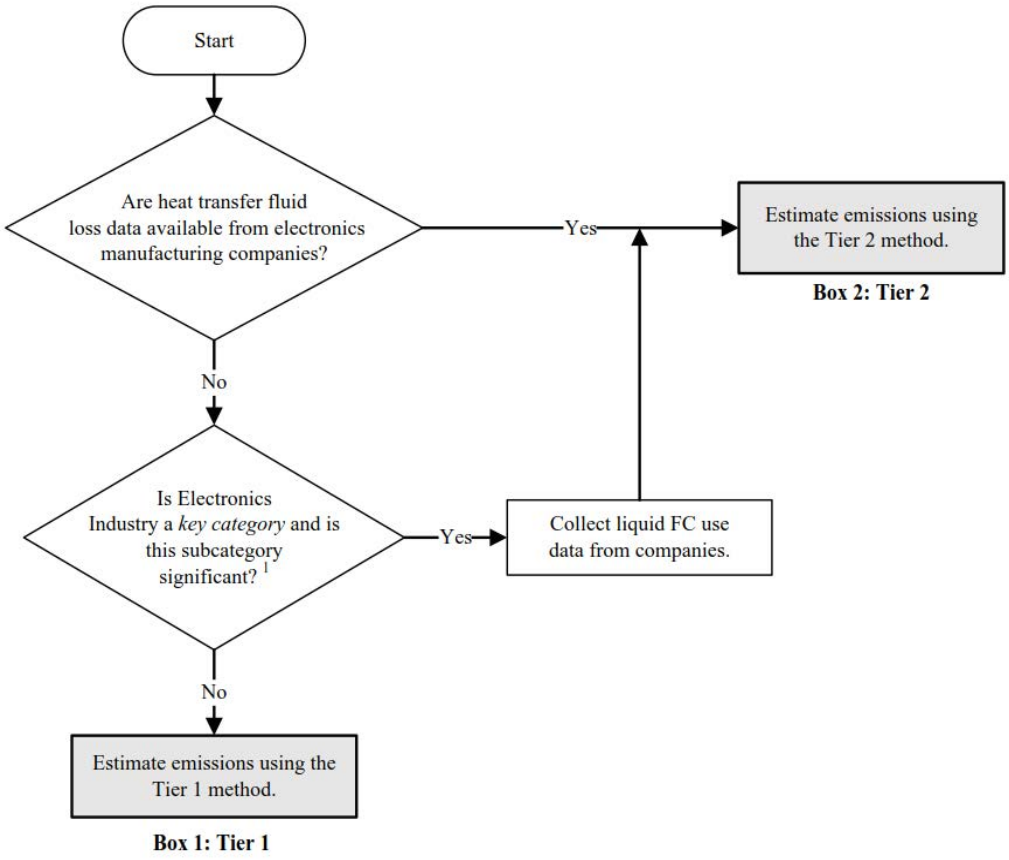
General reference

2006 IPCC Guidelines, volume 3, chapter 6, section 6.2.1.2.

Choice of tier

The 2006 IPCC Guidelines provide two methods for estimating emissions from the use of FCs heat transfer fluids: tier 1 (using generic EFs) and tier 2 (mass balance).

The IPCC decision tree for choosing the estimation method is shown in figure 7-2.



DD. Figure 7-2. 2006 IPCC Guidelines decision tree for estimation of fluorinated compounds emissions from heat transfer fluid loss from electronics manufacturing

Priorities and potential key issues to consider during a review

For the estimation of emissions from all categories in the electronics industry (etching and CVD; and heat transfer), you should verify that, when using tier 1, the Party does not modify the set of FC EFs provided in the IPCC 2006 Guidelines. It is also important to ensure that the use of the tier 1 method or default EFs is not combined with any other higher-tier methods or other EFs for different gases and types of electronics manufacturing industry.

In general, actual emissions are to be reported by Parties in their CRT, including recovered emissions. Data for the consumption of the F-gases in the process (i.e. use (filling) during manufacture) should be reported. The emissions include evaporative losses and by-product emissions. In the case of by-product emissions, a separate row should be added in the CRT, and the information on the relevant AD in the documentation box of the table should be included.

The time-series consistency issue is relevant in these categories because historical data to use higher tiers may not be available at the plant level for the entire time series. In that case, the use of different tiers (presumably tier 1 for the earlier years of the period) is permitted along the time series, as long as the time series has been demonstrated to be consistent despite using two different tiers. Also, a

comparison between the different tiers is a verification procedure (i.e. comparing the estimates for the later years using tier 1 and 2).

Care should be taken that Parties do not include emissions of HFCs used as ODS substitutes with those used in semiconductor manufacturing.

3. Review approach

3.1. Overview

In the following section you will find some examples of potential findings you may be faced with during a review and recommendations you may describe in the relevant tables of the annual review report.

We will consider two cases: in the first you have to fill in a table where recommendations from the previous cycles of reviews are listed; in the second you will need to look for new findings and compile a table in consideration of your own assessment.

- In the table below, you will find some recommendations from the previous reviews. You are asked to indicate if the issue is resolved/not resolved or addressing considering what the Party has reported in its most recent submission (NID/CRT). The type of issue is indicated as Adherence to the UNFCCC Annex I inventory reporting guidelines, Adherence to the MPGs, Completeness, etc.;
- For the new findings, some indications are given so that you will be able to conclude on some issues and give recommendations to the Party. Here you may also indicate the type of issue you have found.

3.2. Case 1 (verifying the implementation of previous recommendations)

Let's consider an example for the first case.

Status of implementation of issues raised in the previous report of Party K

ID#	Issue classification	Recommendation made in previous review report	TERT assessment and rationale
IPPU			
I1.	2.E.1 – Integrated Circuit or Semiconductor Transparency	The Party estimates F-gas emissions from semiconductor manufacturing in accordance with the tier 2a methodology on the basis of an equation accepted by the World Semiconductor Council. The TERT noted that this equation is different from the proposed equation in the 2006 IPCC Guidelines and it is not clear from the NID how these equations correlate. During the review the Party explained that, as reported in the 2006 IPCC Guidelines, total emissions are equal to the sum of emissions from the gas Fci used in the production process plus the emissions of by-product calculated with equation 6.3–6.6 and the formula used gathers the previous equations and refers to total emissions. The TERT	*Note to the reviewer*: To assess this issue, please read the Party's submission below. We will have all the material to make our conclusion on the issue.

ID#	Issue classification	Recommendation made in previous review report	TERT assessment and rationale
		recommends that the Party provide information to present correlation of the formula that is used to calculate F-gas emissions from semiconductor manufacturing and the proposed tier 2a in the 2006 IPCC Guidelines.	

Issue I.1: Party's NID, section on methodology

Extract from the Party's NID:

F-gas emissions from semiconductor manufacturing are estimated using the tier 2a methodology of the 2006 IPCC Guidelines. As reported in the guidelines, total emissions are equal to the sum of emissions from the gas Fci used in the production process plus the emissions of by-product calculated with the equation 6.3/6.4/6.5/6.6. Companies involved in the semiconductor manufacturing provide yearly data on consumption and emissions. The formula gathers the 2006 IPCC Guidelines equations and refers to total emissions (combining equations 6.2/6.3/6.4/6.5/6.6 of the guidelines) and includes both direct and by-product emissions.

$$\textbf{Emissions for } PFC_i = PFC_i*(1-h)[(1-C_i)(1-A_i)*GWP_i + B_i*GWP_{(byproduct)}*(1-A_{(byproduct)}]$$

where:

h = fraction of gas_i remaining in container (heel)
PFC_i = purchases of $gas_i = kgs_i$
kgs_i = mass of gas_i purchased
GWP_i = 100 yr global warming potential of gas_i
C_i = average utilization factor of gas_i (average for all etch and CVD processes) $=1-EF_i$
EF_i = average emission factor of gas_i (average for all etch and CVD processes)
B_i = mass of CF_4 created per unit mass of PFC_i transformed
A_i = fraction of PFC_i destroyed by abatement $= a_{i,j}*V_a$

By product formation

A_{CF4} = fraction of PFC_i converted to CF_4 and destroyed by abatement = $a_{CF4}*V_a$
$a_{i,j}$ = average destruction efficiency of abatement $tool_j$ for gas_i
a_{CF4} = average destruction efficiency of abatement $tool_j$ for CF_4
V_a = fraction of gas_i that is fed into the abatement tools
A_{CF4} = fraction of PFC_i converted to CF_4 and destroyed by abatement = $a_{CF4}*V_a$
$a_{i,j}$ = average destruction efficiency of abatement $tool_j$ for gas_i
a_{CF4} = average destruction efficiency of abatement $tool_j$ for CF_4
A_{C2F6} = fraction of PFC_i that is converted to C_2F_6 and destroyed by abatement = $a_{C2F6}*Va$
a_{C2F6} = average destruction efficiency of abatement $tool_j$ for C_2F_6
A_{C3F8} = fraction of PFC_i that is converted to C_3F_8 and destroyed by abatement = $a_{C3F8}*Va$
a_{C3F8} = average destruction efficiency of abatement $tool_j$ for C_3F_8
V_a = fraction of gas_i that is fed into the abatement tools

Now let's try to verify whether previous recommendations have been implemented based on the information we have gathered.

ID#	Issue classification	Recommendation made in previous review report	TERT assessment and rationale
IPPU I1.	2.E.1 – Integrated Circuit or Semiconductor	The Party estimates F-gas emissions from semiconductor manufacturing in accordance with the tier 2a methodology on the basis of an equation accepted by the World Semiconductor Council. The TERT noted that this equation is different from the proposed equation in the 2006 IPCC Guidelines and it is not clear from the NIR how these equations correlate. During the review the Party explained that, as reported in the 2006 IPCC Guidelines, total emissions are equal to the sum of emissions from the gas FC_i used in the production process plus the emissions of by-product calculated with the equation 6.3–6.6 and the formula used gathers the previous equations and refers to total emissions. The TERT recommends that the Party provide information to present correlation of the formula that is used to calculate F-gas emissions from semiconductor manufacturing and the proposed tier 2a in the 2006 IPCC Guidelines.	Resolved. The Party provided the information needed for correlating the formula used to estimate F-gas emissions from semiconductor manufacturing with the tier 2a methodology of the 2006 IPCC Guidelines.

3.3. Case 2 (new findings)

We will now look for new findings in a Party's submission. Let's check a Party's NID for category 2.E.1 Integrated circuit or semiconductors by reading the following extract and tables from the Party's NID:

Section: Methodological issues

F-gas emissions from semiconductors manufacturing are estimated using the tier 2a methodology of the 2006 IPCC Guidelines. As reported in the guidelines, total emissions are equal to the sum of emissions from the gas Fci used in the production process plus the emissions of by-product calculated using equations 6.3/6.4/6.5/6.6.

Please also check the following CRTs:

		ACTIVITY DATA		IMPLIED EMISSION FACTORS[1]	EMISSIONS	
					Emissions[2]	Recovery[3]
1998		Description	(t)	(t/t)	(t)	(t)
E. Electronics industry						
1. Integrated circuit or semiconductor		Consumption				
HFC-23	HFC-23	Consumption	3.01	0.500	1.51	NO
HFC-32	HFC-32	Consumption	NO	NO	NO	NO
HFC-134a	HFC-134a	Consumption	0.04	0.500	0.02	NO
C_2F_6	C_2F_6	Consumption	4.32	1.091	4.71	NO
CF_4	CF_4	Consumption	2.00	1.776	3.55	NO
C_3F_8	C_3F_8	Consumption	NO	NO	NO	NO
c-C_4F_8	c-C_4F_8	Consumption	0.01	0.500	0.01	NO
SF_6	SF_6	Consumption	4.65	0.500	2.33	NO
NF_3	NF_3	Consumption	0.54	0.500	0.27	NO

1999		ACTIVITY DATA		IMPLIED EMISSION FACTORS[1]	EMISSIONS	
		Description	(t)	(t/t)	Emissions[2] (t)	Recovery[3] (t)
E. Electronics industry						
1. Integrated circuit or semiconductor		Consumption				
HFC-23	HFC-23	Consumption	0.39	4.409	1.70	NO
HFC-32	HFC-32	Consumption	NO	NO	NO	NO
HFC-134a	HFC-134a	Consumption	0.04	1.000	0.04	NO
C_2F_6	C_2F_6	Consumption	2.04	3.110	6.34	NO
CF_4	CF_4	Consumption	2.70	2.043	5.51	NO
C_3F_8	C_3F_8	Consumption	NO	NO	NO	NO
c-C_4F_8	c-C_4F_8	Consumption	0.03	0.700	0.02	NO
SF_6	SF_6	Consumption	0.55	4.727	2.60	NO
NF_3	NF_3	Consumption	0.88	0.807	0.71	NO

2000		ACTIVITY DATA		IMPLIED EMISSION FACTORS[1]	EMISSIONS	
		Description	(t)	(t/t)	Emissions[2] (t)	Recovery[3] (t)
E. Electronics industry						
1. Integrated circuit or semiconductor		Consumption				
HFC-23	HFC-23	Consumption	0.49	0.893	0.44	NO
HFC-32	HFC-32	Consumption	NO	NO	NO	NO
HFC-134a	HFC-134a	Consumption	0.04	1.000	0.04	NO
C_2F_6	C_2F_6	Consumption	7.12	1.131	8.05	NO
CF_4	CF_4	Consumption	8.58	1.062	9.11	NO
C_3F_8	C_3F_8	Consumption	NO	NO	NO	NO
c-C_4F_8	c-C_4F_8	Consumption	0.06	0.708	0.04	NO
SF_6	SF_6	Consumption	1.20	0.729	0.88	NO
NF_3	NF_3	Consumption	2.10	0.710	1.49	NO

2001		ACTIVITY DATA		IMPLIED EMISSION FACTORS[1]	EMISSIONS	
		Description	(t)	(t/t)	Emissions[2] (t)	Recovery[3] (t)
E. Electronics industry						
1. Integrated circuit or semiconductor		Consumption				
HFC-23	HFC-23	Consumption	2.35	0.213	0.50	NO
HFC-32	HFC-32	Consumption	NO	NO	NO	NO
HFC-134a	HFC-134a	Consumption	0.01	NO	0.01	NO
C_2F_6	C_2F_6	Consumption	16.08	0.505	8.12	NO
CF_4	CF_4	Consumption	24.40	0.598	14.59	NO
C_3F_8	C_3F_8	Consumption	4.84	0.210	1.02	NO
c-C_4F_8	c-C_4F_8	Consumption	0.53	0.218	0.12	NO
SF_6	SF_6	Consumption	5.98	0.362	2.17	NO
NF_3	NF_3	Consumption	14.10	0.053	0.74	NO

2002		ACTIVITY DATA		IMPLIED EMISSION FACTORS[1]	EMISSIONS	
		Description	(t)	(t/t)	Emissions[2] (t)	Recovery[3] (t)
E. Electronics industry						
1. Integrated circuit or semiconductor		Consumption				
HFC-23	HFC-23	Consumption	2.01	0.208	0.42	NO
HFC-32	HFC-32	Consumption	NO	NO	NO	NO
HFC-134a	HFC-134a	Consumption	NO	NO	NO	NO
C_2F_6	C_2F_6	Consumption	17.89	0.495	8.85	NO
CF_4	CF_4	Consumption	25.76	0.558	14.37	NO
C_3F_8	C_3F_8	Consumption	5.26	0.219	1.15	NO
c-C_4F_8	c-C_4F_8	Consumption	0.30	0.248	0.07	NO
SF_6	SF_6	Consumption	6.53	0.358	2.34	NO
NF_3	NF_3	Consumption	22.50	0.073	1.63	NO

2006		ACTIVITY DATA		IMPLIED EMISSION FACTORS[1]	EMISSIONS	
		Description	(t)	(t/t)	Emissions[2] (t)	Recovery[3] (t)
E. Electronics industry						
1. Integrated circuit or semiconductor		Consumption				
HFC-23	HFC-23	Consumption	1.82	0.323	0.59	NO
HFC-32	HFC-32	Consumption	0.14	0.792	0.11	NO
HFC-134a	HFC-134a	Consumption	NO	NO	NO	NO
C_2F_6	C_2F_6	Consumption	11.58	0.258	2.99	NO
CF_4	CF_4	Consumption	23.47	0.583	13.67	NO
C_3F_8	C_3F_8	Consumption	0.13	0.435	0.05	NO
c-C_4F_8	c-C_4F_8	Consumption	10.85	0.200	2.17	NO
SF_6	SF_6	Consumption	26.84	0.062	1.66	NO
NF_3	NF_3	Consumption	42.77	0.038	1.64	NO

Findings

What did the finding identify?

- Emission estimates from integrated circuits or semiconductors.

Why is it a problem?

- The issue may relate to the consistency of the time series.

What is an ideal situation?

- The Party collects data from the industry to estimate emissions for 1998–2000.

What is the recommendation by the TERT?

- Improve the consistency of the time series by estimating emissions from these years using data collected from the industry.

Evaluating findings

Nature of the finding

The Party reports F-gas emissions from integrated circuits and semiconductor manufacturing.

You could calculate the inter-annual change between two subsequent years and see that the difference in the 1998–1999 IEFs is the highest figure compared with the other years.

We could ask the Party a preliminary question, with a brief description of the finding, for instance:

- The Party reports F-gas emissions from semiconductor manufacturing. The TERT notes a high inter-annual change between the IEFs of HFC-23 and SF_6 for 1998 and 1999. Can the Party provide information on this potential inconsistency of the time series?
- (*Note*: other gases' IEFs follow the same pattern as HFC-23 and SF6. In a review you would follow up on all the instances. However, in this example we will just focus on HFC-23 and SF6, for simplicity.)

Let's suppose that the Party replies that emissions for 1990–2000 are calculated on the basis of consumption data, whereas for the following years they are calculated on the basis of plant-specific parameters in accordance with the 2006 IPCC Guidelines.

Translating the finding into an issue

What did the finding identify?

- F-gas emissions from semiconductor manufacturing.

Why is it a problem?

- The Party applies different approaches to two periods in the time series.
- This is a possible case of inconsistency of the time series.

What is an ideal situation?

- The Party has a plan to collect data from the industry.

What is the recommendation of the TERT?

- Ensure consistency of the time series using the same approach to estimate emissions based on plant-specific data, if possible, or consider the application of an alternative statistical approach to estimate the figures for those years (e.g extrapolation approach).

Nature of the issue

Consistency (time series consistency)

Reporting findings

Now, let's report our finding in the review report.

ID#	Finding classification	Description of the finding with recommendation or encouragement	Is finding an issue/problem?
I.1	2.E.1 Integrated circuit or semiconductor – HFCs and SF_6	The Party estimates HFC and SF_6 emissions from semiconductor manufacturing. The TERT notes that the inter-annual change between 1998 and 1999 in the IEFs for HFC23 and SF_6 is identified as large in the time series for the emissions of integrated circuits or semiconductors. Following a question on the reason of these high IEFs, the Party replied that plant-specific data were used for the whole times series. For the first three years of the time series (1998–2000), operators provided only consumption data for each gas, whereas from 2001, emissions are estimated at the plant level in accordance with the IPCC 2006 Guidelines on the basis of plant-specific parameters. The TERT recommends that the Party try to collect the complete information on the first years of the time series and if these data are not available provide a comparison between the approach followed and other statistical techniques to show that time-series consistency is ensured.	Yes. Consistency

4. Practical exercises

4.1. Exercise #1 (semiconductor manufacturing)

Read this extract of a Party's NID: "There are two plants of semiconductor manufacturing in the country, owned by two companies which supply yearly consumption and emission data for each plant to the inventory team. F-gas emissions from semiconductor manufacturing are estimated but not reported due to confidentiality".

What would be your comment to this extract?

Select one:

A. Given the Party's explanation, you would accept the fact that emissions are not reported respecting confidentiality laws.
B. Given the Party's explanation, you would ask the Party to show the calculation of the emissions .
C. You would ask the Party to report the emission in the proper category.

Answer

The correct answer is (B).
You would ask the Party about the calculation of the emissions. You would also ask about the confidentiality law that applies to these emissions. You would recommend the Party to include these emissions in the national inventory (for instance together with other emissions at a upper category level to preserve confidentiality).

4.2. Exercise #2.a (PFCs for heat transfer)

A Party estimates PFC emissions from PFC use as a heat transfer medium in CRT category 2.G.4 Other (other product manufacture and use). The Party describes the estimations in its NID as follows: "Activity data on PFC use as a heat transfer medium was collected in 2009 and 2014–2019 from gas distributor data surveys, where one distributor indicated its use. Activity data for 2010–2013 are interpolated between the 2009 and the 2014–2019 data from surveys. A tier 2 method has been used to estimate emissions."

What would be your first question to the Party?
Select one:

A. Ask for the description of the estimation method.
B. Ask for the reason for not reporting these emissions in category 2.E.4 heat transfer fluid

Answer

The correct answer is (A).
You would ask the Party to describe the estimation method, including all data and assumptions. Once you have the information, you would be able to assess if the emissions are misallocated. If misallocated, you would recommend the Party to report those emissions in the correct category.

4.3. Exercise #2.b (PFCs for heat transfer)

If the emissions are correctly calculated but not reported in the correct category (2.E.4 heat transfer fluid), what reporting principle is not being followed?
Select one:

A. Comparability
B. Accuracy
C. Consistency

Answer

The correct answer is (A).
If the emissions are correctly calculated but not reported in the correct category, a problem of comparability with other Parties' occurs.

5. Self-check quiz

5.1. Questions

Question 1

A Party reports in its NIR that PFC emissions from semiconductors are calculated using the tier 2a methodology of the 2006 IPCC Guidelines (vol. 3, chap. 6, equation 6.2) and derived from company-specific data on gas consumption and on emission control technologies. The Party states that companies report their emission figures according to the following formula only:

$$\textbf{Emissions for } FC_i = FC_i * (1 - h) [(1-C_i) (1-A_i) * GWP_i$$

where

h =	fraction of gas_i remaining in container (heel)
$1 - h$ =	fraction of gas_i used
FC_i =	purchase of gas_i = $k\ gs_i$
$k\ gs_i$ =	mass of gas_i purchased
GWP_i =	100 yr global warming potential of gas_i
C_i =	average utilisation factor of gas_i (average for all etch and CVD processes) = 1 - EF_i
EF_i =	average emission factor of gas_i (average for all etch and CVD processes) = 1 - C_i
B_i =	mass of CF_4 created per unit mass of PFC_i transformed
A_i =	fraction of FC_i destroyed by abatment = $a_{ij} * V_a$
$1-A_i$ =	fraction of FC_i non destroyed

Are all emissions estimated?

Select one:

A. Yes
B. No

Question 2

In the electronics industry, different FCs are used. Methodologies for estimating emissions from FC use include:

Select one:

A. Evaporative losses
B. By-product emissions
C. Both A and B

5.2. Answers

Answer 1

The correct answer is (B).

Not all emissions are estimated, because by-product emissions are not considered in this approach.

Total emissions are equal to the sum of emissions from the gaseous FC used in the production process plus the emissions of by-products (e.g. CF_4, C_2F_6) resulting from the use of the gas Fci.

Answer 2

The correct answer is (C).
Evaporative losses occur during cooling of certain process equipment, during testing of packaged semiconductor devices and during vapour phase reflow soldering of electronic components to circuit boards. Also, a number of transformation by-products are generated as a result of FC use for chamber cleaning and etching.

6. Key points to remember

- Actual emissions are to be reported by Parties in their CRTs, including recovered emissions. Data for the consumption of the F-gases in the process (i.e. use (filling) during manufacture) should be reported. The emissions include evaporative losses and by-product emissions.
- A Party should use a higher-tier method to estimate emissions from a key category unless it has mentioned specific national circumstances that prevent this application.

Lesson 8. Product uses as substitutes for ozone-depleting substances

1. Introduction and objectives of the lesson

1.1. Lesson outline

This lesson is organized into six sections and helps you focus on what best complements your prior knowledge of the topic:

1. Introduction and objectives of the lesson
2. Category overview and ethodological information
3. Review approach
4. Practical exercises
5. Self-check quiz
6. Key points to remember

1.2. Categories in product uses as substitutes for ozone-depleting substances

The categories considered in this lesson pertain to product uses as substitutes for ODS, and their codes in the CRTs are as follows:

- 2.F Product uses as substitutes for ODS;
- 2.F.1 Refrigeration and air conditioning;
- 2.F.2 Foam blowing agents;
- 2.F.3 Fire protection;
- 2.F.4 Aerosols;
- 2.F.5 Solvents;
- 2.F.6 Other applications.

This list of categories is consistent with the set of CRTs. Any of these categories could be a key category for a Party and, as such, should be placed relatively high up on your list of priorities when reviewing it. You should refer to the 2006 IPCC Guidelines (vol. 3, chap. 7) for the methodologies to estimate emissions from these categories. Some of the main problems you may encounter when reviewing emissions from these categories are also discussed in this lesson.

The expected time needed to complete lesson 8 depends on the level of your knowledge of GHG inventories for the IPPU sector under the ETF and the 2006 IPCC Guidelines:

- For readers with experience: 15–30 minutes
- For readers with less experience: 25–50 minutes

1.3. 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 product uses as substitutes for ODS;
- Identify whether a Party's reporting for product uses as substitutes for ODS is consistent with the requirements of the MPGs;
- Draft key review recommendations to Parties in relation to emissions from product uses as substitutes for ODS.

2. Category overview and methodological information

2.1. Categories in the lesson

This topic covers HFCs, and partially PFCs, used as alternatives to ODS because the ODS gases are being phased out under the Montreal Protocol.

Substitutes for ODS are used in a variety of industrial applications including refrigeration and air-conditioning equipment, solvent cleaning, foam production, sterilization, fire extinguishing and aerosols.

The emissions from this category occur as leakage from the different types of equipment (also referred to as "applications"), during use of the equipment (e.g. fire protection) and are also due to the destruction of such equipment after use. The subcategories, which are sources of emissions to be reported in the CRT, are as follows:

- Refrigeration and air conditioning;
- Foam blowing agents;
- Fire protection;
- Aerosols;
- Solvents;
- Other applications.

A brief description of the estimation method is given in the 2006 IPCC Guidelines, with reference to the decision trees the choice of AD and EFs, and the reporting in the CRTs.

General reference

2006 IPCC Guidelines, volume 3, chapter 7.

Choice of tier

Each application reported above can be divided into subapplications (for instance, refrigeration and air conditioning are subdivided in commercial, industrial, transport, mobile and stationary; foam blowing agents in closed and open cells). Estimates will benefit from a higher level of disaggregation in their data sets due to the potentially different characteristics.

The 2006 IPCC Guidelines provide tier 1 and tier 2 methods depending on the aggregation at the application level.

The AD may be chemical sales (top-down data) on a substance-by-substance basis, or markets in the form of equipment or product sales at the subapplication level. For chemical data and for product data, information on import and export quantities is needed to derive the consumption data by chemical type and subapplication (production + import – export – destruction).

The tier 1 and tier 2 methods proposed in the 2006 IPCC Guidelines. Tiers 1a and 2a use EFs at the application or sub-application level, respectively. The guidelines also comprise detailed methodologies for the mass-balance approach (tier 1b and tier 2b). The mass-balance approach is relevant when emissions are consistent with consumption of the product for one year, or where consumption occurs only at the point of manufacture, while emissions may continue for a limited extent of time throughout the lifetime of the product. The differences between the two tiers are in the different levels of data aggregation.

Priorities and potential key issues to consider during a review

The major difficulty here is the collection of data from industrial producers. It is important that you understand this availability of data in the Party under review; sometimes, data are provided based on chemical sales, typically on a substance-by-substance basis, or on a market basis, generally in the form of equipment or product sales at the subapplication level.

Occasionally, some companies may stock-pile chemicals when there are coming political or economical changes. For example, when a new rule, tax, or regulation is being prepared, companies commonly stockpile just in case they will not have the ease of access to the same product for some time. This, in turn, might affect the time series consistency of reporting (unusual spikes might appear in the historical trends for some F-gases).

It should be preferable that the Party presents comparable equipment/product-based estimates at the subapplication level (tier 2a) with the mass-balance tier 1b or 2b approach, where appropriate, because EFs at the product level have an inherent associated uncertainty. This technique will also minimize the possibility that certain end uses are not accounted for in the equipment-based approaches.

In the case of confidentiality of data, the Party may have reported those data aggregated to protect the confidentiality. However, the Party should transparently describe the method of aggregation.

Emissions of fluorinated substitutes for ozone-depleting substances in the 2019 Refinement to the 2006 IPCC Guidelines

In this category, some changes occurred in the 2019 Refinement to the 2006 IPCC Guidelines involving the application areas covered and general methodological issues for all ODS substitutes, particularly on the choice of method. Further specific improvements were made to Refrigeration and air conditioning, as described in a specific box in the relevant section.

2.2. Refrigeration and air conditioning (category 2.F.1)

Refrigeration and air-conditioning systems may be classified in up to six subcategories as follows:

- Commercial refrigeration;
- Domestic refrigeration;
- Industrial refrigeration;
- Transport refrigeration;
- Mobile air conditioning;
- Stationary air conditioning.

General reference

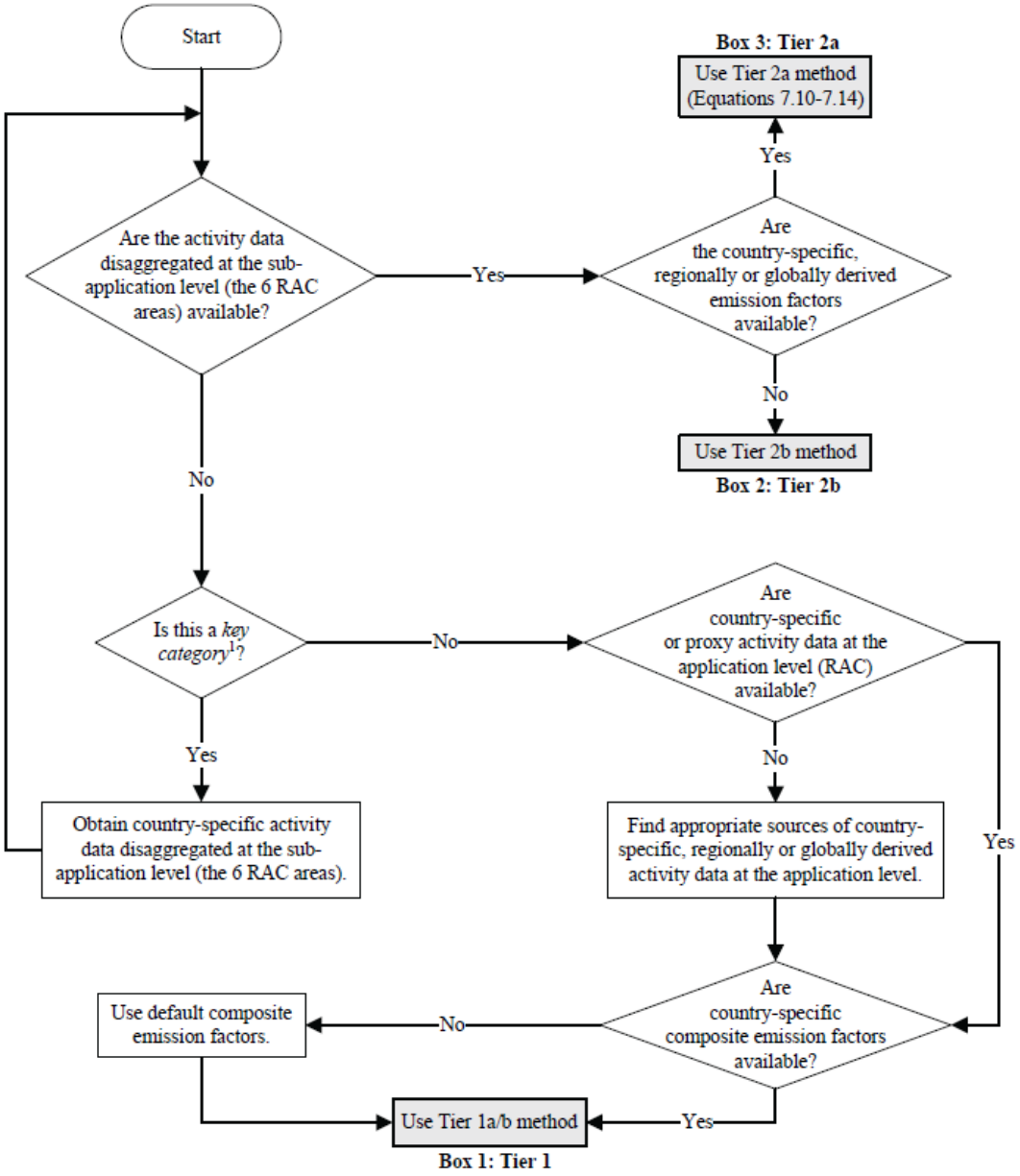
2006 IPCC Guidelines, volume 3, chapter 7, section 7.5.

Choice of tier

The 2006 IPCC Guidelines provide two different tiers for refrigeration and air conditioning: tier 1 (1a and 1b) and tier 2 (either tier 2a or tier 2b).

Equations and default EFs and parameters are provided in section 7.5.2 of the 2006 IPCC Guidelines.

The IPCC decision tree for choosing the estimation method is shown in figure 8-1.



EE. Figure 8-1. 2006 IPCC Guidelines decision tree for estimation of emissions from refrigeration and air-conditioning equipment

Priorities and potential key issues to consider during a review

In estimating annual sales of new refrigerant, total charge of new equipment and original total charge of retiring equipment, inventory compilers should account for imports and exports of both chemicals and equipment. This will ensure that the actual domestic consumption of chemicals and equipment is captured.

As the estimation of these gases is complicated, specific QA/QC procedures and verification activities are outlined in the 2006 IPCC Guidelines. Care is necessary when dealing with refrigerant blends, because these may contain HFCs, PFCs and other compounds (which should not be reported).

You should consider that one drawback of the mass-balance approach is that it can underestimate emissions when stocks are growing, because there is a lag between the time the emissions occur and the time they are detected (through equipment servicing). This underestimate will be relatively large in countries where HFCs have been used in equipment for less than 10 years, because much of the equipment will have leaked without ever being serviced. In this case, the use of alternative approaches is encouraged.

Care is also necessary when assessing data on monitoring the movement of trade in equipment and products.

Care is also needed when assessing banks of chemicals, especially if tier 2 is used and country-specific parameters are introduced. Banks are often misunderstood and miscalculated by countries, especially by countries who do not a prior experience in calculating them.

Confidentiality may be an issue for category 2.F.1.

Refrigeration and air conditioning in the 2019 Refinement to the 2006 IPCC Guidelines

In the 2019 Refinement to the 2006 IPCC Guidelines, some improvements have occurred on the choice of methods, EFs and AD. New guidance on building an HFC emissions inventory (including guidance on data sources and on establishing the existing bank of HFCs) is provided, as well as new and updated tables regarding the identity and distribution of substitutes for ODS by application and by substance for both developing and developed countries. Changes also occurred in the application of tier 2 methods.

2.3. Foam blowing agents (category 2.F.2)

HFCs are being used as replacements for ODS in foam blowing, and particularly in insulation applications.

Emissions from closed cells and open cells foams should be reported; the division of foams into open cells or closed cells relates to the way in which the blowing agent is lost from the products, as follows:

- For open-cell foams, emissions of HFCs used as blowing agents are likely to occur during the manufacturing process and shortly thereafter. The 2006 IPCC Guidelines assume that all emissions occur during manufacturing except for “one component foams”;
- In closed-cell foam, only a minority of emissions occur during the manufacturing phase. Emissions from closed-cell foams therefore extend into the in-use phase, often with the majority of emissions not occurring until the end of life (decommissioning losses). Accordingly, emissions from closed-cell foams can occur over 50 years, or even longer, from the date of manufacture.

General reference

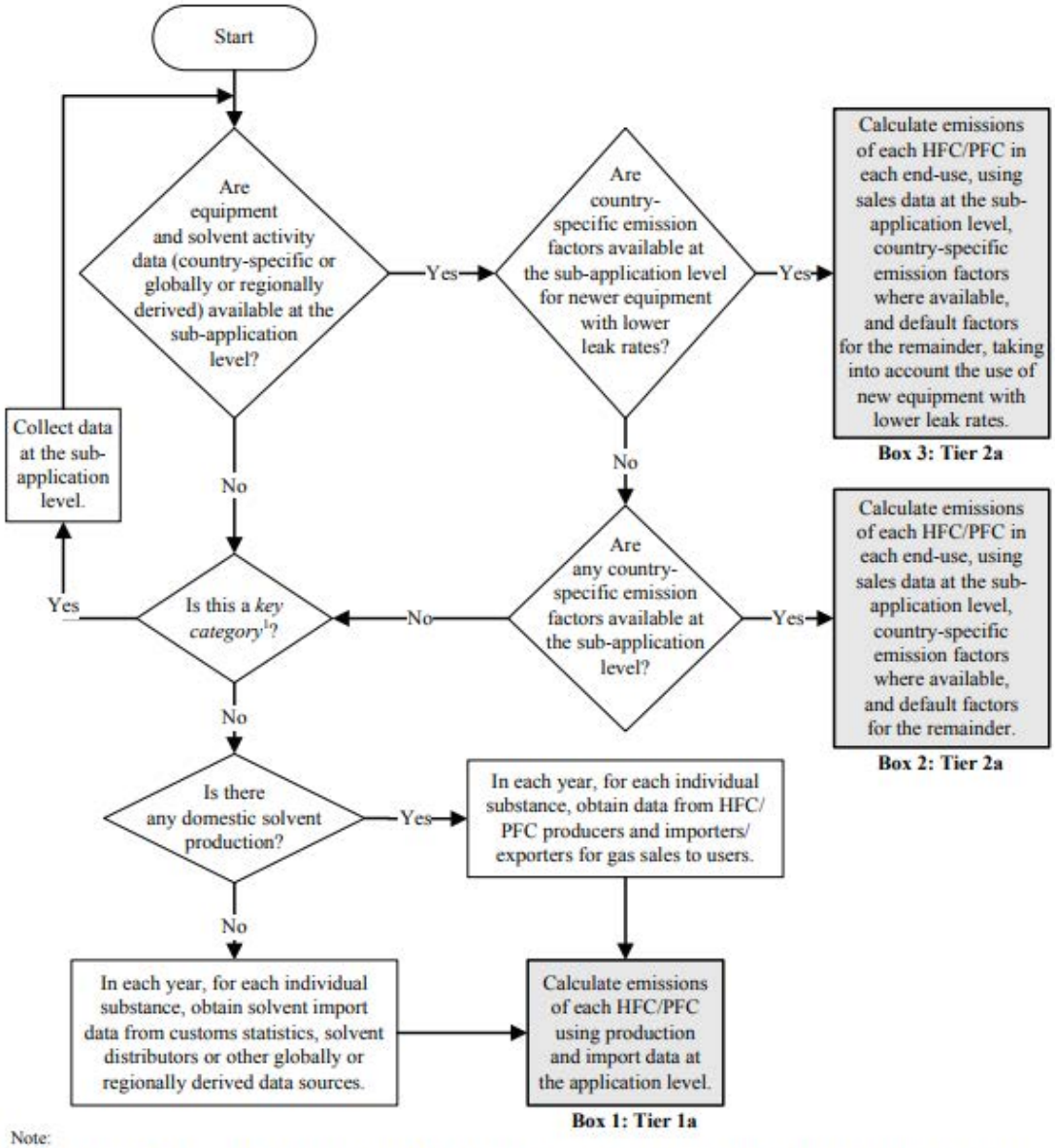
2006 IPCC Guidelines, volume 3, chapter 7, section 7.4.

Choice of tier

The IPCC decision tree for choosing the estimation method is shown in figure 8-2.

The 2006 IPCC Guidelines provide equations and default EFs for applying both the tiers at the appropriate level of disaggregation.

Figure 7.2 Decision tree for actual emissions from the solvents application



Note:
1. See Volume 1 Chapter 4, Methodological Choice and Identification of Key Categories (noting Section 4.1.2 on limited resources), for discussion of *key categories* and use of decision trees.

FF. Figure 8-2. 2006 IPCC Guidelines decision tree for estimation of emissions from foam blowing

Priorities and potential key issues to consider during a review

Completeness may be a relevant issue to consider, as large amounts of HFC blowing agents that can be used in each subapplication, and Parties may not take them all into account within the foam application.

Care is also needed when assessing banks of chemicals, especially if tier 2 is used and country-specific parameters are introduced. Banks are sometimes miscalculated by countries, especially by countries who do not a prior experience in calculating them.

Confidentiality is frequently an issue for this category.

2.4. Fire protection (category 2.F.3)

There are two general types of fire protection (fire suppression) equipment that use HFCs and/or PFCs as partial replacements for ODS: portable (streaming) equipment and fixed (flooding) equipment.

Emissions from the fire protection subsector are expected to be quite small. However, the number of standby fire protection systems (i.e. the stock) is growing. This results in an accumulating bank of future potential emissions.

The HFCs and PFCs that might still be involved in fire protection are HFC-23, HFC-125, HFC-134a, HFC-227ea, HFC-236fa, PFC-14 (CF_4) and PFC-31-10 (C_4F_{10}) (please see table 7.1 of the 2006 IPCC Guidelines, vol. 3, chap. 7).

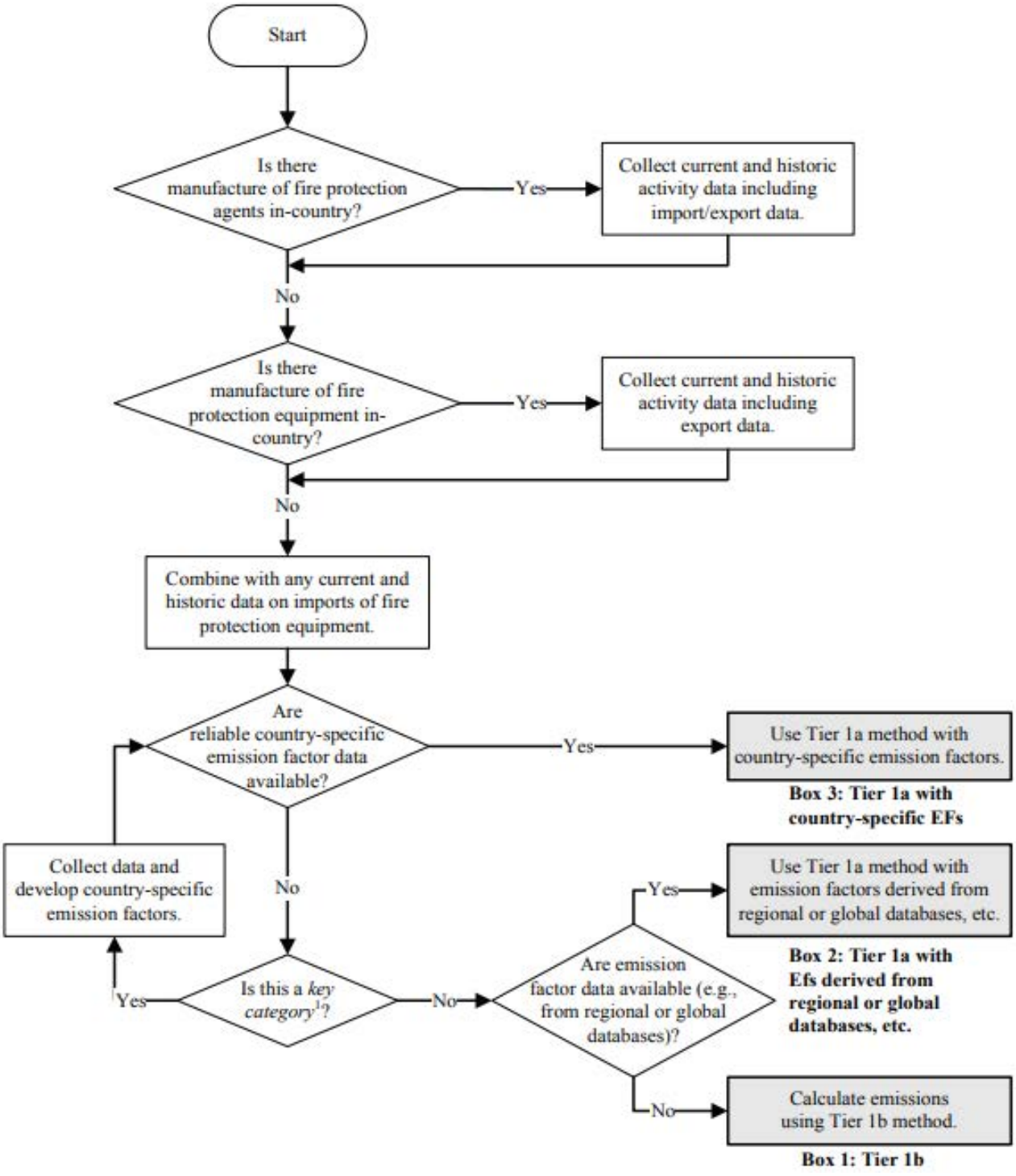
General reference

2006 IPCC Guidelines, volume 3, chapter 7, section 7.6.

Choice of tier

As with refrigeration and air-conditioning applications, both an EF and a mass-balance approach can be used for estimating emissions from fire protection applications.

As the fire protection applications are less numerous and more homogeneous than the refrigeration and air-conditioning applications, the tier 1 method (tier 1a or tier 1b) may be sufficient to estimate emissions. See figure 8-3.



GG. Figure 8-3. 2006 IPCC Guidelines decision tree for estimation of emissions from fire protection applications

HFCs and PFCs in fire protection are emitted over a period longer than one year, so countries need to represent emissions from equipment charged during previous years, and it is necessary to deal with the historical development and tracking of banks.

Emissions in year *t* should be estimated considering the bank of the agent multiplied by the relevant EF, expressed in terms of fraction of agent in the equipment emitted each year and also the emissions of the agent during recovery, recycling or disposal at the time of removal from use.

There are opportunities to recover the gas at the end of life of the equipment (or whenever removed from service). The recovered gas may be destroyed or recycled, so the assumption of zero end-of-life recovery may overestimate end-of-life emissions. Please see equation 7.17, volume 3, section 7.6.2.1 of the IPCC 2006 Guidelines.

For AD, for countries that produce the fire protection agent, it is good practice to assign all the production of that agent to that country unless it is known to have been exported in bulk or destroyed. For countries that do not produce the agent but which produce and fill fire protection systems, the entire bulk agent imported in the country is considered to remain in the country unless it is known to have been re-exported in bulk or destroyed.

Priorities and potential key issues to consider during a review

Confidentiality issues can also occur in this subcategory, so you should check for the transparency of reporting and potentially ask for additional information.

Given the time lag of the emissions, choosing an annual production-based EF to reflect a multi-year emission process can lead to a considerable error and is not considered to be good practice.

Care is also needed when assessing banks of chemicals, especially if tier 2 is used and country-specific parameters are introduced. Banks are sometimes miscalculated by countries, especially by countries who do not a prior experience in calculating them.

2.5. Aerosols (category 2.F.4)

Most aerosol packages contain hydrocarbons as propellants, but HFCs and PFCs may also be used as propellants (or solvents in the aerosols). Emissions from aerosols usually occur shortly after production, on average six months after sale. However, the period between manufacture and sale could vary significantly depending on the subapplication involved. During the use of aerosols, 100 per cent of the chemical is emitted.

The main subapplications in aerosols are as follows:

- MDIs;
- other applications:
  - personal care products (e.g. hair care, deodorant, shaving cream);
  - household products (e.g. air fresheners, oven and fabric cleaners);
  - industrial products (e.g. special cleaning sprays such as those for operating electrical contacts, lubricants, pipe freezers);
  - other general products (e.g. silly string, tyre inflators, aerosol horns).

The HFCs currently used as propellants are HFC-134a, HFC-227ea and HFC-152a. The substances HFC-245fa, HFC-365mfc, HFC-43-10mee and a PFC, perfluorohexane, are used as solvents in industrial aerosol products.

General reference

2006 IPCC Guidelines, volume 3, chapter 7, section 7.3.

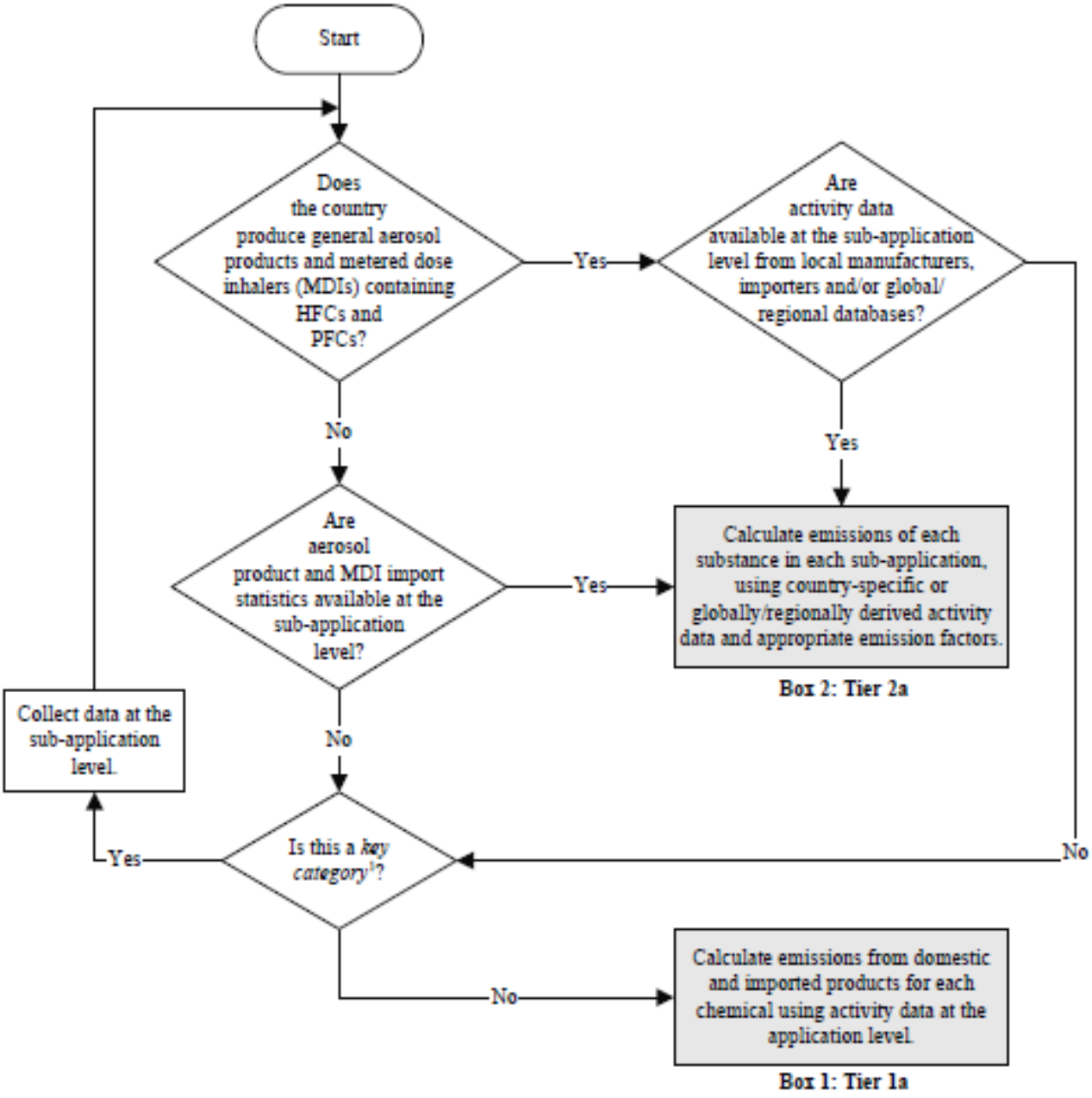
Choice of tier

The 2006 IPCC Guidelines provide two methodological tiers for estimating emissions from aerosols.

Aerosol emissions are considered prompt emissions because all initial charge escapes within the first year or two after manufacture, typically six months after sale for most applications. To estimate emissions, it is necessary to know the total amount of aerosol initially charged in product containers prior to sale.

The difference between the tier 1 and tier 2 methods is that they relate to the availability of data from manufacturers or distributors and the level of subapplication provided. Usually, there is no recovery from these uses.

For this category, the tier 2 method does not result in much better estimates than the tier 1 method, so countries should consider carefully how many resources to invest in developing a tier 2 method. See figure 8-4 for which estimation method Parties should use.



HH. Figure 8-4. 2006 IPCC Guidelines decision tree for estimation of emissions from aerosol applications

Priorities and potential key issues to consider during a review

Completeness may be a potential issue for the references of AD. The collection of AD by the Party may be difficult, especially when a country is not a producer of aerosols but imports them, because it is not

easy to find import statistics that differentiate the use of HFC-containing aerosols from others. You can check for the occurrence of regional or global AD databases.

There are some specific QA/QC procedures (see 2006 IPCC Guidelines, vol. 3, chap. 7, section 7.3.4.1). For example, as the emissions are assumed to occur within two years, you should check that the sum of AD in the two years reaches 100 per cent.

You could also be faced with some confidential data; in this case, if not enough qualitative information is provided on the types of aerosol products consumed, imported and produced within the country, you can ask for additional details.

2.6. Solvents (non-aerosols) (category 2.F.5)

HFCs are now used in solvent applications (non-aerosol), and PFCs are still only very rarely used. HFC/PFC solvent uses occur in four main areas as follows:

- Precision cleaning;
- Electronics cleaning;
- Metal cleaning;
- Deposition applications.

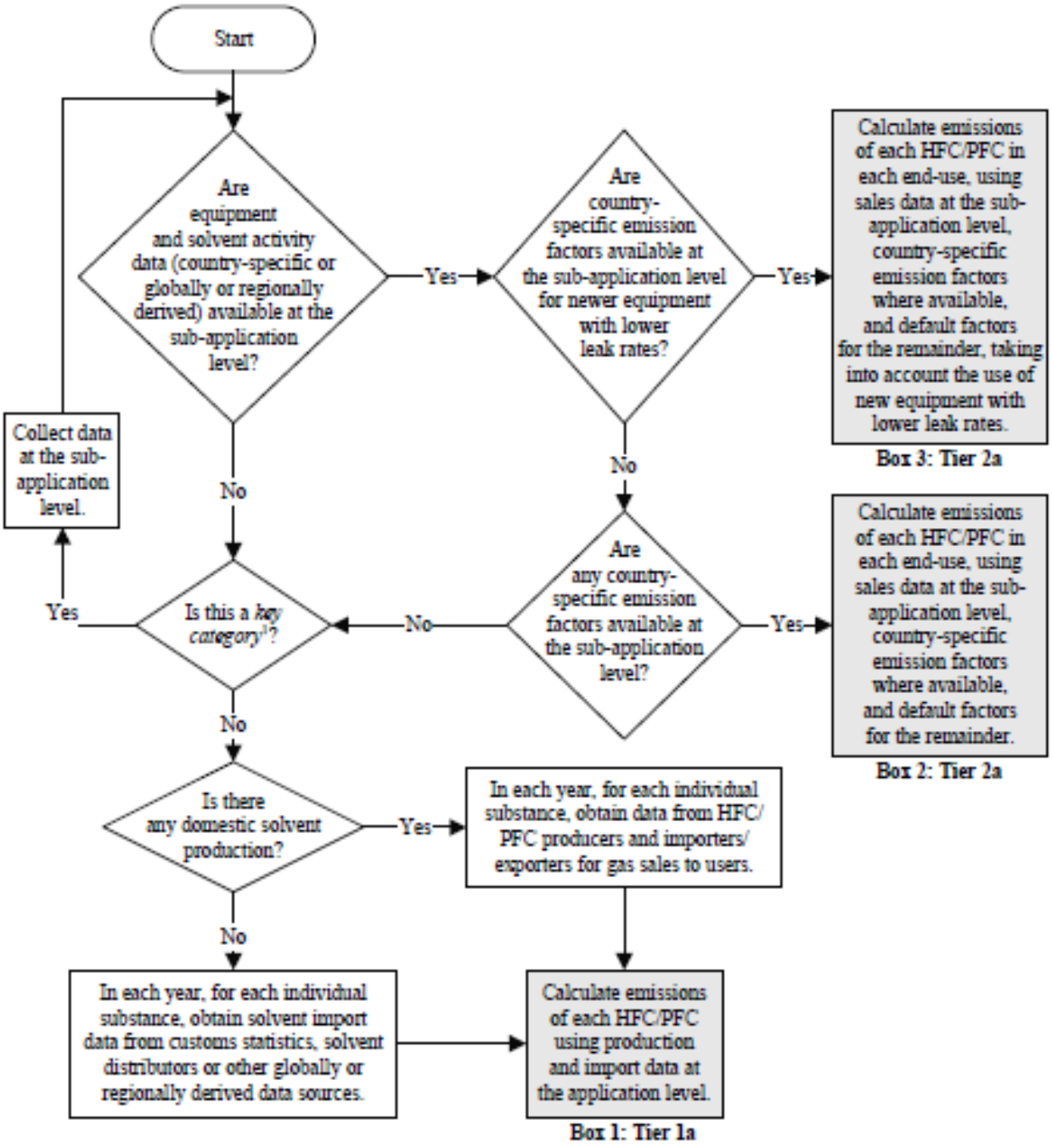
General reference

2006 IPCC Guidelines, volume 3, chapter 7, section 7.2.

Choice of tier

The 2006 IPCC Guidelines provide two methodological tiers for estimating emissions from solvents.

Emissions from solvent applications have generally been considered prompt emissions because 100 per cent of the chemical is typically emitted within two years of initial use. See figure 8-5 for which estimation method Parties should use.



II. Figure 8-5. 2006 IPCC Guidelines decision tree for estimation of emissions from the solvents application

Priorities and potential key issues to consider during a review

You should check the completeness of the inventory, because some countries may have incomplete data on solvent production and import statistics may be incomplete.

Also, potential double counting may occur, with emissions of HFCs and PFCs acting as solvents and contained in aerosols. These should be accounted for as consumption in aerosols.

2.7. Other applications (category 2.F.6)

HFC and PFC emissions from other applications may include HFCs and PFCs used in sterilization equipment, for tobacco expansion applications (the process of puffing leaves of tobacco to decrease the volume of tobacco used in cigarette production) and as solvents in the manufacture of adhesives, coating and inks. However, the focus of this category is on uses of HFCs and PFCs that directly replace ODS.

The end uses for these niche applications will be extremely diverse. As a result, investigating each of these applications separately may not be feasible. Instead, it is suggested that these other miscellaneous applications be divided into emissive applications (similar to solvents and aerosols), and less emissive or contained applications (similar to closed-cell foam and refrigerators). The breakdown of annual gas consumption going to either category should be determined by a survey of end-use applications. The split of usage into emissive and contained will be:

- Emissive = X% of total consumption (where X would typically be >50%)
- Contained = (100 – X)% of total consumption

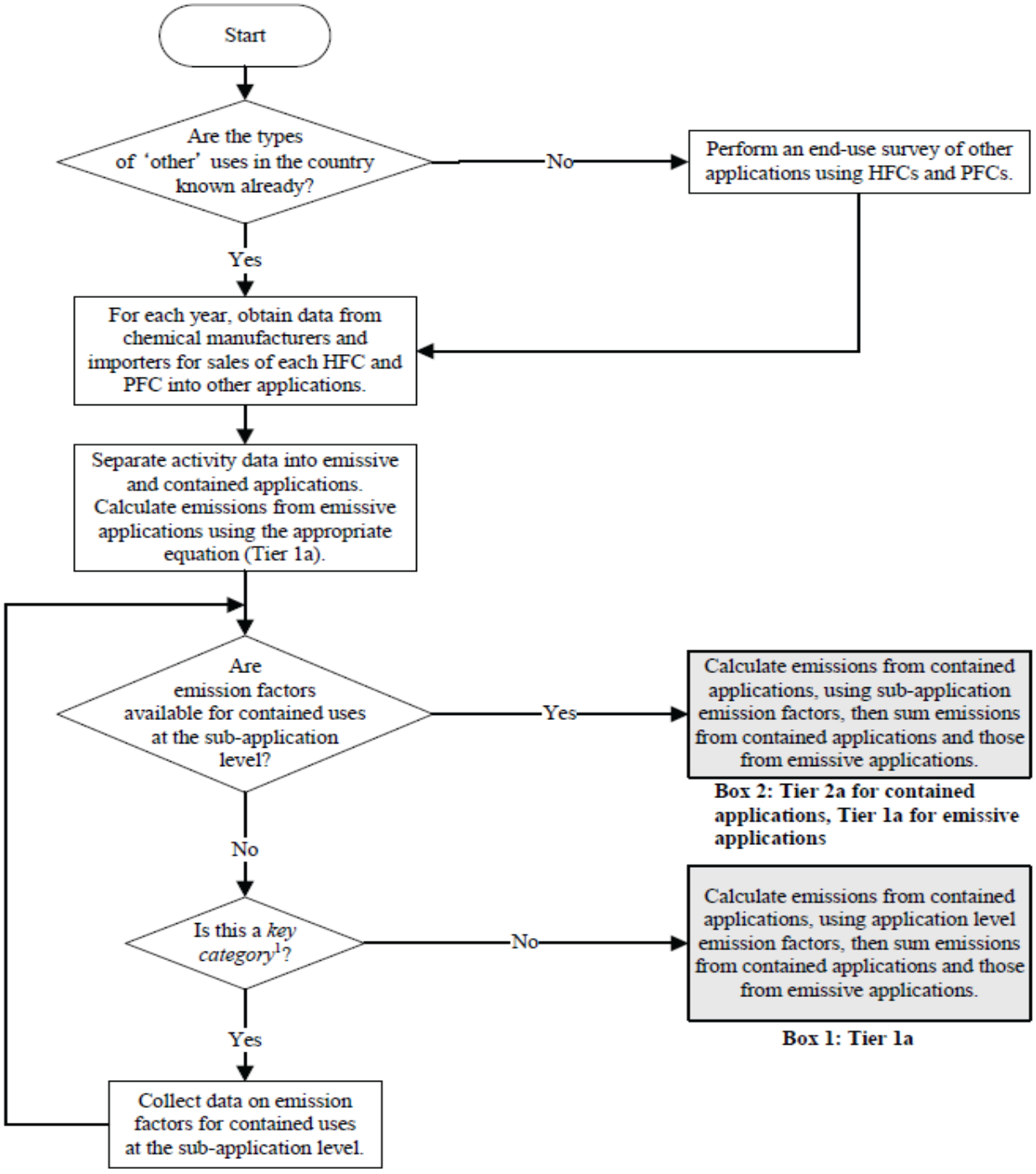
where X is the percentage fraction of a chemical emitted during the first year

General reference

2006 IPCC Guidelines, volume 3, chapter 7, section 7.7.

Choice of tier

The 2006 IPCC Guidelines provide two methodological tiers for estimating emissions from other applications. See figure 8-6.



JJ. Figure 8-6. 2006 IPCC Guidelines decision tree for estimating HFCs and PFCs emissions from other applications

When choosing a method for this category, Parties need to consider whether to treat each "Other" application as a separate application or address them as a group. Depending on this choice, a series of tier 2 methods or a single tier 1 approach will be applied.

In the case of *emissive applications*, a tier 1a method can be used, assuming that 100 per cent of the chemical is emitted on average six months after sale.

For *contained applications*, it is necessary to adjust for the low leakage rate, provided that appropriate data are available. If there is a variation in the nature of contained subapplications, the adoption of a tier 2a method may be considered.

Priorities and potential key issues to consider during a review

You should check that double counting does not occur with the electronics category, solvents or aerosols.

3. Review approach

3.1. Overview

In the following section you will find some examples of potential findings you may be faced with during a review and recommendations you may describe in the relevant tables of the TERR.

Status of implementation of issues raised in the previous review report of Party K

Issue classification	Recommendation made in previous review report	TERT assessment and rationale
Accuracy 2.F Product uses as substitutes for ozone-depleting substances – PFCs	Increase the accuracy of the Party's emission estimates by collecting and using data on PFC use for the entire time series, including 2010–2017, or use surrogate data, extrapolation, interpolation and other methods consistent with splicing techniques contained in the IPCC guidelines.	*Note to the reviewer*: You may check the Party's submission below. We will have all the material to make our conclusion on the issue

Issue I.1: Party's NID, section on methodology

Extract from the Party's NID:

Data on PFC use for 2008 and 2009 were collected from the operators, and these data are used to extrapolate values for 2010–2017.

There are plans to obtain up-to-date data on PFC use and the inclusion of these data in future submissions will depend on the findings of the data analysis.

Verifying the implementation of previous recommendations

Now let's try to assess the previous recommendation with the information we have checked.

Issue classification	Recommendation made in previous review report	TERT assessment and rationale
Accuracy 2.F Product uses as substitutes for ozone-depleting substances – PFCs	Increase the accuracy of the Party's emission estimates by collecting and using data on PFC use for the entire time series, including 2010–2017, or use surrogate data, extrapolation, interpolation and other methods consistent with splicing techniques contained in the IPCC guidelines.	Not resolved. The Party has not implemented this recommendation and the PFC data used in the emission estimation is still extrapolated for 2010–2017 without justifying the consistency of the extrapolation in accorandance with the guidelines. The Party plans to gather data through voluntary data collection and the implementation of this recommendation will depend on the findings of the data analyses.

Now let's check a Party's NID for category 2.F.2 Foam blowing agents by reading the following extract and tables from the Party's NID:

Section. Methodological issues

HFCs

Data on import and export of HFCs are used for emission calculation by means of tier 1a methodology for foam blowing agents (HFC 152a)

In section 3.3 of the Party's NID the Party applies the tier 1 methodology to quantify HFC emissions from use of foam blowing agents. However, there is no indication of the share of the HFC152a for open and closed foam blowing cell types.

The Party does not transparently describe how import and export data on HFC152a are disaggregated according its various applications.

There is no indication of how this consumption is split between open and closed foam blowing cell types.

Finding

What did the finding identify?

- Emission estimates from foam blowing agents are not transparently reported.

Why is it a problem?

- HFC152a is a non-ODS substance that can be used for more than one application (e.g. refrigeration and air conditioning, aerosols, foam blowing).
- Two foam blowing cell types are used in the foam blowing industry (open and closed). The 2006 IPCC Guidelines provide a separate methodological approach for open and closed cell types.
- There is no indication of how the import/export data for HFC152a is split between the three subapplications described above, as required by the disaggregation approach described in figure 7.1 of the 2006 IPCC Guidelines (vol. 3, chap. 7).
- Different applications have different methodological assumptions and emission rates.

- Similarly, different forms of foam blowing present different methodological assumptions.
- Both situations can lead to under/overestimation of emissions.
- The issue may relate to the accuracy of emission estimates.

What is the ideal situation?

- The Party provides supporting information describing how data on HFC 152a use as a foam blowing agent are derived.

What is the recommendation of the TERT?

- Improve transparency by providing information in the NID on the different uses of the gas.

Nature of the finding

The Party reports emission estimates from foam blowing agents using a tier 1 method. However, the description in the NID is not sufficient for the TERT to assess whether the three applications (refrigeration and air conditioning, aerosols, foam blowing) have been considered and which foam blowing cell types are used in the foam blowing industry (open and closed).

We may ask the Party a preliminary question, with a brief description of the finding, for instance:

- The Party reports emissions from foam blowing agents using a tier 1 method. The TERT is not able to assess how these emission estimates are carried out with the information reported in the Party's NID.
- Can the Party provide information on how emission estimates are carried out?

Let's suppose that the Party replies that emissions include the three subapplications and are distinguished between closed and open cell.

Translating the finding into an issue

What did the finding identify?

- HFCs emissions from foam blowing agents.

Why is it a problem?

- The description of the method used by the Party is not sufficiently detailed for the TERT to assess the accuracy of the estimates.

What is the ideal situation?

- The Party provides information showing that emission estimates include the three subapplications and are distinguished between closed and open cell.

What is the recommendation by the TERT?

- Improve transparency by including in the NID the information provided to the TERT during the review.

Nature of the issue

Transparency

ID#	Description of the finding with recommendation or encouragement	Is finding an issue/problem?
I.1	The Party reports emission estimates from foam blowing agents using a tier 1 method. However, the description in the NID is very poor and the TERT is not able to assess whether the three applications (refrigeration and air conditioning, aerosols, foam blowing) have been considered and which foam blowing cell types are used in the foam blowing industry (open and closed). During the review, the Party provided information demonstrating that emission estimates include the three subapplications and are distinguished between closed and open cells. The TERT recommends that the Party include a description on how the emission estimates are divided by subapplications and split between closed and open cells.	Yes. Transparency

4. Practical exercises

4.1. Exercise 1 (2.F.4 HFC emissions from aerosols)

Let's consider HFC emissions from aerosols (category 2.F.4) and the description reported in a Party's NID.

Aerosols

The methodology used to estimate emissions corresponds to an IPCC tier 2a method. Estimates of aerosol HFC emissions have been derived on the basis of fluid consumption data provided by the National Aerosol Manufactures' Association up to 2021. The association discontinued collecting data from 2013 onwards so for these years we have projected estimates of HFC consumption using knowledge of the regulatory landscape and industry insight of the market from a personal contact at the association. An average product lifetime of one year for all aerosols containing HFCs has been assumed, based on discussion with the association, although this may be shorter or longer depending on the specific aerosol application. It is estimated that 1 per cent of HFC emissions from aerosols occur during manufacture. The majority is released during the product lifetime (97 per cent) with end of life emissions accounting for the other 2 per cent. The lifetime and end of life emissions are calculated after import exports have been taken into account.

Metered dose inhalers

The methodology used to estimate emissions corresponds to an IPCC tier 2 method. The current approach is essentially a "national consumption" model. The number of MDIs used each year is derived from the National Health Service (NHS) prescription data. HFC emissions have been calculated with estimates of the species and volumes of HFCs used as MDI propellants. Detailed data from the NHS are used for estimates between 1998 and 2015. Estimates for 1990–1997 are based on extrapolated data from 1998. The NHS data gives no information about the amount of HFC propellant per MDI prescribed. The estimates assume an average figure of 12g/MDI in recent year (Gluckman, 2013).

You may compare the methodology used by the Party and reported in the extract above, with the methodology described in the 2006 IPCC Guidelines (vol. 3, section 7.3.2.1) and conclude on the method the Party uses.

Question

How would you conclude on the method used by the Party?

Select one:

A. The methodology used by the Party is in line with the 2006 IPCC Guidelines
B. The methodology used by the Party is not in line with the 2006 IPCC Guidelines

Answer

The correct answer is (B).

The methodology used by the Party for estimating HFC emissions from aerosols (reported in the extract above) is different from the methodology recommended by the 2006 IPCC Guidelines (vol. 3, section 7.3.2.1). In particular, in the Party's assessment, 1 per cent of HFC emissions from aerosols occurs during product manufacture, 97 per cent during product lifetime and 2 per cent at the end of product life. According to the 2006 IPCC Guidelines, 50 per cent of the initial charge of aerosols is emitted in the first year and 50 per cent in the second year of aerosols use. The methodology applied by the Party does not take into account the delay in aerosols use, so the estimates may be not accurate.

The IPCC good practice is to use the default emission factor of 50% for this category only for tier 1a. If a tier 2a is applied, a Party could use country-specific EFs, so using different numbers by itself is not wrong because the Party applied the tier 2a methodology. However (and this is most important!), according to the 2006 IPCC Guidelines, inventory compilers should use alternative EFs only when empirical evidence is available for the majority of aerosol products at either the application level (Tier 1a) or the sub-application level (Tier 2a). And such evidence and justification are missing in the Party's NID.

One possible way to approach the issue would be the following:

Prepare

The TERT should first review the Party's submission to assess the information provided.

Assess (through communication with the Party)

The methodology applied by the Party does not take into account the delay in aerosols use so the estimates may be not accurate. Since you cannot judge if there is an underestimation in emissions here you may ask the Party to provide a justification for the choice of the current EFs for aerosols production and use (i.e. 1 per cent of HFC emissions from aerosols occur during product manufacture, 97 per cent during product lifetime and 2 per cent at the end product of life).

Assuming that the response by the Party would not be sufficient in terms of references for the choice of EFs, what would be your recommendation to the Party?

Draft

Since you cannot judge if there is an underestimation in emissions here you may recommend that the Party include references in the NID that justify the choice of the current EFs for aerosols production and use (i.e. 1 per cent of HFC emissions from aerosols occur during product manufacture, 97 per cent during product lifetime and 2 per cent at the end product of life) or estimate HFC emissions from aerosols in accordance with the 2006 IPCC Guidelines.

This issue may be considered an issue of accuracy.

4.2. Exercise 2 (2.F.4 Aerosols)

Please consider HFC134-a emissions from MDIs (under aerosols) reported by a Party (see CRT for 2013 below). The Party has reported the AD for the amount of HFCs remaining in products at decommissioning as "NE". In its NIR, the Party reports that "according to a national law, refrigerators, air-conditioning equipment and aerosols/metered dose inhalers must be emptied before decommissioning by recovery, reuse or destruction of the remaining gases".

The Party reported the following figures in its CRT for 2013:

GREENHOUSE GAS SOURCE	Gas *(please specify) One row per substance*	ACTIVITY DATA *Amount*			IMPLIED EMISSION FACTORS			EMISSIONS [2]			Recovery [3] [4]
		Filled into new manufactured products	In operating systems (average annual stocks)	Remaining in products at decommissioning	Product manufacturing factor	Product life factor	Disposal loss factor	From manufacturing	From stocks	From disposal	
		(t)			%			(t)			
2.F. Product uses as substitutes for ODS											
2.F.1. Refrigeration and air-conditioning											
2.F.1.a. Commercial refrigeration	e.g. HFC-134a, 152a, 227ea, 245fa										
2.F.1.b. Domestic refrigeration	e.g. HFC-134a										
2.F.1.c. Industrial refrigeration	e.g. HFC-152a										
2.F.1.d. Transport refrigeration	e.g. HFC-125										
2.F.1.e. Mobile air-conditioning	e.g. HFC-143a										
2.F.1.f. Stationary air-conditioning	e.g. HFC-32										
2.F.2. Foam blowing agents	e.g. HFC-23										
2.F.2.a. Closed cells	e.g. HFC-236fa										
2.F.2.b. Open cells	e.g. HFC-245fa										
2.F.3. Fire protection	e.g. HFC-227ea										
2.F.4. Aerosols											
2.F.4.a. Metered dose inhalers	HFC-143a	531	NO	NE	100	NA	NA	NO	6.841	NO	NO
2.F.4.b. Other *(please specify - one row per substance)*											

Question

Which statement would you report in the TERR considering that the Party has provided you with the information on a national law that states "when a refillable or non-refillable F-gas container reaches the end of its life, the person utilizing the container for transport or storage purposes shall be responsible for putting in place arrangements for the proper recovery of any residual gas it contains to ensure its recycling, reclamation or destruction"?

Select one:

A. You would recommend that the Party change its reporting for AD from "NE" to "NO"
B. You would recommend that the Party estimate the AD for HFCs remaining in MDIs, even if no emissions occur owing to 100 per cent recovery
C. You would write that the underreporting of AD does not lead to an underestimation of emissions, because the national law requires users to recover any remaining gas at disposal and either reuse or destroy it
D. You would encourage the Party to contact the recovery centres to verify that the recovery rate can be assumed as 100 per cent (i.e. that no fugitive losses occur)
E. Both A and B
F. Both B and C.

G. Both B and D

Answer

The correct answer is (G) (i.e. both B and D are correct).

It is important to report information on AD at decommissioning and emissions "recovered" to improve the transparency of the description of the methodology followed.

For AD, the Party should replace "NO" with the amount of gas remaining in products at decommissioning. The Party should also report, in the column "recovery", the amount of emissions recovered (originally reported incorrectly as "NO").

For emissions from disposal, there may be an environmental law but the actual implementation may not be complete. Even if there is an environmental law in place in the country, you should ask for further evidence that the recovery rate at the end of life is 100 per cent. In addition, the Party can contact some of the treatment centres to understand how the gases are recovered or destroyed ensuring that no leakage occurs from decommissioned equipment (i.e. even if 100 per cent equipment is processed, there may be emissions due to leakage).

Even if no underestimation of emissions occurs, it is important to report information on AD at decommissioning and emissions "recovered" to improve the transparency of the description of the methodology followed.

5. Self-check quiz

5.1. Questions

Question 1

When estimating emissions of F-gases from refrigeration and air conditioning, as well as from fire extinguishing equipment it is important to take into consideration the time lag between manufacturing and emissions. Is this sentence true?

Select one:

A. Yes
B. No

Question 2

The characterization of each major subapplication in the case of both refrigeration applications and fire protection equipment is equally an important issue.

Select one:

A. Yes, equally important in both cases
B. More important for refrigeration applications than for fire protection
C. More important for fire protection than for refrigeration applications

5.2. Answers

Answer 1

The correct answer is (A).

The time lag between manufacturing and emissions may be considerable for refrigeration and fire extinguishing equipment. A time lag results from the fact that a chemical placed in a new product may only slowly leak out over time, often not being released until the end of the product's life.

Answer 2

The correct answer is (B).

The subapplications of the fire protection category are less numerous and more homogeneous than the refrigeration applications; for fire protection, a lower-tier method may be sufficient to provide appropriate emission estimates for refrigeration.

6. Key points to remember

- The major difficulty in estimating HFC and PFC emissions when they are used as ODS is the collection of data from industrial producers. It is important that you understand this difficulty of data availability among Parties; sometimes, data are provided based on chemical sales, typically on a substance-by-substance basis, or on a market basis, generally in the form of equipment or product sales at the subapplication level.
- In the case of refrigerants, you should check if in estimating annual sales of new refrigerant, total charge of new equipment and original total charge of retiring equipment, inventory compilers account for imports and exports of both chemicals and equipment. This will ensure that they capture the actual domestic consumption of chemicals and equipment.
- Confidentiality may be an issue in the reporting of some Parties for some categories.
- Banks of chemicals, especially the incorrect calculation of those banks, could be an issue too.

Lesson 9. Other manufacture and use

1. Introduction and objectives of the lesson

1.1. Lesson outline

This lesson is organized into six sections and helps you focus on what best complements your prior knowledge of the topic:

1. Introduction and objectives of the lesson
2. Category overview and methodological information
3. Review approach
4. Practical exercises
5. Self-check quiz
6. Key points to remember

1.2. Categories in other manufacture and use

The categories considered in this lesson pertain to other manufacture and use, and their codes in the CRTs are as follows:

- 2.G Other product manufacture and use;
- 2.G.1 Electrical equipment (SF_6 and PFC emissions);
- 2.G.2 SF_6 and PFCs from other product use;
- 2.G.3 N_2O from product uses;
- 2.G.4 Other.

This list of categories is consistent with the set of CRTs. Any of these categories could be a key category for a Party and, as such, should be placed relatively high up on your list of priorities when reviewing it. You should refer to the 2006 IPCC Guidelines (vol.3, chap. 8) for the methodologies to estimate emissions from these categories. Some of the main problems you may encounter when reviewing emissions from these categories are discussed in this lesson.

The expected time needed to complete lesson 9 depends on the level of your knowledge of GHG inventories for the IPPU sector under the ETF and the 2006 IPCC Guidelines:

- For readers with experience: 15–30 minutes
- For readers with less experience: 25–50 minutes

1.3. 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 other manufacture and use;
- Identify whether a Party's reporting for other manufacture and use is consistent with the requirements of the MPGs;
- Draft key review recommendations to Parties in relation to emissions from the Other manufacture and use category.

2. Category overview and methodological information

2.1. Electrical equipment

SF_6 is used for electrical insulation and current interruption in equipment used in the transmission and distribution of electricity. Emissions occur at each phase of the equipment life cycle, including manufacture, installation, use, servicing and disposal. Most of the SF_6 used in electrical equipment is used in gas-insulated switchgear and substations and in gas circuit breakers, although some SF_6 is used in high-voltage gas-insulated lines, outdoor gas-insulated instrument transformers and other equipment.

These applications may be divided into two categories:

- Sealed pressure systems (or "sealed for life equipment"), which is defined as equipment that does not require any refilling (topping up) with gas during its lifetime and which generally contains less than 5 kg of gas per functional unit. Electricity distribution equipment normally falls into this category;
- Closed pressure systems, which is equipment that requires refilling, and which typically contains between 5 kg and several hundred kg per unit. Electricity transmission equipment normally belongs to this category.

Both categories of equipment have lifetimes of more than 30–40 years. SF_6 is also emitted during the manufacture of electrical components, when SF_6 is used during the casting/blowing process for the solid insulation of the product.

The 2006 IPCC Guidelines include methods for estimating PFCs and SF_6 emissions from this category.

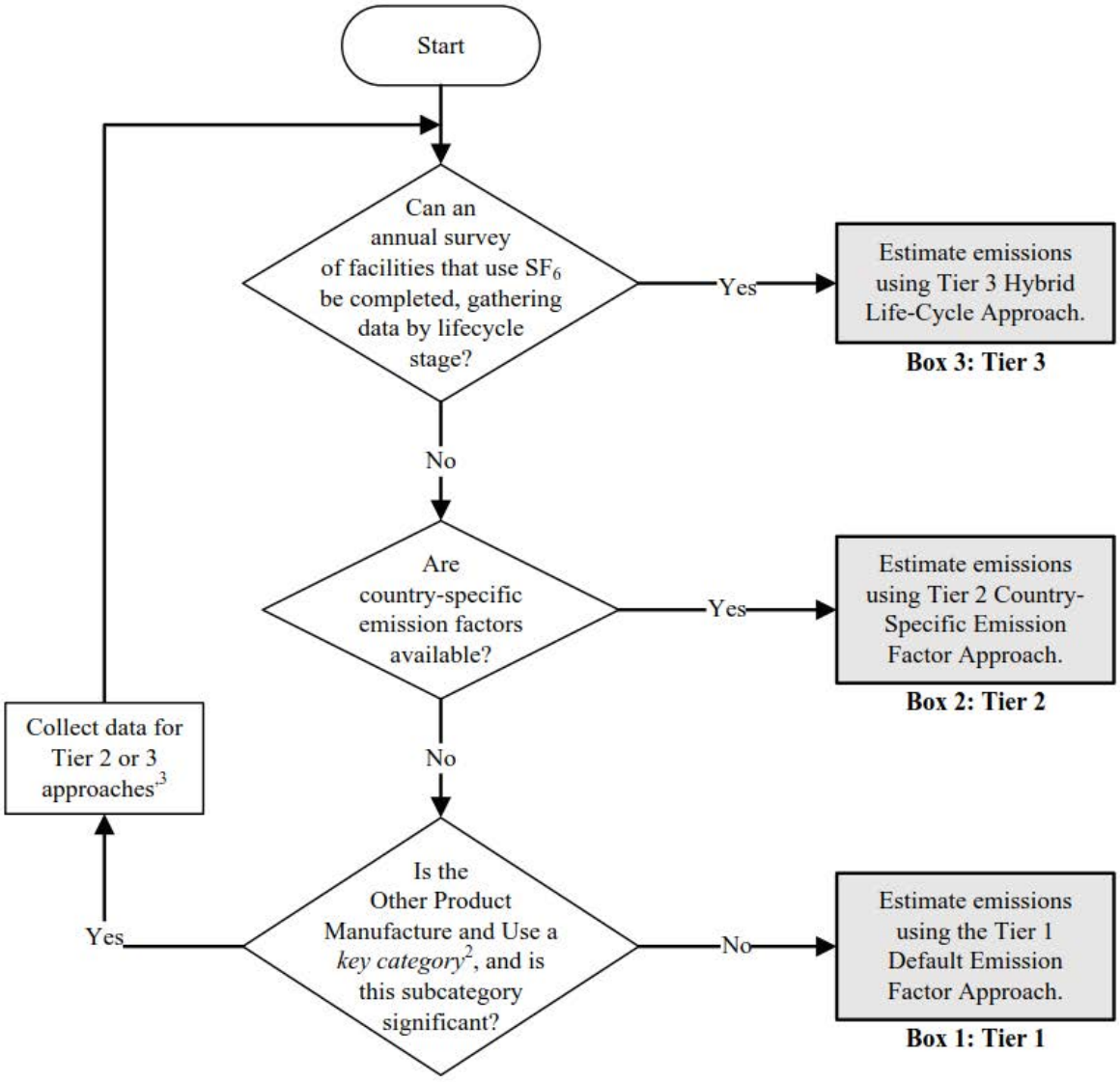
General reference

2006 IPCC Guidelines, volume 3, chapter 8, section 8.2.

Choice of tier

The 2006 IPCC Guidelines provide three methodological tiers for estimating SF_6 and PFC emissions: a tier 1 method (the default EF approach), a tier 2 method (the country-specific EF approach) and a tier 3 method (a hybrid approach that can use either mass-balance or EF approaches for different life cycle stages).

The IPCC decision tree for choosing the estimation method is shown in figure 9-1.



KK. Figure 9-1. 2006 IPCC Guidelines decision tree for estimation of SF_6 and perfluorocarbon emissions from electrical equipment (note: in this figure, "SF_6" indicates "SF_6 and/or perfluorocarbons")

Parties should also identify and report emissions from industrial, military and small utility applications, if these are believed to contribute substantially to total emissions from the electrical equipment category.

Priorities and potential key issues to consider during a review

The primary issue within this category is the completeness of a Party's inventory, which is the requirement that all significant SF_6 and PFC users (manufacturers and utilities) be identified.

The collection of sufficiently detailed, accurate and complete AD is critical, in particular, collecting gas purchase and/or usage data from companies, as there are a large number of point sources in terms of installed switch breakers and other equipment. Data on the amount and usage of gas remaining in cylinders and the equipment at decommissioning may also be important.

Emissions and AD from equipment installation on site should be reported under manufacturing for equipment installed within the country (including if the installer or manufacturer are foreign).

Completeness may be confirmed by different QA/QC procedures, such as a comparison between the emission estimates obtained using different approaches or a comparison of emission rates with those of other countries or between sites.

You can also deal with some confidential data issues, in that SF_6 or PFCs emissions can be reported at an aggregate level and you should evaluate the verification process supporting these data either by the industry itself or by the inventory compilers.

Double counting or omitting emissions is an issue when the EF approach and the mass-balance approach are used for estimating emissions for different stages of the life cycle of the equipment.

When using approaches based on banks and EFs (e.g. tier 2 method), countries require information on the capacity and emission rate of equipment purchased and installed for 30–40 years preceding the years of interest. It is **not** good practice to apply post-2000 overall loss rates to years before 2000.

2.2. SF_6 and PFCs emissions from other product use

This category includes several sources:

- SF_6 and PFCs used in military applications (e.g. airborne radar systems and heat transfer fluids in high-powered electronic applications);
- SF_6 used in universities and for research in particle accelerators;
- PFCs used as heat transfer fluids in commercial and consumer applications, in cosmetics, in medical applications and for other uses;
- Adiabatic applications utilizing the low permeability through rubber of SF_6 and some PFCs (e.g. car tyres and sports shoe soles);
- SF_6 used in sound-proof windows.

The CRT disaggregate these emissions into the following reporting subcategories:

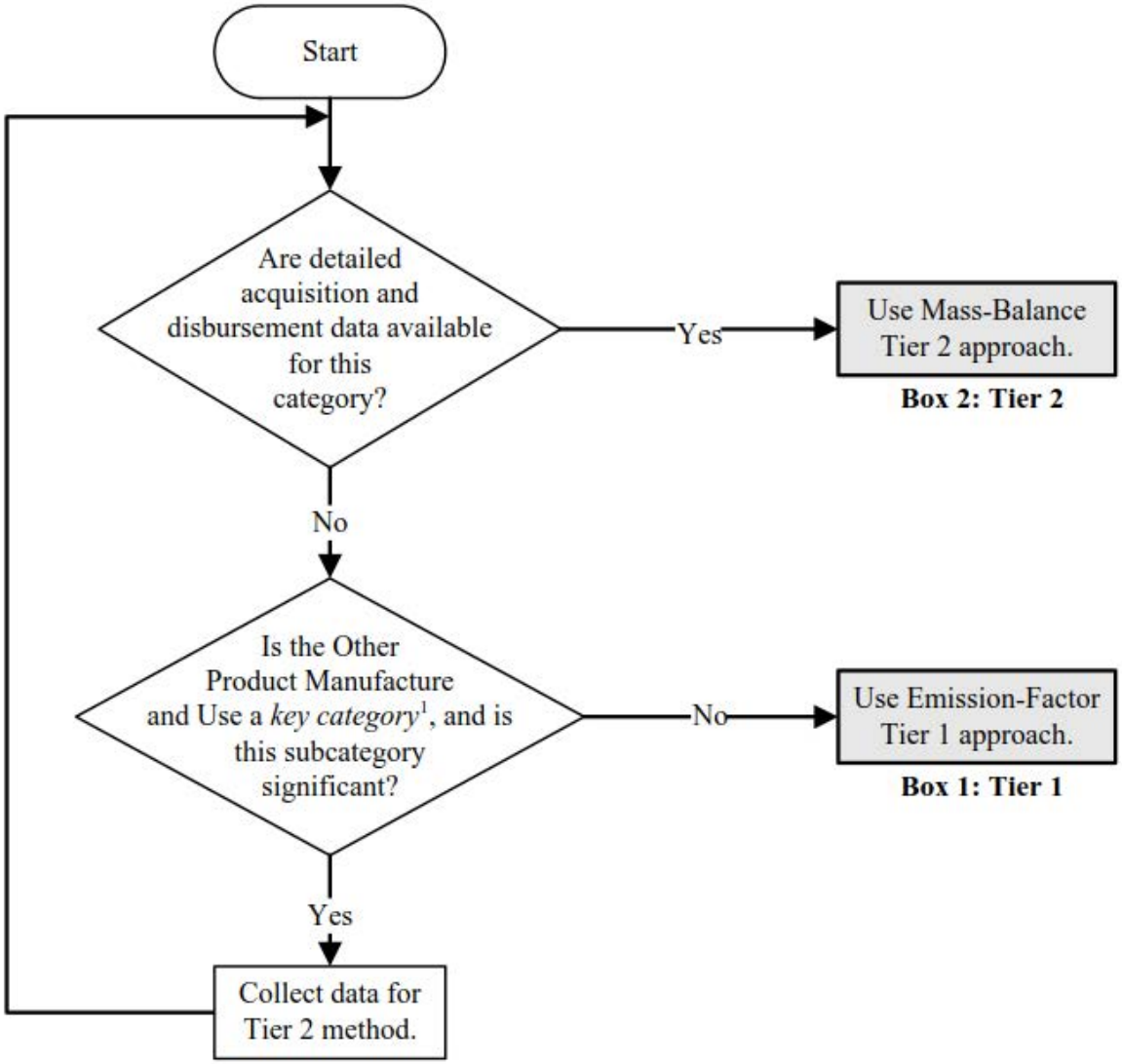
- Military applications;
- Accelerators;
- Sound-proof windows;
- Adiabatic properties (e.g. shoes and tyres);
- Other (e.g. waterproofing electronic circuits).

General reference

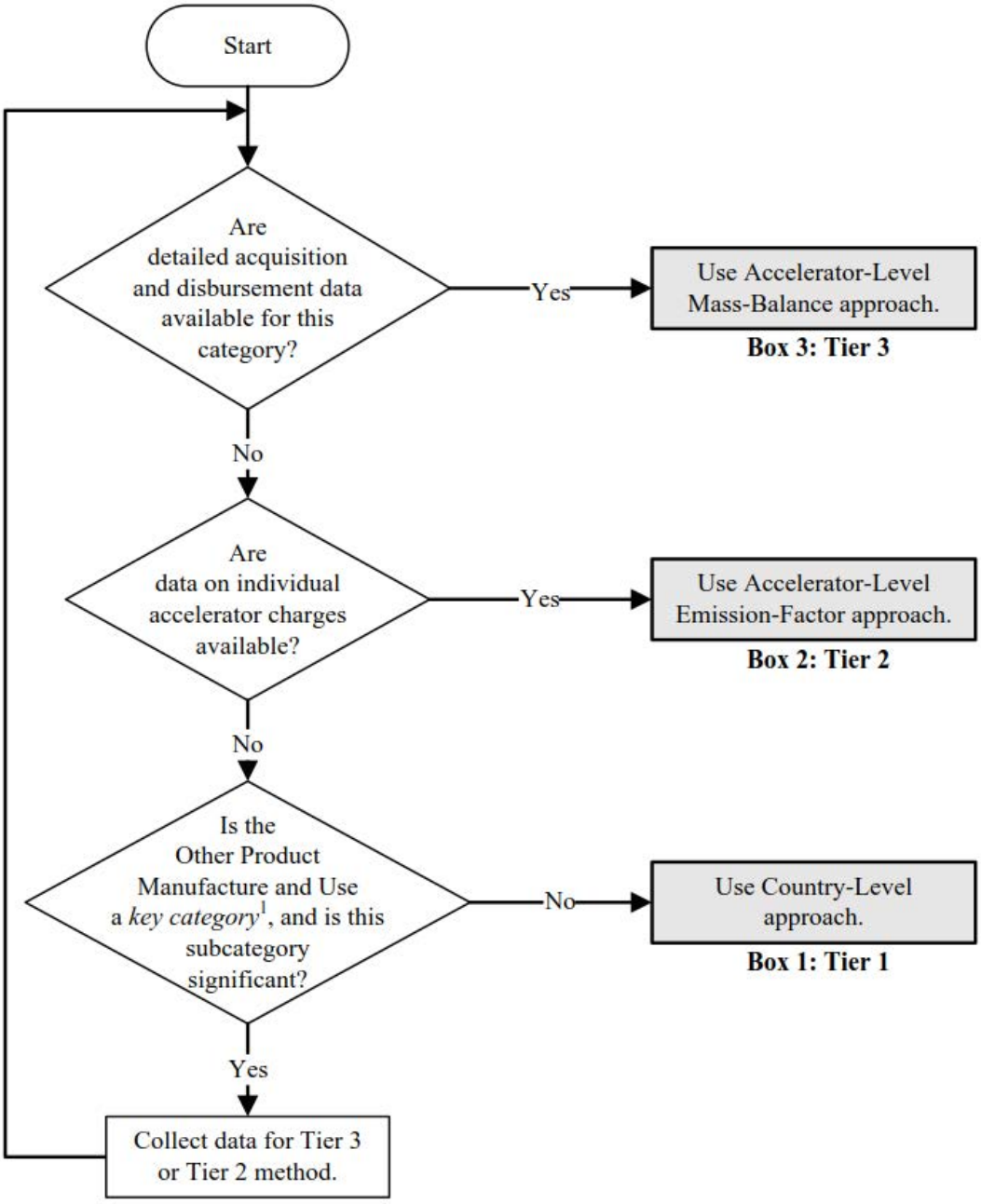
2006 IPCC Guidelines: volume 3 (IPPU), chapter 8, section 8.3.

Choice of tier

The 2006 IPCC Guidelines provide a choice of tiers for estimating emissions from these subcategories. The IPCC decision trees for choosing the estimation methods are shown in figure 9-2 below. For the other applications of SF_6 and PFCs, the 2006 IPCC Guidelines present only one method (see vol.3, chap.8, pages 8.31 and 8.32).



LL. Figure 9-2. 2006 IPCC Guidelines decision tree for estimation of SF_6 emissions from airborne early warning and control systems



MM. Figure 9-3. 2006 IPCC Guidelines decision tree for estimation of SF_6 emissions from research accelerators

Priorities and potential key issues to consider during a review

Methods for estimating emissions from these subcategories are relatively new, and you should understand the type and detail of information available to the Party and which categories are relevant.

The good practice method is to use either (1) consumption data from users of SF_6 or PFCs or (2) top–down import, export and consumption data from national producers and distributors, disaggregated by major type of SF_6 or PFC application. Acquiring this data will probably entail a survey of all producers, distributors or consumers, so completeness can be an issue for these emissions.

When using data per application on import, export and consumption from national SF_6 and PFC producers and distributors, it is important to make sure that (1) all SF_6 and PFC producers and distributors are identified; (2) domestic consumers only purchase SF_6 and PFCs from national suppliers; and (3) imports and exports in products (e.g. sport attributes) are negligible. It is good practice to check regularly for additional distributors to ensure that no gas is imported directly (in bulk) by end users and that products identified as containing SF_6 or PFCs are not imported in sizeable amounts.

A QA/QC check that inventories could implement (and what could also be useful when reviewing an inventory) is comparing the emissions from other SF_6 and PFC end uses included in the national inventory with information submitted by other similar countries. For each source, emissions per capita or per unit of GDP should be compared with the corresponding emission rates of other countries. If national figures appear to be very high or very small, justification should be provided.

SF_6 and PFCs emissions from other product use in the 2019 Refinement to the 2006 IPCC Guidelines

In the 2019 Refinement to the 2006 IPCC Guidelines, some changes occurred to the choice of method for military and other applications, and new guidance was provided for waterproofing of electronic circuits.

2.3. N_2O from product uses

Evaporative emissions of N_2O can arise from various types of product use. The two most likely important sources of emissions are:

- Medical applications (e.g. anaesthetic use, analgesic use and veterinary use);
- Propellants in aerosol products, primarily in the food industry (e.g. pressure-packaged whipped cream).

N_2O is used for anaesthetic (for human and animals), both on its own or together with fluorinated anaesthetics. N_2O is also used as an analgesic where pain relief is required for a short duration (e.g. childbirth or dressing changes for burns patients).

N_2O is also used as a propellant in aerosol products primarily in the food industry. Typical usage is to make whipped cream, where cartridges filled with N_2O are used to blow the cream into foam.

General reference

2006 IPCC Guidelines, volume 3, chapter 8, section 8.4.

Choice of tier

The 2006 IPCC Guidelines present only one method for estimating emissions from this category. N_2O emissions should be estimated from data of quantity of N_2O supplied that are obtained from manufacturers and distributors of N_2O products. There will be a time delay between manufacture,

delivery and use, but as it is probably small the guidelines assume, for the estimation calculation, that the N_2O supplied will be used within one year.

Priorities and potential key issues to consider during a review

Data per application on import, export and consumption from national N_2O manufacturers and distributors will suffice, provided that all N_2O manufacturers and distributors are identified, domestic consumers only purchase N_2O from national suppliers, and imports and exports in products (e.g. sport attributes) are negligible.

In the absence of reliable methods, you can compare the results (emissions per capita or per unit of GDP) with those of countries with similar circumstances.

3. Review approach

3.1. Overview

In the following section you will find some examples of potential findings you may be faced with during a review and recommendations you may describe in the relevant tables of the annual review report.

We will consider two cases: in the first you have to fill in a table where recommendations from the previous cycles of reviews are listed; in the second you will need to look for new findings and compile a table in consideration of your own assessment.

- In the table below, you will find the type of issue and some recommendations from the previous reviews. You are asked to indicate if the issue is resolved/not resolved or addressing considering what the Party has reported in its most recent submission (NID/CRT);
- For the new findings, some indications are given so that you will be able to conclude on some issues and give recommendations to the Party. Here you may also indicate the type of issue you have found.

3.2. Case 1 (verifying the implementation of previous recommendations)

Let's consider an example for the first case.

Status of implementation of issues raised in the previous review report of Party K

ID#	Issue classification	Recommendation made in previous review report	TERT assessment and rationale
IPPU			
I.1	SF_6 and PFCs from other product use – PFCs and SF_6 Completeness	Complete the blank cells for SF6 and PFC emissions for this category in the CRT tables by investigating whether the SF_6 and PFC uses mentioned in the 2006 IPCC Guidelines (vol. 3, section 8.3) occur in the country. If emissions from such uses do not occur, report them as "NO". If such emissions do occur, estimate and report them, or, if they are considered insignificant, report them as "NE", provide in the NID a justification for the	*Note to the reviewer*: To assess this issue, please read the Party's submission below. We will have all the material to make our conclusion on the issue.

ID#	Issue classification	Recommendation made in previous review report	TERT assessment and rationale
		insignificance, in accordance with paragraph 32 of the MPGs, and explain in CRT 9 why these emissions are reported as “NE”.	

Issue I.1: Party's NID, section on methodology

What follows is an extract from a Party's NID:

Sales data were collected from gas distributors from voluntary data surveys which indicate that SF_6 may be used for some applications within the source category SF_6 and PFCs from other product use, but these emissions are not found to exist at a detectable level.

Planned improvement

Improvements are planned for collecting more information.

In addition, the Party reported all SF_6 and PFCs emissions from this category as "NE" in its CRT. The only justification in the NID was in the NID extract shown above, i.e. the Party did not justify the insignificance of the emissions in accordance with paragraph 32 of the MPGs.

Now let's try to evaluate the implementation of previous recommendation based on the information we found.

ID#	Issue classification	Recommendation made in previous review report	TERT assessment and rationale
IPPU			
I.1	SF_6 and PFCs from other product use – PFCs and SF6 Completeness	Complete the blank cells for SF6 and PFC emissions for this category in the CRT tables by investigating whether the SF_6 and PFC uses mentioned in the 2006 IPCC Guidelines (vol. 3, section 8.3) occur in the country. If emissions from such uses do not occur, report them as "NO". If such emissions do occur, estimate and report them, or, if they are considered insignificant, report them as "NE", provide in the NID a justification for the insignificance, in accordance with paragraph 32 of the MPGs, and explain in CRT 9 why these emissions are reported as "NE".	Addressing. The Party reported SF_6 and PFCs emissions of this category as "NE" (i.e. it changed the notation key compared with the previous submission). However, the TERT considers that the recommendation has not yet been fully addressed because there is no scientific information and its reference for insignificant emissions in its NID.

3.3. Case 2 (new findings)

Let's check the reporting of a Party for the category N_2O from product use by reading the following extract and tables from the Party's NID:

Category description

N_2O emissions from the use of N_2O for anaesthesia and explosives are estimated. Specifically:

- *the national association of manufacturers and distributors of N_2O products has supplied data on the use of N_2O for anaesthesia from 1994;*
- *N_2O emissions from explosives are considered on account of the amount of explosive consumption obtained from a specific study.*

However, no information has been obtained from the national association of aerosol producers on the annual production of aerosol cans used for whipped cream which contain N_2O as propellant.

Questions

In evaluating the information provided by the Party, you should consider the following questions, for which we have provided examples of adequate responses.

What did the finding identify?

- N_2O emission estimates from product use. There may be cases where N_2O emissions from aerosol cans used in the food industry (e.g for whipped cream which contain N_2O as propellant) do occur.

Why is it a problem?

- The issue may relate to the completeness of emission estimates.

What is an ideal situation?

- The Party confirms that N_2O emissions from aerosol cans do not occur or estimates and reports the relevant emission estimates.

What is the recommendation of the TERT?

- Improve transparency including in the NID information on the use of N_2O for aerosol cans.
- Estimate these emissions if they occur.

Nature of the finding

The TERT notes that there are no references in the NID explaining that the use of N_2O for aerosol cans does not occur in the country.

We would ask the Party a preliminary question, with a brief description of the finding, for instance:

- The Party reports N_2O emissions from the use of N_2O for anaesthesia and explosives. However, the TERT notes that no references are given in the NID on the use of N_2O for aerosol cans. Can the Party provide information on the use of N2O for aerosol cans in the food industry?

Let's suppose that the Party replies that there is no evidence of this use but a comprehensive survey of all potential source categories of N_2O emissions will be carried out with the industrial association.

Translating the finding into an issue

What did the finding identify?

- N_2O emissions from use in aerosol cans are not reported.

Why is it a problem?

- These emissions may occur.
- This is a possible case of emission estimates that are missing.

What is an ideal situation?

- The Party provides information that either shows that these emissions did not occur or provides emission estimates.

What is the recommendation of the TERT?

- Ensure completeness by providing information on the potential emission estimates.

Nature of the issue

Completeness

Reporting the findings

Now, let's report our finding in the review report.

I.1	The Party reports N_2O emissions from the use of N_2O for anaesthesia and explosives. The TERT notes that no references are given in the NID on the use of N_2O for aerosol cans. During the review the Party explained that there is no evidence of this use but a comprehensive survey of all potential source categories of N_2O emissions will be carried out with the relevant industrial association. The TERT recommends that the Party consider estimating N_2O emissions from aerosol cans if they occur, or provide a reference in the NID that justifies the exclusion of emissions from this category.	Yes. Completeness

4. Practical exercises

4.1. Exercise 1 (2.G. Consumption of halocarbon and SF_6 – HFCs)

A Party states in its NID that HFC emissions from disposal are included in the emissions from use. The Party has reported emissions from disposal as "IE" in the CRT. However, it is not clear how this works in practice (i.e. how the Party can be sure that all F-gases remaining in the products at decommissioning are accounted for as emissions or as completely recovered).

Question 1

How would you consider the issue?

Select one:

A. The reporting of emissions by the Party is not in line with the 2006 IPCC Guidelines, and you would recommend that the Party report all emissions under the appropriate category
B. You would ask the Party how F-gases remaining in the products at decommissioning are accounted for: as emissions or completely recovered
C. Both A and B

Answer

The correct answer is (C).

Responses A and B are both correct. The allocation is not fully in line with the 2006 IPCC Guidelines (emissions at decommission versus recovered emissions) but you may look for further clarification from the Party. One possible way to approach the issue would be the following:

Prepare

The TERT should first assess the Party's submission to check the information provided.

Assess (through communication with the Party)

You should ask the Party how HFCs remaining in the products at decommissioning are accounted for: as emissions or completely recovered.

Question 2

Assuming that the response from the Party is that according to national legislation, when equipment is disposed of it is a legal requirement to recover the remaining HFCs and either reuse or destroy them. What would be then your recommendation to the Party?

Select one:

A. You would ask the Party to change the notation key
B. You would ask the Party to make contact with the treatment centres to verify that the recovery rate can be assumed to be 100 per cent (i.e. that no fugitive losses occur)
C. Both A and B

Answer

The correct answer is (C).

Draft

Since the Party has explained that emissions at disposal do not occur, the TERT would recommend that the Party change the notation key used for HFC emissions from disposal in the CRT to "NO". Furthermore, it is reasonable for the TERT to recommend that the Party verify that the recovery rate can be assumed to be 100 per cent (i.e. that no fugitive losses occur) so no HFC emissions are expected during disposal.

This issue may be considered an issue of transparency.

4.2. Exercise 2 (2.G.1 SF_6 emissions from electrical equipment)

A Party estimates SF_6 emissions from electrical equipment, a non-key category, by using the tier 1 method of the 2006 IPCC Guidelines (vol. 3, chap. 8, equation 8.1):

Total emissions = Manufacturing emissions + Equipment installation emissions + Equipment use emissions + Equipment disposal emissions

From the CRT below, it is evident that the Party reports SF_6 emissions resulting from the disposal of electrical equipment together with the operational emissions (4.83 t SF_6) because the Party reported "IE". This is not fully consistent with the 2006 IPCC Guidelines because these SF_6 emissions should be reported separately in order to assess whether the appropriate AD and EFs are applied.

GREENHOUSE GAS SOURCE AND SINK CATE	Gas *(please specify)*	ACTIVITY DATA *Amount*			IMPLIED EMISSION FACTORS (1)			EMISSIONS (2)			RECOVERY (3,4)
		Filled into new manufactured products	In operating systems (average annual	Remaining in products at decommissioning	Product manufacturing factor	Product life factor	Disposal loss factor	From manufacturing	From stocks	From disposal	
		(t)			%			(t)			
2.C. Other product manufacture and use											
2.G.1. Electrical equipment (11)	SF6	NO	540.82	IE	NO	0.0089	IE	NO	4.83	IE	NA
2.G.2. SF_6 and PFCs from other product use (12)											

In its NID, the Party explained that it reported EFs obtained from facilities, which reflect emissions from the operation of equipment and also emissions from disposal, and are supported by a national study. A separate estimate of emissions from disposal is not available.

Question 1

What would be your conclusion on the issue?

Select one:

A. You would accept the estimates as supported by the operators and a national study, but you would make a recommendation to report the emissions separately
B. You would accept the estimates as supported by the operators and a national study, and you would make an encouragement to report the emissions separately

Answer

The correct answer is A.
As indicated in the question, these SF_6 emissions should be reported separately in order to assess whether the appropriate AD and EFs are applied. For most electrical equipment, the default EF for disposal (0.95) is 35–475 times higher than the default EF for equipment use (0.02–0.026), so if the default EF for the equipment use is applied to the equipment disposal, it would result in an underestimate of emissions from the category. If the Party does not follow the 2006 IPCC Guidelines, you should always make a recommendation in the TERR to follow the 2006 IPCC Guidelines.

4.3. Exercise 3 (2.G.2 SF_6 in double-glazed sound-proof windows)

At the national level, the use of SF_6 in double-glazed sound-proof windows was introduced in 1991 and ceased in 2001. To estimate SF_6 emissions from this category, a Party assumed that the lifetime of double-glazed windows was 20 years. At the end of the lifetime, the Party assumed that all SF_6 contained in double-glazed windows was emitted. The Party reported the following figures in its CRT for 2013:

GREENHOUSE GAS SOURCE	Gas *(please specify)* *One row per substance*	ACTIVITY DATA *Amount*			IMPLIED EMISSION FACTORS			EMISSIONS [2]			Recovery [3] [4]
		Filled into new manufactured products	In operating systems (average annual stocks)	Remaining in products at decommissioning	Product manufacturing factor	Product life factor	Disposal loss factor	From manufacturing	From stocks	From disposal	
		(t)			%			(t)			
2.G. Other product manufacture and use											
2.G.1. Electrical equipment [11]	SF_6										
2.G.2. SF_6 and PFCs from other product use [12]											
2.G.2.a. Military applications											
2.G.2.b. Accelerators											
2.G.2.c. Soundproof windows	SF6	NO	29.39	NO	NA	100	NA	NO	3.65	NO	NO
2.G.2.d. Adiabatic properties: shoes and tyres											
2.G.2.e. Other *(please specify - one row per substance)*											
Drop-down list:											
2.G.2.e.i. Waterproofing electronic circuits											
2.G.2.e.ii. Other *(please specify - one row per substance)*											
2.G.4. Other											

Question

What would be your conclusion?

Select one:

A. Given the Party's assumptions, you would expect AD for SF_6 under decommissioning, so you would ask for additional information before concluding that an underestimation of emissions has occurred
B. Given the Party's assumptions, you would expect SF_6 emissions from disposal, so you would ask for additional information before concluding that an underestimation of emissions has occurred
C. Both A and B

Answer

The correct answer is (C).

Information on the amount of SF_6 remaining in products at decommissioning and the related emissions from disposal are expected to be reported in the relevant cells of the CRT; but with the information provided in the CRT by the Party ("NO") you cannot conclude about underestimation because you would at least need to know if those missing figures are not included in the estimations under stocks.

If AD and emissions are included in the estimations for stocks, you would recommend that the Party change the "NO" to "IE" and add an explanation of where these emissions are reported. Or, even better, you would recommend that the Party report the emissions from stocks and from decommission separately. If AD and emissions are not included in the inventory, you would recommend that the Party estimate and report those emissions.

5. Self-check quiz

Question 1

In estimating emissions from the use of N_2O as a propellant in aerosol food products, it is assumed that all N_2O is emitted to the atmosphere (i.e. EF equal to 1).

Is this sentence true?

Select one:

A. Yes
B. No

Answer 1

The correct answer is (A).

For N_2O used as a propellant in pressurized and aerosol food products, none of the N_2O is reacted during the process and all the N_2O is emitted to the atmosphere resulting in an EF of 1.0 for this source.

6. Key points to remember

- For SF_6 and PFCs used in military applications, in universities and for research in particle accelerators, in adiabatic applications and sound-proof windows, and PFCs used as heat transfer fluids in commercial and consumer applications, in cosmetics, in medical applications you need to consider that methods to estimate emissions are relatively new, and you should understand the type of information and level of detail available to the Party and which categories are relevant.
- For N_2O emissions as propellant, data per application on import, export and consumption from national N_2O manufacturers and distributors will suffice and, in the absence of reliable methods, you can compare the results (emissions per capita or per unit of GDP) with those of countries with similar circumstances.