HANDBOOK FOR REVIEW OF NATIONAL GHG INVENTORIES

CHAPTER IV: INDUSTRIAL PROCESSES SECTOR ISSUES

Introduction

1. Emissions from industrial processes can occur when:

- Chemical reactions result in the production of carbon dioxide (CO_2) or other greenhouse gases, a portion of which are released into the atmosphere either deliberately or via leakages, or
- Greenhouse gases are used in industrial processes, e.g., as a cooling medium, or as a cover to protect the production process from other chemicals such as oxygen from the atmosphere.

2. Industrial process emissions include emissions from:

- Production of mineral products (cement, lime, etc.)
- Production of certain bulk chemicals (ammonia, nitric and adipic acids, etc.)
- Production of ferrous and non-ferrous metals
- Other production processes (pulp and paper, food and drink, etc.)
- Production of halocarbons and SF_6
- Use of halocarbons and SF_6

3. Many industrial processes also require inputs of energy in the form of heat, process steam or electricity that are produced by the combustion of fuels. Emissions caused by these energy inputs should be reported in Sector 1.A: Fuel Combustion Activities, and should not be included in the Industrial Processes emissions reported in Sector 2.

4. In cases where a party is using data provided by industrial facilities directly, care must be taken to:

- Ensure the use of a proper QA/QC system to check data delivered by the industry to the relevant authorities, and the efficient and accurate transfer of this information to the national inventory
- Ensure that smaller enterprises not taking part in a national emissions reporting system are included in the national inventory
- Ensure that double counting is not occurring

Table 2: All Industrial Processes

Source Category	2 All Industrial Processes - Overview		
Definition	Emissions from industrial processes should only include those emissions that do not result from the direct combustion of fuel.		
Potential Key Issues:	Company data on emissions of greenhouse gases may be used by multiple parties, in which case several problems may occur. During an in-country review these issues should be carefully assessed, and the accessibility of the company emission reports and the accompanying auditing report (if relevant) for the review team should be established.		
General References	IPCC Guidelines: Chapter 2 IPCC good practice guidance and Uncertainty Management in National Greenhouse Gas Inventories section 3		
Source Category		**2 All Industrial Processes - Details**	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	All gases	Check whether company provided data have been used. If so:	
		Check whether extrapolation to include all production facilities has been applied and an appropriate method has been used.	Data might have been reported by the largest industries in an industrial sub-sector only. In these cases the party should have applied an extrapolation to include all production facilities in the sub-sector.
		Check whether process emissions have been clearly separated from combustion emissions.	Reporting emission data by industries is in many cases based on environmental reporting legislation. In several countries such legislation only requests total company emissions data, without the underlying activity data. In some cases this could produce a summation of combustion and process emissions that is inaccurate or difficult to understand.
		Identify the system the party might have in place for quality control of emission reports by industries.	A quality assurance / quality control system within the country can greatly enhance the level of confidence in the data, particularly when an independent auditing scheme is put in place within the local legal framework and the auditing reports are readily available.
Emission Factor	All gases	What emission factors are used?	National inventories should document key assumptions and emission factors used.
Activity Data	All gases	Check the units of the activity data.	The units of the activity data should correspond with the units of the emission factor.
Completeness	All gases	Does the source category estimate cover all sources, as well as all gases, for the entire country?	National inventories should cover all sources and sinks, and all GHGs, within the national boundaries of the reporting Party.
Recalculations/ Consistent time series	All gases	Have methods changed within the time series or since the last inventory submissionl?	It is good practice to recalculate historic emissions when methods are changed or refined (see GPG 7.3)
Uncertainty	All	Have uncertainty ranges	It is good practice to report on the sources of

	gases	been identified for emission estimates and are these uncertainties quantified?	uncertainties in national inventories.
Reporting and documentation	All gases	Check documentation of data delivered by individual industries, as well as the documentation of any extrapolation methods applied.	For some industrial processes the party may use company provided data. This approach should be employed when the source is key and the decision tree prescribes the use of company specific information. Any data provided by the companies should be traceable and documented. In cases where emissions also occur at several smaller plants, the country may have applied an extrapolation, either with respect to production statistics or other statistical data. Such a method should be well documented.
QA/QC	All gases	Check whether expert review of data for the different source categories has taken place and is well documented.	It is good practice to conduct quality control checks as outlined in Chapter 8 of the IPCC good practice guidance. Tier 1 General Inventory Level QC Procedures, and an expert review of the emissions estimates. Additional quality control checks as outlined in Chapter 8, Section 8.7, Source Category-specific QC Procedures (Tier 2), and quality assurance procedures may also be applicable, particularly if higher tier methods are used to determine emissions from this source category. Inventory agencies are encouraged to use higher tier QA/QC for key source categories as identified in Chapter 7, Methodological Choice and Recalculation.

Table 2.A.1: Cement Production

Source Category	2.A.1 Cement Production - Overview
Definition	Carbon dioxide is produced during the production of clinker, an intermediate product from which cement is made. High temperatures in cement kilns chemically change calcium carbonate ($CaCO_3$) into lime (CaO) and CO_2. The conversion of the lime into cement clinker (grayish-black pellets about 12 mm in diameter) then results in the release of the CO_2. The energy required for the cement production is often obtained from a separate combustion process; emissions from this process should be reported in the Energy sector.
Potential Key Issues:	When company provided data are used, emissions from combustion in the kiln may be included. These emissions should preferably be reported in Sector 1, Energy. If necessary, the combustion portion of the emissions can be subtracted from the total emissions by using the default emission factor of the Guidelines.
General References	IPCC Guidelines: Chapter 2.3 IPCC good practice guidance and Uncertainty Management in National Greenhouse Gas Inventories section 3.1.1

Source Category		2.A.1 Cement Production - Details	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	CO_2		
Emission Factor	CO_2	CO_2 emissions are directly proportional to the lime content of the clinker. If the emission factor deviates from the default ones, this should be explained as the result of the use of a different default lime content of the clinker (64.6%). Check whether the associated combustion emissions are included in the Energy sector.	Since the emission is due to a chemical process, the emission factor is known with high precision, and deviations of the default value need to be explained. Company reported data sometimes include both process and fuel emissions.
Activity Data	CO_2	If the source is key, clinker production data should be used. If not, using cement production data is allowed.	See decision tree in the IPCC good practice guidance.
Completeness	CO_2	Check whether or not all cement producing facilities are included.	Cement or clinker production data from national statistics may not be complete in countries where a substantial part of production comes from numerous small kilns, particularly vertical shaft kilns, for which data are difficult to obtain.
Recalculations/ Consistent time series	CO_2	Recalculation is most likely required only when improved cement production data have been used.	The emission factor is well known.
Uncertainty	CO_2	Uncertainty in this source category is determined by the uncertainty in the activity data. The lime content of the clinker in some cases may also produce some uncertainty.	The emission factor is known to a precise degree. Even when production of cement is used instead of clinker, the uncertainty in the emission factor is relatively low.
Reporting and documentation	CO_2	Check archiving of company data See Industrial Processes section of NIR	Cement is typically produced in only a small number of large facilities. When production data for individual companies are used, the company reports should be archived properly.
QA/QC	CO_2	See Industrial Processes section of the NIR.	An independent auditing scheme for company provided activity data will greatly enhance the confidence in the data.

Table 2.A.2: Lime Production

Source Category	2.A.3 Lime Production - Overview
Definition	Lime production results in emissions of CO_2 through two processes: when calcium carbonate ($CaCO_3$) is heated to high temperatures to produce calcium oxide (CaO), or quicklime; and when dolomitic quicklime ($CaO \cdot MgO$) is produced through the decomposition of dolomite ($CaCO_3$ $MgCO_3$). Lime is an important raw material with applications in a number of industries, including steel, construction, pulp and paper, and environmental pollution control.
Potential Key Issues:	Accurate estimation of emissions requires comprehensive and accurate information on the individual quantities of each type of lime produced.
General References	IPCC Guidelines 2.4 IPCC good practice guidance and Uncertainty Management in National Greenhouse Gas Inventories section 3.1.2

Table 2.A.3: Limestone and Dolomite Use

Source Category	2.A.3 Limestone and Dolomite Use - Overview		
Definition	Industrial applications involving the heating of limestone or dolomite at high temperatures generate CO_2. Limestone ($CaCO_3$) and dolomite ($CaCO_3.MgCO_3$) are basic raw materials having commercial applications in a number of industries, including metallurgy (e.g., iron and steel), glass manufacture, agriculture, construction and environmental pollution control.		
Potential Key Issues:	Good quality activity data of use of these materials in industries is needed.		
General References	IPCC Guidelines: Chapter 2.5		
Source Category		**2.A.3 Limestone and Dolomite Use - Details**	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	CO_2		
Emission Factor	CO_2	Check whether the party used specific purity factors for limestone and dolomite Check whether materials (and the corresponding stoichiometric ratio) are specified and diverge from IPCC defaults.	Emission factors are calculated from stochiometry, using the fractional purity of the material. If no data on fractional purity are available, its value should be set to 1. The emission factor can be based on the stoichiometry of the chemical reaction assuming pure limestone/dolomite. This, however, will result in a high emission estimate.
Activity Data	CO_2	Check whether data on the use of different limestone/dolomite types is collected and used. Check whether some of limestone reported is actually dolomite, which has a higher carbon content.	Different limestone/dolomite types lead to different stochiometric ratios, and hence to different emission factors. Complete activity data include both limestone/dolomite production data and data on limestone/dolomite structure (including types and proportion of hydrated limestone/dolomite).
Completeness	CO_2	Consumption of limestone or dolomite is assumed to equal material mined (or dredged) plus material imported minus material exported.	Limestone or dolomite used for producing cement, lime and magnesium, agricultural activities and processes where CO_2 is not generated should be excluded from this calculation. CO_2 from liming of agricultural soils should be reported in Land-Use Change and Forestry.
Recalculations/ Consistent time series	CO_2	Recalculations can be performed if more complete activity data have been collected.	Since the emission factor is relatively certain, recalculation will typically be performed when better activity data have become available.
Uncertainty	CO_2	Check whether the reported uncertainty is based on the uncertainty of the limestone/ dolomite composition.	The stoichiometric ratio is an exact number, and the uncertainty of the emission factor is therefore the uncertainty of limestone/dolomite composition.
Reporting and documentation	CO_2	Is the methodology used well documented and have assumptions been clearly identified?	Inventory documentation should ensure transparency and facilitate understanding, replication of results, and assessment of the inventory.
QA/QC	CO_2	Was a QA/QC plan prepared for this category, and is there evidence that QA/QC prodedures were implemented?	It is good practice to implement QA/QC procedures, taking into account the needs of particular source categories and national circumstances.

Table 2.A.4: Soda Ash Production and Use

Source Category	2.A.4 Soda Ash Production and Use - Overview
Definition	Soda ash (Na_2CO_3) is an alkali used as a raw material in industrial processes, in consumer products such as glass, chemicals, soaps, and detergents, and in flue gas desulphurization. It may be produced through natural processes (monohydrate, sesquicarbonate and direct carbonation), or synthetically through the Solvay process, which accounts for about 75% of world production. In this process, soda ash is produced in a series of reactions involving sodium chloride brine, limestone, coke and ammonia as raw materials. CO_2 is emitted to the atmosphere during the production of both natural and synthetic soda ash. Consumption of soda ash may also result in significant emissions of CO_2.
Potential Key Issues:	This is typically a minor source, and specific IPCC good practice guidance is not available.
General References	IPCC Guidelines: Chapter 2.6

Source Category		2.A.4 Soda Ash Production and Use - Details	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	CO_2	Check possible double counting.	CO_2 emissions associated with the use of coke in soda ash production should be accounted for separately, and those emissions associated with the non-energy use of coke subtracted from the totals in the combustion section.
Emission Factor	CO_2	Check production process employed and associated emission factors.	Emissions from Soda Ash production vary significantly with the manufacturing process. There are four different processes used to produce soda ash commercially. The emission factor for the natural methods is 0.097 tons CO_2/ton trona. The synthetic approach has essentially zero emissions associated with production.
		Check total consumption of soda ash.	Carbon dioxide emissions are associated with the use of soda ash. For each use category, it is assumed that one mole of CO_2 is emitted for each mole of soda ash consumed (U.S. EPA, 1994b).

Activity Data	CO_2	Check the proportion of natural vs. synthetic soda ash, and the type of synthetic processing employed.	The 1996 Revised IPCC Guidelines state that one of the four processing methods – the Solvay process – is classified as a synthetic approach and does not result in CO_2 emissions during production. However, the 2006 IPCC Guidelines explain that the CO_2 coming from limestone is process neutral but that, in practice, some CO_2 is emitted to the atmosphere during production by the Solvay process because more CO_2 is produced than is stoichiometrically required. The excess CO_2 arises from calcining the limestone with metallurgical grade coke. The limestone is combined with the coke at approximately 7 per cent of limestone by weight. Since the generation of CO_2 from limestone calcination is stoichoimetrically neutral within the process, all excess CO_2, and consequent CO_2 emissions, can be assumed to result from coke combustion. Although the coke combustion produces additional CO_2 for the chemical reactions, the coke is primarily used as an energy source. Consequently, emissions should be reported under the Energy Sector.
Completeness	CO_2	Check whether all emissions from production and consumption have been included.	Both production and consumption of soda ash result in emissions.
Recalculations/ Consistent time series	CO_2	Check whether there is a shift in production processes.	Emissions of CO_2 from the production of soda ash vary substantially with the specific manufacturing process employed.
Uncertainty	CO_2	Uncertainty is determined primarily by consumption, since it is dependent upon the type of processing used.	The emissions factors for soda ash production are relatively certain. More uncertainty may be associated with those used to estimate emissions from consumption.
Reporting and documentation	CO_2	Confidentiality issues may arise in countries where there are a limited number of manufacturers.	In such cases, production may be estimated from more aggregate data, or from consumption statistics.
QA/QC	CO_2	Was a QA/QC plan prepared for this category, and is there evidence that QA/QC prodedures were implemented?	It is good practice to implement QA/QC procedures, taking into account the needs of particular source categories and national circumstances.

Table 2.A.5: Asphalt Roofing

Source Category	2.A.5 Asphalt Roofing - Overview
Definition	Asphalt blowing is the process of polymerizing and stabilizing asphalt to improve its weathering characteristics. Air blown asphalts are used in the production of asphalt roofing products. The blowing may take place in a refinery, an asphalt processing plant or an asphalt roofing plant. This activity leads to emissions of greenhouse gas precursors.
Potential Key Issues:	This is typically a minor source, and specific good practice guidance is not available.
General References	IPCC Guidelines: Chapter 2.7

Source Category		2.A.5 Asphalt Roofing - Details	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	NMVOC	Check whether data on asphalt blowing have been used.	If these data are not available, it may be assumed that all of the asphalt for non-paving uses will be blown.
Emission Factor	NMVOC	Emission factors are given in the Guidelines as a reference to CORINAIR.	Air Pollution Engineering Manual (1992), Hot Mixing Asphalt Mixing Facilities: There is not much emphasis on documenting and quantifying gaseous emissions. Little data exist in the public domain relative to these emissions.
Activity Data	NMVOC	Check the units of the activity data.	To use the emission factors, activity data should be expressed as tonnes product used.
Completeness	NMVOC	Does the source category estimate cover all sources for the entire country?	National inventories should cover all sources and sinks, and all GHGs, within the national boundaries of the reporting Party.
Recalculations/ Consistent time series	NMVOC	Have methods changed within the time series or since the last inventory submittal?	It is good practice to recalculate historic emissions when methods are changed or refined (see GPG 7.3)
Uncertainty	NMVOC	Have uncertainty ranges been identified for emission estimates and are these uncertainties quantified?	It is good practice to report on the sources of uncertainties in national inventories.
Reporting and documentation	NMVOC	Is the methodology used well documented and have assumptions been clearly identified?	Inventory documentation should ensure transparency and facilitate understanding, replication of results, and assessment of the inventory.
QA/QC	NMVOC	Was a QA/QC plan prepared for this category, and is there evidence that QA/QC prodedures were implemented?	It is good practice to implement QA/QC procedures, taking into account the needs of particular source categories and national circumstances.

Table 2.A.6: Road Paving with Asphalt

Source Category	2.A.6 Road Paving with Asphalt - Overview		
Definition	Asphalt road surfaces are composed of compacted aggregate and asphalt binder. Greenhouse gas precursors are emitted from the asphalt plant, road surfacing operations and the subsequent road surface itself.		
Potential Key Issues:	This is typically a minor source, and specific good practice guidance is not available.		
General References	IPCC Guidelines: Chapter 2.7		
Source Category		**2.A.6 Road Paving with Asphalt - Details**	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	NMVOC	Check whether the estimate is based on asphalt used or road surface paved.	A conversion factor of 100 kg asphalt/m2 road surface may be used.
Emission Factor	NMVOC	The amount of diluent used is usually lower in warm countries than in the colder.	Lower emission factors may be expected in tropical countries.
Activity Data	NMVOC	Check activity data	A conversion factor of 100 kg asphalt/m2 road surface may be used.
Completeness	NMVOC	Does the source category estimate cover all sources for the entire country?	National inventories should cover all sources and sinks, and all GHGs, within the national boundaries of the reporting Party.
Recalculations/ Consistent time series	NMVOC	Have methods changed within the time series or since the last inventory submittal?	It is good practice to recalculate historic emissions when methods are changed or refined (see GPG 7.3).
Uncertainty	NMVOC	Have uncertainty ranges been identified for emission estimates and are these uncertainties quantified?	It is good practice to report on the sources of uncertainties in national inventories.
Reporting and documentation	NMVOC	Is the methodology used well documented and have assumptions been clearly identified?	Inventory documentation should ensure transparency and facilitate understanding, replication of results, and assessment of the inventory.
QA/QC	NMVOC	Was a QA/QC plan prepared for this category, and is there evidence that QA/QC prodedures were implemented?	It is good practice to implement QA/QC procedures, taking into account the needs of particular source categories and national circumstances.

Table 2.A.7: Other Mineral Products

Source Category	2.A.7 Other Mineral Products - Overview		
Definition	This section includes the production processes for concrete pumice stone and glass.		
Potential Key Issues:	These mineral production processes may emit pollutants. While probably not significant on a global scale, they may be significant nationally or locally. There is generally little information about emissions from these processes. This is typically a minor source, and specific good practice guidance is not available.		
General References	IPCC Guidelines: Chapter 2.7		
Source Category		**2.A.7 Other Mineral Products - Details**	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	NMVOC Ozone precursors		There is generally little information available about emissions from these processes. Since they will in most cases be minimal, however, the review need not be detailed.
Emission Factor	NMVOC Ozone precursors	For glass production: Emissions depend on type of glass being manufactured and the process employed.	For flat glass: the only contributor to emissions is gas combustion in the annealing oven.
Activity Data	NMVOC Ozone precursors	Check the units of the activity data.	The units of the activity data should correspond with the units of the emission factor.
Completeness	NMVOC Ozone precursors	Does the source category estimate cover all sources for the entire country?	National inventories should cover all sources and sinks, and all GHGs, within the national boundaries of the reporting Party.
Recalculations/ Consistent time series	NMVOC Ozone precursors	Have methods changed within the time series or since the last inventory submittal?	It is good practice to recalculate historic emissions when methods are changed or refined (see GPG 7.3)
Uncertainty	NMVOC Ozone precursors	Have uncertainty ranges been identified for emission estimates and are these uncertainties quantified?	It is good practice to report on the sources of uncertainties in national inventories.
Reporting and documentation	NMVOC Ozone precursors	Is the methodology used well documented and have assumptions been clearly identified?	Inventory documentation should ensure transparency and facilitate understanding, replication of results, and assessment of the inventory.
QA/QC	NMVOC Ozone precursors	Was a QA/QC plan prepared for this category, and is there evidence that QA/QC prodedures were implemented?	It is good practice to implement QA/QC procedures, taking into account the needs of particular source categories and national circumstances.

Table 2.B.1: Ammonia Production

Source Category	2.B.1 Ammonia Production - Overview
Definition	CO_2 emissions occur during the production of ammonia, a chemical used as a feedstock for the production of several chemicals. In most instances, anhydrous ammonia is produced by catalytic steam reforming of natural gas (mostly CH_4) or other fossil fuels. CO_2 at plants using this process is released primarily during regeneration of the CO_2 scrubbing solution, with additional but relatively minor emissions resulting from condensate stripping.
Potential Key Issues:	This is typically a minor source, and specific IPCC good practice guidance is not available.
General References	IPCC Guidelines: Chapter 2.8

Source Category		2.B.1 Ammonia Production - Details	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	CO_2	The most accurate method of estimation will be based on the consumption of natural gas.	Emissions of CO_2 will depend on the amount and composition of natural gas or oil used in the process. It is assumed that all carbon eventually is emitted to the atmosphere. The CO_2 from production may be used for producing urea or dry ice. Since this carbon will be stored only for a short time, no adjustment should be made for intermediate binding of CO_2 in downstream manufacturing processes and products. Avoid double counting of carbon during feedstock treatment of natural gas in ammonia production.
Emission Factor	CO_2	Check the whether emission factor is based on natural gas consumed or ammonia produced.	When gas consumption is not available, an alternative method is to calculate the emissions from the ammonia produced. The recommended emission factor is 1.5 tonnes CO_2 per tonne NH_3 produced, which excludes natural gas used as a fuel.
Activity Data	CO_2	Check the units of the activity data.	The units of the activity data should correspond with the units of the emission factor.
Completeness	CO_2	Does the source category estimate cover all sources for the entire country?	National inventories should cover all sources and sinks, and all GHGs, within the national boundaries of the reporting Party.
Recalculations/ Consistent time series	CO_2	Recalculation is usually needed only when improved production data have been used.	Emissions of CO_2 will depend on the amount and composition of gas (or oil) used in the process.
Uncertainty	CO_2	The uncertainty is determined by the natural gas consumption data, or by the emission factor.	Data on natural gas consumption may be difficult to acquire. The emission factor represents an average across all plants, which may not accurately represent the true emissions in some cases.

Reporting and documentation	CO_2	Is the methodology used well documented and have assumptions been clearly identified? Are there issues of confidentiality associated with the data?	Natural gas consumption data may be considered confidential business information, and public reporting may be subject to confidentiality considerations.
QA/QC	CO_2	Was a QA/QC plan prepared for this category, and is there evidence that QA/QC prodedures were implemented?	It is good practice to implement QA/QC procedures, taking into account the needs of particular source categories and national circumstances.

Table 2.B.2: Nitric Acid Production

Source Category	2.B.2 Nitric Acid Production - Overview
Definition	The production of nitric acid generates nitrous oxide (N_2O) as a by-product of the high temperature catalytic oxidation of ammonia (NH_3). Nitric acid is used primarily as a raw material in the manufacture of nitrogen-based fertilizer. Nitric acid may also be used in the production of adipic acid and explosives (e.g., dynamite), for metal etching and in the processing of ferrous metals.
Potential Key Issues:	Nitric oxide (NO), an intermediate in the production of nitric acid, is also documented to readily decompose to N_2O and nitrogen dioxide (NO_2) at high pressures for a temperature range of 30 to 50°C.
General References	IPCC Guidelines: Chapter 2.9 IPCC good practice guidance and Uncertainty Management in National Greenhouse Gas Inventories section 3.2

Source Category		2.B.2 Nitric Acid Production - Details	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	N_2O	Check whether plant specific data have been used when the source category is key.	The decision tree in the IPCC good practice guidance asks for industry supplied emission estimates with appropriate QA/QC, audits and review.
Emission Factor	N_2O	Check origin of emission factors. Check for presence of emission control devices. The nitric acid industry uses many different types of systems to control N_2O and NO_X emissions. Emission estimates should reflect efficiencies of abatement systems. In cases where nitric acid plants control for nitrogen oxide (NO_X) emissions, check whether emission factors have been adjusted for plants using non-selective catalytic reduction (NSCR).	When plant-specific emission factors are not available, it is good practice to use default factors. These default values often represent midpoint or mean values of data sets (as determined by expert analysis). NSCR may eliminate up to 90 percent of N_2O produced, significantly reducing the emission factor. The use of other methods (i.e. selective catalytic reduction [SCR] or extended absorption) to reduce NO_X emissions does not eliminate N_2O.
Activity Data	N_2O	Check origin of activity data.	If plant-level data are not available, nationally compiled production data may be used. If neither plant-level nor

			national-level activity data are available, information on production capacity can be used.
Completeness	N_2O	Compare production statistics with international data.	Studies that compare global statistics compiled from national data on nitric acid production with industry estimates of global production suggest that the national statistics account for only 50 to 70% of the total. This is probably due to nitric acid production that is integrated as part of larger production processes.
Recalculations/ Consistent time series	N_2O	Recalculation is required if the inventory agency changes from the use of default values to actual values determined at the plant level.	N_2O emissions should be recalculated for all years whenever emission calculation methods are changed substantially. Such a recalculation is required to ensure that any change in emission trends is real and not the result of changes in procedure.
Uncertainty	N_2O	The uncertainty of default values determined for N_2O generation is much greater than 1%.	This is due to the production process. First, N_2O may be generated in the gauze reactor section of nitric acid production as an unintended by-product reaction. Second, the exhaust gas may or may not be treated to control for NO_X emissions, and the NO_X abatement system may or may not reduce (or may even increase) the N_2O emissions. Emission factors at each plant may also vary significantly due the production technology employed.
Reporting and documentation	N_2O	Where there are only one or two producers in a country, activity data may be considered confidential.	In this case, operators and the inventory agency should determine the level of aggregation at which information can be reported while still protecting confidentiality. Detailed information (including instrumentation records) should still be archived at the plant level.
QA/QC		Compare plant-specific factors to the IPCC defaults.	Agencies should explain and document any differences between plant-specific factors and default factors, particularly any differences in plant characteristics that might lead to these differences.

Table 2.B.3: Adipic Acid Production

Source Category	2.B.3 Adipic Acid Production - Overview
Definition	Adipic acid is a dicarboxylic acid manufactured from a cyclohexanone/cyclohexanol mixture oxidized by nitric acid. N_2O is generated as a by-product of this process. Adipic acid is used in the manufacture of products including synthetic fibres, coatings, plastics, urethane foams, elastomers and synthetic lubricants. The production of Nylon 6.6 accounts for the bulk of adipic acid use.
Potential Key Issues:	
General References	IPCC Guidelines: Chapter 2.10 IPCC good practice guidance and Uncertainty Management in National Greenhouse Gas Inventories section 3.2

Source Category		2.B.3 Adipic Acid Production - Details	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	N_2O	Check whether plant-specific data have been used when the source category is key.	The decision tree in the IPCC good practice guidance asks for industry supplied emission estimates with appropriate QA/QC, audits and review.
Emission Factor	N_2O	Check origin of emission factors.	When plant-specific emission factors are not available, it is good practice to use default factors. These default values often represent midpoint or mean values of data sets (as determined by expert analysis).
Activity Data	N_2O	Check origin of activity data.	Nationally compiled production data may be used when plant-specific data are not available. If neither are available, information on production capacity may be used.
Completeness	N_2O	Does the source category estimate cover all sources for the entire country?	National inventories should cover all sources and sinks, and all GHGs, within the national boundaries of the reporting Party.
Recalculations/ Consistent time series	N_2O	Recalculation is required if the inventory agency changes from the use of default values to actual values determined at the plant level.	N_2O emissions should be recalculated for all years whenever emission calculation methods are changed substantially. Such a recalculation is required to ensure that any change in emission trends is real and not the result of changes in procedure.
Uncertainty	N_2O	Adipic acid default emission factors are derived from the stoichiometry of an intended chemical reaction (nitric acid oxidation) and N_2O-specific abatement systems. N_2O conversion catalysts have been installed in many North American adipic acid plants.	The uncertainty in the emission factor for adipic acid represents a variability in N_2O generation due to differences in the composition of the cyclohexanone and cyclohexanol feedstock (i.e. ketone and alcohol) that are used by different manufacturers. Higher ketone content results in increased N_2O generation, whereas higher alcohol content results in less. An individual plant should be able to determine the production of N_2O (based on HNO_3 consumption) within 1%.
Reporting and documentation	N_2O	Where there are only one or two adipic acid producers in a country, as is often the case, activity data may be considered confidential.	In this case, operators and the inventory agency should determine the level of aggregation at which information can be reported while still protecting confidentiality. Detailed information (including instrumentation records) should still be archived at the plant.
QA/QC	N_2O	Compare plant-based factors to the IPCC defaults.	Agencies should explain and document any differences between plant-specific factors and default factors, particularly any differences in plant characteristics that might account for differences.

Table 2.B.4: Carbide Production

Source Category	2.B.4 Carbide Production - Overview		
Definition	Carbides (e.g., silicon carbide, calcium carbide) are produced in chemical reactions, with CO_2 and CH_4 emitted as reaction by-products. Silicon carbide (SiC) is made by reacting quartz (SiO_2) with petroleum coke. Calcium carbide is made by heating calcium carbonate and subsequently reducing CaO with carbon (e.g., petroleum coke); both steps lead to emissions of CO_2.		
Potential Key Issues:	This is typically a minor source, and specific IPCC good practice guidance is not available.		
General References	IPCC Guidelines: Chapter 2.11 No reference in the IPCC good practice guidance.		
Source Category		**2.B.4 Carbide Production - Details**	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	CO_2 CH_4	Emissions may be calculated from the use of raw materials (limestone and coke).	If the quantity of coke consumed is not known, CO_2 and CH_4 emissions can be estimated from carbide production data.
Emission Factor	CO_2 CH_4	Check emission factor.	Limestone contains about 98 per cent $CaCO_3$. 1,750 kg limestone (or 950 kg CaO) and 640 kg reducing agent (including 20 kg carbon electrodes) are required to produce 1 tonne of carbide. For CH_4, an emission factor of 11.6 kg CH_4 / metric ton SiC produced may be used (derived from experience at Norwegian SiC plants).
Activity Data	CO_2 CH_4	Check the units of the activity data.	The units of the activity data should correspond with the units of the emission factor.
Completeness	CO_2 CH_4	Does the source category estimate cover all sources, as well as all gases, for the entire country?	National inventories should cover all sources and sinks, and all GHGs, within the national boundaries of the reporting Party.
Recalculations/ Consistent time series	CO_2 CH_4	Have methods changed within the time series or since the last inventory submittal?	It is good practice to recalculate historic emissions when methods are changed or refined (see GPG 7.3)
Uncertainty	CO_2 CH_4	Have uncertainty ranges been identified for emission estimates and are these uncertainties quantified?	It is good practice to report on the sources of uncertainties in national inventories.
Reporting and documentation	CO_2 CH_4	Is the methodology used well documented and have assumptions been clearly identified?	Inventory documentation should ensure transparency and facilitate understanding, replication of results, and assessment of the inventory.
QA/QC	CO_2 CH_4	Was a QA/QC plan prepared for this category, and is there evidence that QA/QC prodedures were implemented?	It is good practice to implement QA/QC procedures, taking into account the needs of particular source categories and national circumstances.

Table 2.B.5: Other Chemical Industry

Source Category	2.B.5 Other Chemical Industry - Overview
Definition	Production of chemicals other than nitric acid and adipic acid may be sources of nitrous oxide, but more studies are needed to determine whether they represent a significant source of N_2O. Production of caprolactam, acrylonitrile, and catalytic cracking of oil may be significant sources. Although most individual sources of methane are small, collectively they may be significant. Chemical manufacturing processes (e.g., those involved in the production of carbon black, ethylene, dichloroethylene, styrene and methanol) are potential sources of methane. However, sources in addition to those mentioned here may also be of importance.
Potential Key Issues:	This is typically a minor source, and specific IPCC good practice guidance is not available.
General References	IPCC Guidelines: Chapter 2.12

Table 2.C.1: Iron and Steel Production

Source Category	2.C.1 Iron and Steel Production - Overview
Definition	Iron is produced through the reduction of iron oxide ore using metallurgical coke as the reducing agent in a blast furnace. Steel is subsequently made from iron and scrap. In iron and steel plants emissions of carbon dioxide occur primarily as a result of coke oxidation, with some emissions also resulting from steel production.
Potential Key Issues:	In most iron furnaces, the process is aided by the use of carbonate fluxes (limestone). Carbon plays the dual role of fuel and reducing agent. It is important not to count the carbon from the consumption of coke or other reducing agents if it has already been accounted for in the Energy Sector as fuel consumption.
General References	IPCC Guidelines: Chapter 2.13.3 IPCC good practice guidance and Uncertainty Management in National Greenhouse Gas Inventories section 3.1.3

Source Category		2.C.1 Iron and Steel Production - Details	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	CO_2		
Emission Factor	CO_2	Check plant-specific emission factors against default values for steel produced in an electric arc furnace (EAF).	For the Tier 2 method, a default emission factor of 5 kg CO_2 per tonne of steel produced in an EAF should be used for the electrode consumption (emission factor EAF).
Activity Data	CO_2	If the source is key, activity data should be collected at plant-level.	When biomass carbon is used (wood chips, charcoal) the emissions should be reported in the Land Use, Land-Use Change and Forestry sector.
Completeness	CO_2	Additional emissions occur as the limestone or dolomite flux releases CO_2 during reduction of pig iron in the blast furnace. However, this source category should be covered as emissions from limestone use.	In estimating emissions from this source category, there is a risk of double counting or omission in either the Industrial Processes or the Energy Sector. Since the primary use of coke oxidation is to produce pig iron, the emissions are considered to be industrial processes, and it should be reported as such. If this is not the case it should be explicitly mentioned in the inventory. Inventory agencies should perform a double counting/completeness check. This will require good knowledge of the inventory

			in that source category.
Recalculations/ Consistent time series	CO_2	Emissions should be calculated using the same method for every year in the time series.	Where data are unavailable to support a more rigorous method for all years in the time series, these gaps should be recalculated according to the guidance provided in Chapter 7, Methodological Choice and Recalculation.
Uncertainty	CO_2	Check the uncertainty estimate.	The uncertainty in the emission factors for the reducing agent (e.g., coke) is generally within 5% (tier 2).
Reporting and documentation	CO_2	Check if there is an explanation of the linkage with the Fuel Combustion Sub-sector estimate (Tier 2 Method)	This demonstrates that double counting or omission of emissions have not occurred.
QA/QC	CO_2	Check for any inconsistency between data from different plants.	This is particularly relevant to the plant-specific estimates of the mass of the reducing agent. Inconsistency may reflect errors or different measurement techniques, or may result from real differences in emissions, operational conditions or technology.

Table 2.C.2: Ferroalloys Production

Source Category	2.C.2 Ferroalloys Production - Overview		
Definition	In ferroalloy production, raw ore, coke and slagging materials are smelted together at high temperature. Emissions in covered arc furnaces consist almost entirely of CO, due to the strong reducing environment. All CO is assumed to be converted to CO_2 within days afterwards.		
Potential Key Issues:			
General References	IPCC Guidelines: Chapter 2.13.4		
Source Category		2.C.2 Ferroalloys Production - Details	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	CO_2	Use Tier 1a if quantity of reducing agent is known. Use Tier 1b if quantity of reducing agent is unknown.	Tier 1a: The most accurate methodology is to calculate the emissions from the amount of reducing agent used. Tier 1b: The suggested emission factors assume (if not otherwise specified) that all carbon is fossil.
Emission Factor	CO_2	Emission factors are specific to the materials used.	The emissions may be calculated from the production volume.
Activity Data	CO_2	Check whether biomass has been used in production.	Ferroalloy production may also be based on biomass carbon (wood and wood waste). Such emissions should be reported in the Land Use, Land-Use Change and Forestry sector.

Completeness	CO_2	Does the source category estimate cover all sources for the entire country?	National inventories should cover all sources and sinks, and all GHGs, within the national boundaries of the reporting Party.
Recalculations/ Consistent time series	CO_2	Have methods changed within the time series or since the last inventory submittal?	It is good practice to recalculate historic emissions when methods are changed or refined (see GPG 7.3)
Uncertainty	CO_2	Uncertainity is determined by the emission factors.	Graphite may be used in place of coke, which may generate different amounts of CO_2 per unit of material produced.
Reporting and documentation	CO_2	Is the methodology used well documented and have assumptions been clearly identified?	Inventory documentation should ensure transparency and facilitate understanding, replication of results, and assessment of the inventory.
QA/QC	CO_2	Was a QA/QC plan prepared for this category, and is there evidence that QA/QC prodedures were implemented?	It is good practice to implement QA/QC procedures, taking into account the needs of particular source categories and national circumstances.

Table 2.C.3: Aluminum Production

Source Category	2.C.3 Aluminum Production - Overview		
Definition	Primary aluminum is produced in two steps. First, bauxite ore is ground, purified and calcined to produce alumina. Following this, the alumina is electrically reduced to aluminum in large pots. (Molten) aluminium is formed while the anode is consumed in the reaction. This process results in emissions of CO_2. During primary aluminium smelting, alumina (Al_2O_3) is dissolved in a fluoride melt consisting primarily of cryolite (Na_3AlF_6). PFCs are formed during a phenomenon known as the Anode Effect (AE) when alumina levels are low.		
Potential Key Issues:	Emissions of CF_4 and C_2F_6 vary significantly from one aluminium smelter to the next. Actual emission measurements should be used.		
General References	IPCC Guidelines: Chapter 2.13.5 IPCC good practice guidance and Uncertainty Management in National Greenhouse Gas Inventories section 3.3		
Source Category		2.C.3 Aluminum Production - Details	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	CO_2 PFCs	If aluminum production is a *key source* in the country, check whether Tier 2 or Tier 3 is applied. Depending upon both the availability of data and country-specific conditions, Tier 1 may be used in some cases.	The most accurate method is either to monitor smelter emissions continuously (Tier 3a), or to develop a smelter-specific long term relationship between measured emissions and operating parameters and then apply this relationship using activity data (Tier 3b).

Emission Factor	CO_2 PFCs	Check if the smelter-specific coefficients are based on comprehensive measurements of CF_4 and C_2F_6 emissions with simultaneous collection of process data (Tier 3b Method). If smelter-specific measurements are unavailable, default coefficients may be used (Tier 2 Method).	Emission factors are to be measured over a period of time long enough to reflect the variability of the process and account for both emissions captured by the off gases collection system and fugitive emissions. The default coefficients must be applied by technology type specific to each smelter. If more than one technology type is used at a smelter, the appropriate default coefficients must be applied separately for each technology segment.
Activity Data	CO_2 PFCs	If smelter-level production data are unavailable.	Smelter capacity data may be used along with aggregate national production to estimate smelter production.
Completeness	CO_2 PFCs	There is no reason to report the terms NA and NE for this source category.	All inventory agencies should be able to implement the Tier 1 method at a minimum level and ensure completeness of reporting.
Recalculations/ Consistent time series	CO_2 PFCs	Check consistency over time if the estimation method for a smelter changes.	It is good practice to recalculate emission estimates using both the past and current methodologies to ensure that any trends in emissions are real and not the result of changes in estimation methodologies.
Uncertainty	CO_2 PFCs	Check what method has been used to estimate source level uncertainty.	CO_2 emissions vary depending on the technology used. Since emissions of CF_4 and C_2F_6 vary significantly by aluminum smelter cell type and AE parameters, the estimations will be highly uncertain unless actual emission measurements have been made. It is possible to apply classical statistical quantitative approaches to estimate uncertainty ranges for the Tier 1, Tier 2 and Tier 3 methods.
Reporting and documentation	CO_2 PFCs	Much of the production and process data are considered proprietary by operators, especially where there is only one smelter in a country.	It is good practice to exercise appropriate techniques, including aggregation of data, to ensure protection of confidential data.
QA/QC	CO_2 PFCs	Inventory agencies should check if the estimated emission factors are within the range of default emission factors provided for the Tier 1 method.	If the emission factors are outside of this range, an explanation should be provided and documented, with particular attention given to the smelter-specific conditions that account for the differences. It may be necessary to repeat measurements for validation purposes.

Table 2.C.4: SF6 Used in Aluminum and Magnesium Foundries

Source Category	2.C.4 SF_6 Used in Aluminum and Magnesium Foundries - Overview
Definition	In the magnesium industry, SF_6 is used as a cover gas in foundries to prevent oxidation of molten magnesium. It is assumed that all SF_6 is emitted to the atmosphere. (In the aluminium industry, SF_6 is used as a cover gas only for special foundry products.) The Norwegian producer of magnesium has attempted to assess whether SF_6 used as a cover gas reacts with other components in the furnaces; the results obtained thus far indicate that SF_6 is quite inert.
Potential Key Issues:	Since it is assumed that all SF_6 is emitted to the atmosphere, consumption figures are therefore used as emission estimates.
General References	IPCC Guidelines: Chapter 2.13.8 IPCC good practice guidance and Uncertainty Management in National Greenhouse Gas Inventories section 3.4

Source Category		2.C.4 SF_6 Used in Aluminum and Magnesium Foundries - Details	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	SF_6		
Emission Factor	SF_6	Check if emission factor has been used.	There is no need to use emission factors or coefficients when SF_6 consumption data are available. The direct reporting method assumes that all SF_6 consumed is emitted.
Activity Data		Check if there is some direct reporting of SF6.	If there is some direct reporting, assess the share of the total magnesium production that is represented by the plants that are directly reporting SF_6 data.
Completeness	SF_6	Check if national data sets are covered.	Some plants may supply to niche markets that are not captured by national data sets.
Recalculations/ Consistent time series	SF_6	There may be issues of data availability associated with establishing historical emissions, particularly when implementing a direct reporting approach.	It is good practice to use historical SF_6 data where available, but SF_6 purchase records for previous years may not be archived by magnesium manufacturers.
Uncertainty	SF_6	Estimation of SF_6 emissions on the basis of sales to the magnesium industry each year.	This method is highly uncertain. SF_6 may be purchased in bulk quantities and not used until later years. The uncertainty in this case will be bounded by the total sales data.
Reporting and documentation	SF_6	In most countries, the magnesium industry will be represented by a small number of plants.	In this industry, the activity level data and the associated SF_6 emissions may be considered confidential business information, and public reporting may be subject to confidentiality considerations.
QA/QC	SF_6	If emissions were calculated using data from individual plants (bottom-up approach).	Inventory agencies should compare the estimate to emissions calculated using national SF_6 consumption or national magnesium production data (top-down approach).

Table 2.C.5: Other Metal Production

Source Category	2.C.5 Other Metal Production - Overview
Definition	This includes production of all non-ferrous metals except aluminum. The metals may be produced using carbon as reducing agents or by other methodologies. The emission of CO_2 depends on the production process: for example, some ores are not reduced with carbon, hence, CO_2 emissions from these processes are low.
Potential Key Issues:	This is typically a minor source, and specific IPCC good practice guidance is not available.
General References	IPCC Guidelines: Chapter 2.13.7

Table 2.D: Other Production

Source Category	2.D Other Production - Overview
Definition	Emissions of greenhouse gases are not expected in any other production processes. Ozone precursors may however be emitted in the pulp and paper and the food and drink industries.
Potential Key Issues:	Only ozone precursor emissions occur in this category.
General References	IPCC Guidelines: Chapter 2.14

Table 2.E: Production of Halocarbons and SF6

Source Category	2.E Production of Halocarbons and SF_6 – Overview
Definition	In some industrial processes, chemical substances may be released into the atmosphere. Emissions of such chemicals may occur during the production and distribution of halocarbons and SF_6. During the manufacture of chlorodifluoromethane (HCFC-22 or $CHClF_2$), a refrigerant, the GHG trifluoromethane (HFC-23 or CHF_3) is emitted as a by-product. HFC-23 has an extremely high 100-year Global Warming Potential (GWP) of 11,700, a value that is second only to SF_6 (with a GWP of 23,900).
Potential Key Issues:	
General References	IPCC Guidelines: Chapter 2.16 IPCC good practice guidance and Uncertainty Management in National Greenhouse Gas Inventories section 3.5.3

Source Category		2.E Production of Halocarbons and SF_6 – Details	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	HFCs PFCs SF_6	The IPCC Guidelines provide two tiers for estimating emissions of HFC-23. Tier 1 estimates emissions through the application of a default emission factor to the quantity produced. Tier 2 involves direct measurement of the concentration and flow rate at the condenser vent.	It is considered good practice to use the more accurate Tier 2 method. In countries where plant-specific data are unavailable and HFC-23 emission sources are not key sources, the Tier 1 method may be used.
Emission Factor	SF_6	The IPCC Guidelines do not provide a default emission factor for inadvertent losses during production and handling of SF_6. Although these emissions are likely to be small, emissions may be significant in some countries.	For example, an emission factor of 8% of the gas produced has been estimated based on experience in Japan, which includes handling losses during disposal of residual gas in returned cylinders (Suizu, 1999). This is due to the large demand for highly purified SF_6 gas, which may lead to impure gas being released.

Activity Data	HFCs PFCs SF_6		
Completeness	SF_6 PFCs SF_6	Check whether smaller producers and recycling firms in particular are included. No problems should arise with HFC-23 because the total number of HCFC-22 plants worldwide is small.	Initial estimates based on the national mass balance of SF_6 should determine whether such entities provide a sizeable contribution to total national emissions.
Recalculations/ Consistent time series	HFCs PFCs SF_6	Have methods changed within the time series or since the last inventory submittal?	It is good practice to recalculate historic emissions when methods are changed or refined (see GPG 7.3)
Uncertainty	SF_6 PFCs SF_6	Production emissions may be negligible (e.g., when scrubbers capture the SF_6 gas released). The uncertainty associated with HFC-23 emissions is generally small with Tier 2 and very large with Tier 1.	The estimated uncertainty range for the default emission factor is therefore 0.2 ± 0.2 (%). The relative uncertainty of the default 8% emission factor is of the same order. The Tier 2 method can achieve an accuracy of 1-2%. The uncertainty associated with Tier 1 method may be as high as 50%.
Reporting and documentation	SF_6 PFCs SF_6	Confidentiality issues may arise where there are limited numbers of manufacturers.	In such cases, more aggregate reporting of total national applications may be necessary. If survey responses cannot be released as public information, third-party review of survey data may be necessary to support data verification efforts.
QA/QC	SF_6 PFCs SF_6	In cooperation with producers, inventory agencies should investigate significant discrepancies or unexplained differences.	Inventory agencies should compare the estimate based on aggregated producer-level data to an estimate based on national production data and the suggested default emission factor of 8% for SF_6 and 4% for HFC-23. In the case of HFC-23, a Tier 1 estimate may be used to check the estimate obtained using Tier 2.

Table 2.F: Consumption of Halocarbons and SF6

Source Category	2.F Consumption of Halocarbons and SF_6 – Overview
Definition	Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6) are used as alternatives to ozone depleting substances (ODS) being phased out under the Montreal Protocol. Their use is also common in semiconductor manufacturing. Emissions of halocarbons and SF_6 in this case occur as leakage from use of equipment and from the destruction of such equipment after use.
Potential Key Issues:	Emissions of SF_6 from Electrical Equipment. PFC, HFC and SF_6 emissions from Semiconductor Manufacturing. ODS substitutes and estimation of ODS emissions using Tier 2a (bottom-up) approaches (see CRF ODS source category).
General References	IPCC Guidelines: Chapter 2.17 IPCC good practice guidance and Uncertainty Management in National Greenhouse Gas Inventories section 3.5/3.6

Source Category		2.F Consumption of Halocarbons and SF_6 - Details	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	HFCs PFCs SF_6	For ODS substitutes: The IPCC Guidelines provide two tiers for estimating emissions. Tier 1, the ”potential” method, estimates emissions based on current consumption, defined as production plus imports minus exports and destruction. There are two options for Tier 2; Tier 2a and 2b. Both of the Tier 2 methods are ”actual” methods and are more complex than the Tier 1 method. They estimate emissions by taking into account the time period between sales and use of these chemicals produced by the operational characteristics and lifespan of equipment (e.g., refrigerators) which use them. The methodology behind the Tier 2a (bottom-up) method is also know as a vintaging approach. Tier 2b is known as a top-down approach.	The Tier 2 methods require significantly more data, and are preferred. Its use is therefore considered good practice. The Tier 2a approach estimates the emissions of each GHG by tracking the annual vintages of each type of equipment using these gases. Data are collected to estimate the quantity of equipment sold, discarded, or replenished with ODS substitutes in a given year. Leakage rates are then applied to each class of equipment to estimate the total net annual emissions. In countries where the ODS substitute emission sources are not key sources, the Tier 1 method may be used.
Emission Factor		What emission factors are used?	National inventories should document key assumptions and emission factors used.
Activity Data	HFCs PFCs SF_6	Semiconductor manufacturing: Activity data for this industry consists of data on gas sales, purchases, or use.	Semiconductor manufacturing: For the more data-intensive Tier 2 methods, gas purchase data at the company or plant-level are necessary. For the Tier 1 method, it is preferable that company-level gas purchase data are used.
Completeness	HFCs	Semiconductor manufacturing:	Semiconductor manufacturing There are four issues that

	PFCs SF_6	In most countries the number of companies and plants are limited, so a complete accounting of emissions from the semiconductor industry should be achievable. For ODS substitutes, fugitive emissions released during production are not accounted for in either the Tier 1 or Tier 2 method.	should be addressed: Other By-products; New Chemicals; Other Sources; and Other Products or Processes It is good practice to include fugitive emissions from domestic production. The IPCC good practice guidance recommends a default factor of 0.5%.
Recalculations/ Consistent time series	HFCs PFCs SF_6	Have methods changed within the time series or since the last inventory submittal?	It is good practice to recalculate historic emissions when methods are changed or refined (see GPG 7.3)
Uncertainty	HFCs PFCs SF_6	Electrical equipment: When using Tier 3 methods, the resulting emission estimates are likely to be more accurate than Tier 2 or Tier 1 methods, on the order of ± 10%. Estimation of ODS substitute emissions.	Electrical equipment: Particular sources of uncertainty in the Tier 3 methods estimates may include: SF_6 exported by equipment manufacturers (either in equipment or separately in containers); SF_6 imported by foreign equipment manufacturers (either in equipment or in containers); SF_6 returned to foreign recycling facilities; Time lag between emissions and servicing; and Lifetime of the equipment. Given the large numbers and types of equipment using these substances, the difficulty in obtaining accurate sales and use data, and the variations in leakage and use patterns of equipment, the uncertainty associated with ODS substitute emissions can be quite significant. The Tier 2 approaches will generally be preferred.
Reporting and documentation	HFCs PFCs SF_6	Semiconductor manufacturing: Given confidentiality concerns, inventory agencies may wish to aggregate information across manufacturers. ODS substitutes: For Tier 2, the general design and assumptions of the vintaging model used should be documented.	Semiconductor manufacturing: In cases where manufacturers in a country have reported different emission or conversion factors for a given emission and process, inventory agencies may provide the range of factors reported and used.
QA/QC	HFCs PFCs SF_6	Semiconductor manufacturing: Due to the highly competitive nature of the semiconductor industry, provisions for handling confidential business	Semiconductor manufacturing: Methods used should be documented and a periodic audit of the measurement and calculation of data should be considered. A QA audit of the processes and procedures should also be considered.

		information should be incorporated into the verification process. For ODS substitutes, estimates prepared using the Tier 2 (actual) method should be checked against estimates using Tier 1 (potential).	The Tier 1 method tends to overstate the emissions, and thus may provide an upper bound to Tier 2 calculations.