DRAFT
GHG Projection Guidelines

Part B: Sectoral Guidance

Mt CO$_2$-equivalent

EU27 GHG trends and projections 1990-2020 - emission by sector
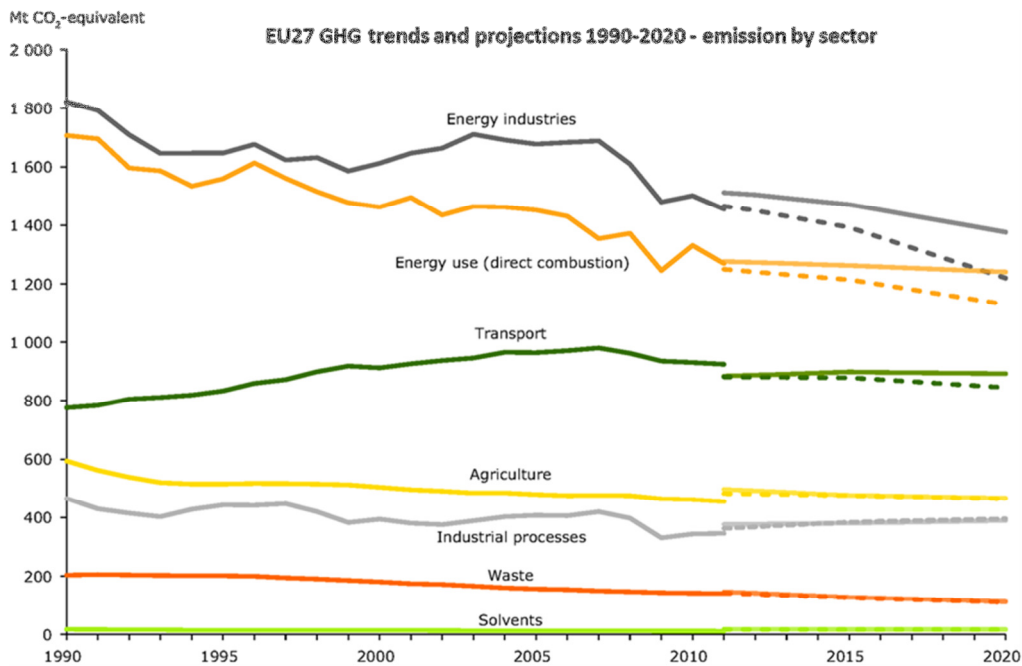
Note: Solid lines represent historic emissions up to 2011 and WEM GHG emission projections from 2011 onwards. Dashed lines represent WAM GHG emission projections.

Source: EEA, 2012. Greenhouse gas emission trends and projections in Europe 2012. Tracking progress towards Kyoto and 2020 targets. EEA Report No 6/2012

Part B   Sectoral Guidance

This part of the guidance follows the sector and source category definitions as presently used in inventory reporting under the EU Monitoring Mechanism, the UNFCCC annual inventory submissions and the Kyoto Protocol.

Preamble

The guidelines do not prescribe a specific projection method to each MS, but guide the MS in a graded methodological approach to reflect different approaches and data situations at MS level and to provide all information on projections' assumptions, parameters, algorithms and results that allow the Commission to derive EU-wide projections that can be seen as a consolidation of the individual MS national projections.

B.1 Energy (IPCC sector 1)

1.1   Introduction

The energy sector is the most important sector within a greenhouse gas emissions inventory and hence also in any greenhouse gas emissions projection. The sector includes all combustion emissions and fugitive emissions from exploration, exploitation, fuel conversions, storage and transport related to the energy system of a country. Every source category section includes a table which is derived from the 2006 IPCC Guidelines but also follows the 1996 IPCC Guidelines. These tables define the category and sub-category splits and give their description. The last column indicates whether a source category needs to be reported. Those that are not checked are recommended sub-categories when additional more detailed method could be applied.

Table 1 Sector split for Energy.

IPCC 2006 source category		Description	Re-port
1	ENERGY	This category includes all GHG emissions arising from combustion and fugitive releases of fuels. Emissions from the non-energy uses of fuels are generally not included here, but reported under Industrial Processes and Product Use Sector.	☑
1A	Fuel Combustion Activities	Emissions from the intentional oxidation of materials within an apparatus that is designed to raise heat and provide it either as heat or as mechanical work to a process or for use away from the apparatus.	☑
1B	Fugitive Emissions from Fuels	Includes all intentional and unintentional emissions from the extraction, processing, storage and transport of fuel to the point of final use.	☑

Source: IPCC (2006)

Below guidance is provided for both the combustion and fugitive emissions.

1.2   Fuel Combustion (IPCC 1.A)

1.2.1   Source description

Fuel combustion occurs in many parts of the society. Projected emissions are to be reported in the source categorization of the UNFCCC CRF report, based on the IPCC 1996 Guidelines. The IPCC 2006 Guidelines are in this sector fully compatible with the 1996 Guidelines. The table below provides the subcategories included in the Fuel Combustion subsector.

Table 2 Detailed sector split for Fuel Combustion.

IPCC 2006 source category		Description	IPCC 1996	Re-port
1A	Fuel Combustion Activities	Emissions from the intentional oxidation of materials within an apparatus that is designed to raise heat and provide it either as heat or as mechanical work to a process or for use away from the apparatus.	1A	☑
1A1	Energy Industries	Comprises emissions from fuels combusted by the fuel extraction or energy-producing industries.	1A1	☑
1A2	Manufacturing Industries and Construction	Emissions from combustion of fuels in industry. Also includes combustion for the generation of electricity and heat for own use in these industries. Emissions from fuel combustion in coke ovens within the iron and steel industry should be reported under 1 A 1 c and not within manufacturing industry. Emissions from the industry sector should be specified by sub-categories that correspond to the International Standard Industrial Classification of all Economic Activities (ISIC). Energy used for transport by industry should not be reported here but under Transport (1 A 3). Emissions arising from off-road and other mobile machinery in industry should, if possible, be broken out as a separate subcategory. For each country, the emissions from the largest fuel-consuming industrial categories ISIC should be reported, as well as those from significant emitters of pollutants. A suggested list of categories is outlined below.	1A2	☑
1A3	Transport	Emissions from the combustion and evaporation of fuel for all transport activity (excluding military transport), regardless of the sector, specified by sub-categories below. Emissions from fuel sold to any air or marine vessel engaged in international transport (1 A 3 a i and 1 A 3 d i) should as far as possible be excluded from the totals and subtotals in this category and should be reported separately.	1A3	☑
1A4	Other Sectors	Emissions from combustion activities as described below, including combustion for the generation of electricity and heat for own use in these sectors.	1A4	☑
1A5	Non-Specified	All remaining emissions from fuel combustion that are not specified elsewhere. Include emissions from fuel delivered to the military in the country and delivered to the military of other countries that are not engaged in multilateral operations Emissions from fuel sold to any air or marine vessel engaged in multilateral operation pursuant to the Charter of the United Nations should be excluded from the totals and subtotals of the military transport, and should be reported separately.	1A5	☑

Source: IPCC (2006)

Below specific issues for each of these subsectors is provided. The energy system in a country however should also be seen as a complex, but very related system of primary energy supply, energy transformation processes and final energy use in both stationary and mobile uses.

1.2.2   Activity projections

1.2.2.1   General

It is good practice to project fuel use (for combustion) for the years in the projection in the same level of detail as the historic emissions inventories and hence following the EUROSTAT level of detail (see Annex B.1.I to B.1.I.3). For each of the source categories within the subsector 1.A Fuel Combustion, one can choose a Grade 1, a Grade 2 or a Grade 3 approach, depending on the availability of data and the impact each source category has on both the level of the projected emissions and the trends between the historic inventories and the projected emissions. Grade 1 approach is not recommended for a key (in level and/or in expected trend) source categories.

The IPCC Guidelines for retrospective reporting require a very high level of detail, mainly to allow the use of fuel specific emission factors for each fuel. All Member States reported an inventory of emissions from a historic period of time (e.g. EUMM GHG emissions reported for 1990 – 2009) where fuels were aggregated to the level of "solid fuels", "liquid fuels", "gaseous fuels" and "biomass". These figures are based on the more detailed fuel split as available in the national energy statistics as delivered to EUROSTAT and described above.

In broadly used prospective economic and energy models like the PRIMES model (Annex B.1.II), fuels might be treated at a higher aggregation level. For projections, it is desirable to have such models generate disaggregated results that allow consistency between the historic inventory and the projections. In this case there are two possibilities:

- o Information on the projected specification of the aggregated fuels towards the ones used in energy statistics is available. In this case this information can be used to disaggregate the projected fuel use; and
- o Information on the projected specification of the aggregated fuels towards the ones used in energy statistics is not available. In this case an assumption would be needed. The assumption could simply be that the latest split into the detailed fuels will remain the same during the years of the projection. The Member State could of course also use different assumptions although these should be well documented.

For activity projections in the Fuel Combustion sector, the main output variables would show detailed energy balance, including:

- o Detailed balance for electricity and steam/heat;
- o Production of new fuels;
- o Transport activity, modes/means and vehicles;
- o Association of energy use and activities; and
- o These projected output activity variables then can be used to calculate projected emissions.

1.2.2.2   Grades and Decision Tree

Figure B.1-1 presents a generalized decision tree for selecting grades for future activity data for fuel combustion. This decision tree applies in general for each of the fuel combustion activities. Grade 1 is not recommended for fuel combustion.
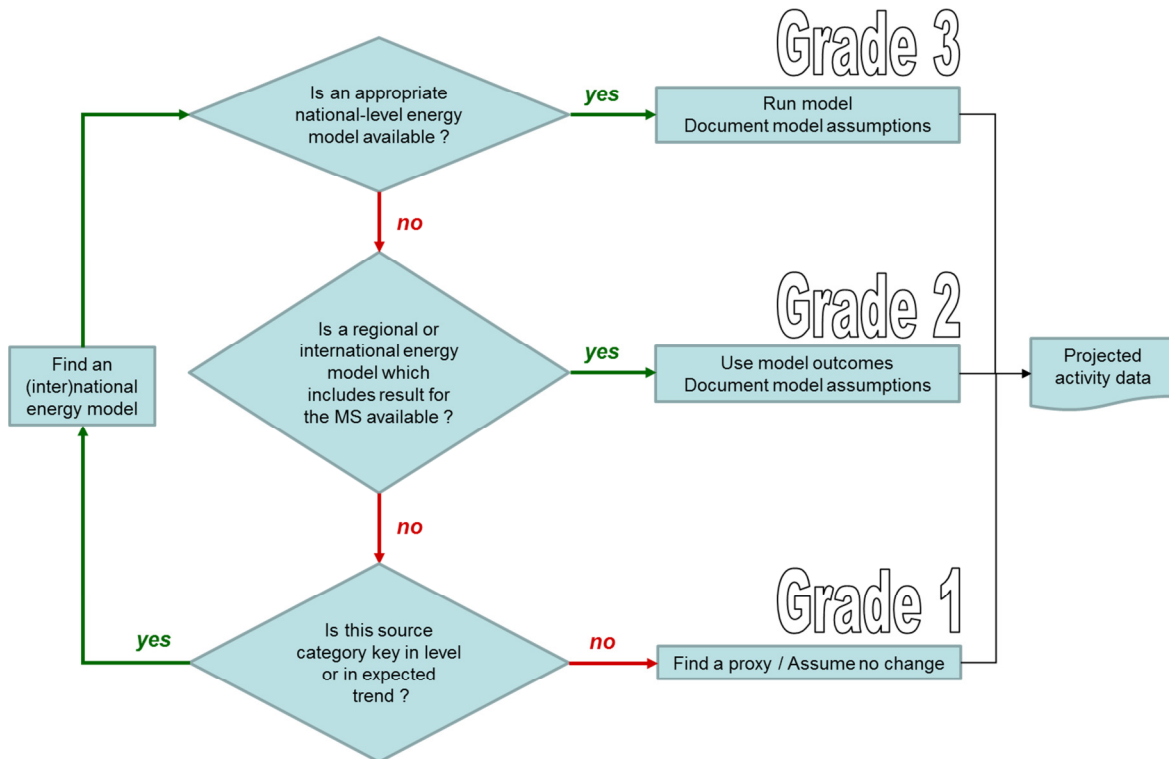
Figure B.1-1 Generalised decision tree for future activity data for fuel combustion activities.

1.2.2.3   Grade 1

Fuel combustion sector is a significant source of GHG emissions. Therefore using the historical activity data, unchanged from the most recent inventory or using proxies to simulate future changes in activities (Grade 1) is not recommended.

1.2.2.4   Grade 2

In Grade 2, the projection of activity data in the Fuel Combustion sectors would be derived from an available multi-sector, regional or international energy model which includes results for the Member States.

- o   At present, the European Commission uses the PRIMES model to project greenhouse gas (GHG) emissions from fuel combustion in the European Union[1]. Under the Grade 2 approach, one could use the detailed activity projections of

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[1]   The European Commission's Energy Efficiency Plan 2011 set an objective of 20% primary energy savings in 2020 compared to projections http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SEC:2011:0277:FIN:EN:PDF . More information on PRIMES can be found e.g. at www.euclimit.eu. Latest EU energy and CO2 projection results with detailed results at Member State level can be accessed under http://ec.europa.eu/energy/observatory/trends_2030/

the PRIMES model. The PRIMES model's outputs include full detailed EUROSTAT Energy Balance sheets per country and per year, energy demand per country and per year, energy costs, producer and consumer prices, power generation park, load curves, load factors, investment and marginal costs (central systems, combined heat-power, exchanges), endogenous treatment of energy savings and new technologies, etc. For further details on the PRIMES model please refer to Annex B.1.II for more information.

o   Another multi-sector energy model is the World Energy Model by the International Energy Agency. The model's power generation module provides outputs such as new generation capacity needed, amount of electricity generated, fuel consumption of the power generation sector, electricity prices, etc. For the industry sectors, the model projects the intensity of energy consumption per unit of each subsector's output and the share of each energy source. For further details on the World Energy Model please refer to Annex B.1.III.

Where data from such models are not provided at the required level of disaggregation for reporting purposes, it may be necessary to apportion activity data using a simplified approach such as pro-rata using data from the historical inventory.

Whichever source is used, the data should be linked to/check against MS level activity data from the emissions inventory, in order to ensure consistency. If any inconsistencies are apparent (e.g. baseline activity data differs significantly between the model and MS inventory), a simple approach would be to take the percentage changes from the external energy model and apply these to the data used in the national inventory.

It is not good practice to use a Grade 2 method for categories which are key sources and/or are expected to become a key source category.

The projection of activity data in the Fuel Combustion sectors may be derived from a Grade 2 projection where some parameters (and or variables) are replaced by results from more country or regional specific models. Examples of this kind of exogenous information are:

o   Economic activity;
o   GDP and economic growth per sector;
o   Interest rates, risk premiums, etc.;
o   Energy prices;
o   Energy supply outlook – prices of fossil fuels;
o   Parameters of supply curves for primary energy, potential of sites for new plants especially regarding power generation sites, renewables potential per source type, etc.;
o   Technology parameters;
o   Technical and economic characteristics of future energy technologies;
o   Policies and measures;
o   Taxes and subsidies;
o   Environmental policies and constraints; and

  o Energy consumption habits, parameters about comfort, rational use of energy and savings, energy efficiency potential, etc.

The "simple" inclusion of exogenous information in the model results can compromise the consistency (and integrity) of the energy balance. For instance the large scale introduction of electric transport modes (decrease in fossil fuel use) has to be accompanied by a related increase in electricity production (and thus fuel used for generating electricity). Therefore it is good practice for the MS using a method to provide ample documentation with the projection on how the integrity of the energy balance was safeguarded. This documentation is crucial for transparency of the projection.

1.2.2.5 Grade 3

The Grade 3 approach is to use a detailed Member State-specific model of fuel use, covering either all of the relevant sectors and fuels, or specific models for individual sectors[2]. However, it is good practice that these models use input data that is consistent with national economic, energy and activity projections used elsewhere in the projected emissions estimates.

The types of models typically available for modelling of energy demand and supply include:

  o Econometric models;
  o Optimisation models;
  o Simulation models; and
  o Engineering models.

Examples of key types of input and output data for such models include the following:

Table 3 Summary of modelling approach, main inputs and outputs for different types of models according to VITO (2008)

Model type	Modelling approach	Inputs	Outputs
General equilibrium models (top-down)	These models assume that all economic agents optimise their behaviour and price mechanisms work to clear all markets by equating supply and demand for goods and inputs. Economy-wide and long-term abatement costs are well represented but their representation of technology details is weak.	Data related to international economic context: world market development, exchange rates, fuel prices and emission trading prices.	Macro-economic data such as GDP, (un)employment and labour activity data, government balances, sectoral values added. Fuel consumption data per fuel type, electricity consumption and CO_2 emissions. Energy and process related GHG emissions are linked to (aggregated) activity levels
Macro-economic models (top-down)	These models represent the behaviour of the economy through relationships (i.e. energy demand to prices or income) based on key economic factors.	Data related to the international economic context: world market development, exchange rates, fuel prices and emission	Macro-economic data such as GDP, (un)employment and labour activity data, government balances, sector values added. Fuel consumption data per fuel

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[2] For a detailed description on generic approach to projection models, please go to Part A. General Guidance Chapter 2 Modeling Projections.

Model type	Modelling approach	Inputs	Outputs
	The effect of individual policies and measures, unless they are primary economic policies and measures, are difficult to assess.	trading prices.	type, electricity consumption and CO_2 emissions.
Optimisation / linear programming models (bottom up)	These models represent the energy system of a country by a detailed set of technology options and therefore are useful for assessing GHG mitigation policies and measures. However, they neglect feedback effects on the rest of economy and undervalue transaction costs of these policies and measures.	Physical characteristics of the sectors e.g. characteristics for power plants, fluctuations in electricity demand, load curves for electricity, industrial installations, housing stock, other building types, transport equipment. Require an external scenario for end-use energy consumption. Fuel prices and emission trading prices also needed.	Fuel consumption per fuel type and sector, energy related GHG emissions, GHG emissions linked to specific processes, load of electricity plants, unused capacity, shadow prices (marginal production costs) for energy.
Engineering models (bottom-up)	These are usually for specific sectors such as waste, agriculture, residential, etc. Whilst sector-specific policies and measures can be assessed most appropriately, economic measures and feedback to the rest of economy is limited.	Activity data and emissions factors, plus technology data	Emissions
Simulation models (bottom-up)	Similar to optimisation models, these models represent the energy system by a number of technologies and energy carriers.	Base-year energy balance data (energy consumption per fuel type and per sector), base year price and tax levels and characteristics of energy conversion technologies (efficiency of conversion, lifetime of equipment). Activity levels, international fuel prices.	Fuel consumption per fuel type, energy related GHG emissions and GHG emissions linked to specific processes.
Focus on demand models (bottom up)	These models provide a pre-defined framework for the development of energy demand scenarios for specific end-users on a disintegrated level. These rely on accounting relationships and do not consider price effects.	Socio-economic scenario which would determine important key variables such as the penetration of fuel types and the evolution of energy efficiencies.	Energy demand scenarios for specific end-users on a disintegrated level.

Source: VITO (2008)

There are a number of desirable characteristics that models for energy consumption, in order to produce robust projections, should have, such as:

- o   incorporating rigidities of the system related to existing production, characterised by capacities, efficiencies and lifetime of existing plants;
- o   considering investment decisions in different technologies, which may be exogenous (input parameter) or endogenous (model results) based on economic and technological characteristics of technologies;

- o   being able to evaluate the impact of fuel prices assumptions on operational load factors for different technologies;
- o   being able to explore the growth potential and the limitations for renewable energies and for CHP;
- o   being able to analyse the effect of CO_2 tax and emission trading;
- o   ability to split ETS and non-ETS covered sources of emission;
- o   ability to incorporate carbon capture and sequestration into the projections;
- o   ability to incorporate assumptions on electricity imports/exports; and
- o   being able to analyse effects on international exchanges and on pricing of electricity.

Many Member States have their own models which have been developed to fit their specific national circumstances. No specific model or type of model is prescribed by the guideline but Member States should consider providing justification for use of models that do not have these characteristics and/or which have not been tested against the QA/QC processes described in 1.A. Fuel Combustion section 1.2.5.

Where Member States run their own energy models, it is good practice to use a common set of assumptions used by the European Commissions' PRIMES model in order to increase harmonisation across the projections at the MS level and at the EU-27 level. Examples of common assumptions include carbon price, fuel prices and macroeconomic assumptions. Member States may prefer to use deviating assumptions on all aspects mentioned above. This would decrease comparability between Member States and pose a problem when combining Member States' projection to one EU level projection. In such cases, it is good practice to run sensitivity analyses that show the differences between the modelling output that uses the harmonised common assumptions and the Member State specific assumptions. In addition, it is advised that good practices outlined in the QA/QC section of the general guidelines (Part A Chapter A.8: Quality Assurance and Quality Control (QA/QC) for Projections) such as documenting the differences (i.e. transparency) are taken into account when the Member State models use its own assumptions.

1.2.3   Emission Factor projections

1.2.3.1   Grades and Decision Tree

Guidelines for emission factor projections adopt the Grade-based approach of the 2006 IPCC Emission Inventory Guidelines.
Figure B.1-2 presents a generalized decision tree for selecting grades for future emission factors for fuel combustion. This decision tree applies in general for each of the fuel combustion activities.
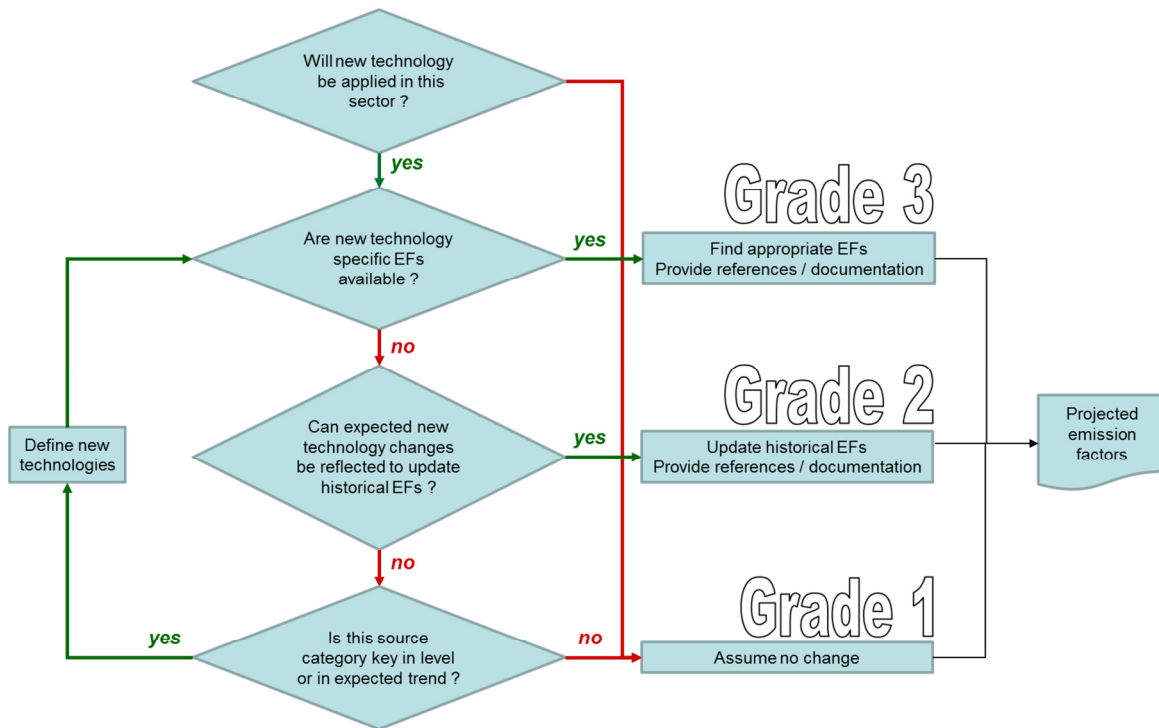
Figure B.1-2 Generalised decision tree for future emission factors for fuel combustion activities.

1.2.3.2   Grade 1

Grade 1 will use the emission factors from the most recent historic inventory. Where no data are available on emission factors at the Member State level, the default emission factors for stationary combustion in energy industries in the latest adopted IPCC Inventory Guidelines can be used.

Grade 1 projection methods can be applied to non-key categories and sources not expected to become a key category.

1.2.3.3   Grade 2

Grade 2 projections are expected to take account of future technology changes thus future changes to emission factors. Grade 2 emission factors are extrapolated from the historic values, using information on the expected changes in technologies and practices relevant for the emissions in some or all source categories.

As with the IPCC Emission Inventory Guidelines on emission factors, the Grade 2 approach is to use country-specific emission factors derived from measurement (or calculation). These may include national emission factors and/or regional emission factors.

It is good practice that such emission factors are based on a sufficient number of sources to provide a good representation of the average conditions in the Member State for the source type, taking into account fuel type and composition, type and size of the combustion unit, firing conditions, load, type of control technologies and maintenance level.

1.2.3.4 Grade 3

The Grade 3 approach includes technology-specific emission factors. Emissions factors and activity projections are interdependent with each other in generating GHG projections, as energy models use technology specific emission factors and calculate country specific emission factors at various levels of detail as a model output.

1.2.4 Policies and measures

1.2.4.1 General

The projections developed should either directly incorporate or be checked against legislative and other limits on emissions. These include EU-level commitments (such as the EU ETS and ESD) as well as national and/or regional targets (such as carbon budgets/caps for countries, regions or sectors). It is recommended that Member States set out clearly (e.g. in a tabular format) how each of the policies and measures has been taken into account in the projections.

Considering that there are a number of policies and measures directed to specific sectors such as energy or transportation, the table below lists only the policies and measures that are cross-cutting for the sectors that fall under the Fuel Combustion sector in the EU-27.

Table 4 Policies and Measures and related parameters affected by implementation of particular EU-level PAM in Fuel Combustion sector.

Sector	Description	Legislation	Parameters/Variables
Cross-cutting	*Directives:*		
	Industrial Emissions Directive (IED)	Directive 2010/75/EC	*Emission ceilings for air pollutants,* *Emission factors,* *Energy production,* *Final energy consumption by sector by fuel type,* *Fuel efficiency,* *Share of different technologies*
	Emissions Trading Scheme (ETS) Directive	Directive 2003/87/EC, amending Directive 2009/29/EC	*Electricity consumption,* *Emission factors,* *Final energy consumption by sector by fuel type,* *Share of different forms of energy,* *CO_2 price*
	Renewable Energy Sources (RES) Directive[1]	Directive 2009/28/EC amending and subsequently repealing 2001/77/EC and 2003/30/EC	*Consumption of renewable energy for cooling,* *Consumption of renewable energy for heating,*

Sector	Description	Legislation	Parameters/Variables
			Consumption of renewable energy for cooling *Energy efficiency,* *Final energy consumption by sector by fuel type,* *Fuel specification,* *Share of biofuels in transport,* *Share of renewables in electricity generation* *Share of renewables in energy production*
	Kyoto Protocol project mechanisms	Directive 2004/101/EC	*Emission Factors*
	Decision:		
	Effort Sharing Decision[1]	Decision 406/2009/EC	*Electricity consumption,* *Final energy consumption by sector by fuel type,* *Share of different forms of energy*

Note 1: The RES Directive and Effort Sharing Decision do not have direct impacts on the listed parameters as they mainly set targets. When Member States implement national measures in order to meet the national targets set out by the RES Directive and/or Effort Sharing Decision, these national measures may have direct impacts on the listed parameters.

1.2.4.2   ETS and non-ETS split

Many of the emission sources in this sector are covered by the EU ETS. In addition, the Effort Sharing Decision (ESD) requires Member States to limit emissions for sources covered under the Decision and specifies national level emission targets. It is necessary to report projected emissions for sources covered by the EU ETS separately.

General principles that should be taken into account for developing projections split between ETS and non-ETS sources include the following:

- o In general, the basis for calculation of the emission projections should be consistent with historical time series data. However, the methods to split the emissions from ETS and non-ETS sources may be improved in the future and/or availability and quality of data useful for allowing Member States to split emissions may improve. Such improvements may lead to changes in historic estimates of emissions, but this shouldn't be perceived as an inconsistency problem.
- o The projections should be developed based on the planned mitigation activities to help Member States meet the ETS targets. It is not recommended that Member States automatically assume that the ETS emissions targets will be met without mitigation activities. Projections should be based on existing and planned mitigation policies and not on mitigation targets.

- In the case of the ETS Directive, the overall emission reduction target is at the EU-level and individual installations have the obligation to meet the targets. For ETS-covered sources, the level of compliance would be modelled based on the carbon price.
- In the case of the ESD, individual Member States have emission reduction targets which are to be met by implementing national measures. Therefore, emission projections should be based on existing and planned mitigation policies rather than the assumption that the national mitigation targets set by the ESD would be met automatically.
- It is also important to note that the situation under the ESD for the period post-2020 is currently uncertain as the ESD targets cover only 2013 to 2020, whereas the ETS does not have an "expiry date" according to Article 9.
- In regards to the flexible mechanism, the projections should be independent from how much of the flexible mechanism would be utilised by Member States to meet the emissions targets, as the projections should be based on fuel consumption activities rather than how the emissions targets are met.

Options for estimating the share of emissions for sources covered by the EU ETS vary in terms of level of complexity and potential accuracy and include the following:

- o Option 1: The first option is to split the fuel consumption between EU ETS installations and non-ETS sources, in the energy model allowing the generation of separate GHG projections. The reason behind this approach is that the activity data are in the end derived from the energy model and the fuels as projected by the energy model should be all combusted within the system. Whatever fuel that would be wrongly attributed to either ETS or non-ETS sources would therefore only be a misallocation and not a mis-estimation of the total national projected emissions in this (and other) sectors. The energy model may include assumptions on carbon price under EU ETS as well as different emission factors for fuel consumption activities from ETS and non-ETS sources. This approach would be appropriate for key sources of emissions. However, the various energy models currently used by Member States may not allow separation of fuel consumption by ETS and non-ETS sources.
- o Option 2: This approach can be used if the energy models do not allow the approach described in Option 1. Based on information from the latest historical inventory data and from the Registries (national level and Community Independent Transaction Log (CITL), one can estimate the share of emissions within the sector that arise from sources covered by the EU ETS. Unless there is information available on how the ETS and non-ETS split might change in the future, it should be assumed that the percentage share will remain constant in the future. It is not a good practice to assume the emissions from the ETS sectors will decline at the same rate as the decline in the EU level cap (i.e. 1.74% per year between 2013 and 2020).
- o Option 1 is the preferred approach. Option 2 would only be used if Option 1 is not possible.

1.2.5   Source Specific QA/QC

It is important to ensure that resulting emission projections have similar verification and QA/QC as applied to the historic inventory.

First step is to apply a "general" QA/QC (described in Part A: General Guidance Chapter A.8: Quality Assurance and Quality Control (QA/QC) for Projections) to ensure the quality (TCCCA) of the projections. It is good practice to check:

- o   "Completeness": the missing sources/fuels;
- o   "Accuracy": errors in application of assumptions or biased assumptions;
- o   "Comparability": misallocation of estimates to subsectors; and
- o   "Consistency": inconsistency in the time series (including historic to projected) or between approaches for different pollutants/categories.

Issues to take into consideration in addition to the general QA/QC guidelines include:

- o   The projections should be estimated using appropriate national assumptions on implementation of PAMs. These PAMs are put in place in order for Member States to achieve legislative and other limits on emissions. These include EU-level commitments (such as the EU ETS) as well as national and/or regional targets (such as ESD targets and carbon budgets/caps for countries, regions or sectors). . For instance, Member States would determine what set of emission mitigation actions would be implemented as a part of complying with the ESD, and these activities should be the basis of the emissions projections. It is not recommended that these targets would be automatically met without planned mitigation activities and the forecast of emissions is 'back-casted'.
- o   Checking input and output data against those data in international models/outputs such as PRIMES and World Energy Model by IEA, and accounting for any divergences.
- o   Checking emission projections against those developed by international models such as GAINS.
- o   Checking against the historical time series for activity data and emission factors as well as overall emissions.

1.3   Energy Industries (IPCC 1.A.1)

1.3.1   Source description

This emissions source comprises emissions from fuels combusted by the fuel extraction or energy-producing industries. As set out in the 2006 IPCC guidelines, it incorporates:

Table 5 Detailed sector split for Energy Industries.

IPCC 2006 source category		Description	IPCC 1996	Re-port
1A1	Energy Industries	Comprises emissions from fuels combusted by the fuel extraction or energy-producing industries.	1A1	☑
1A1a	Main Activity Electricity and Heat Production	Sum of emissions from main activity producers of electricity generation, combined heat and power generation, and heat plants. Main activity producers (formerly known as public utilities) are defined as those undertakings whose primary activity is to supply the public. They may be in public or private ownership. Emissions from own on-site use of fuel should be included. Emissions from autoproducers (undertakings which generate electricity/heat wholly or partly for their own use, as an activity that supports their primary activity) should be assigned to the sector where they were generated and not under 1 A 1 a. Autoproducers may be in public or private ownership.	1A1a	☑
1A1ai	Electricity Generation	Comprises emissions from all fuel use for electricity generation from main activity producers except those from combined heat and power plants.	1A1ai	
1A1aii	Combined Heat and Power Generation (CHP)	Emissions from production of both heat and electrical power from main activity producers for sale to the public, at a single CHP facility.	1A1aii	
1A1aiii	Heat Plants	Production of heat from main activity producers for sale by pipe network.	1A1aiii	
1A1b	Petroleum Refining	All combustion activities supporting the refining of petroleum products including on-site combustion for the generation of electricity and heat for own use. Does not include evaporative emissions occurring at the refinery. These emissions should be reported separately under 1 B 2 a.	1A1b	☑
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Combustion emissions from fuel use during the manufacture of secondary and tertiary products from solid fuels including production of charcoal. Emissions from own on-site fuel use should be included. Also includes combustion for the generation of electricity and heat for own use in these industries.	1A1c	☑
1A1ci	Manufacture of Solid Fuels	Emissions arising from fuel combustion for the production of coke, brown coal briquettes and patent fuel.	1A1ci	
1A1cii	Other Energy Industries	Combustion emissions arising from the energy-producing industries own (on-site) energy use not mentioned above or for which separate data are not available. This includes the emissions from own-energy use for the production of charcoal, bagasse, saw dust, cotton stalks and carbonizing of biofuels as well as fuel used for coal mining, oil and gas extraction and the processing and upgrading of natural gas. This category also includes emissions from pre-combustion processing for CO_2 capture and storage. Combustion emissions from pipeline transport should be reported under 1 A 3 e.	1A1cii	

Source: IPCC (2006)

The last column of the table indicates whether or not emissions and activity data are to be reported in the CRF tables.

1.3.2   Activity data projections

1.3.2.1   Grades and Decision Tree

A wide variety of different modelling approaches and datasets are available and in use at an EU level and by individual Member States. The proposed approach to projecting future activity data depends on the available information. Figure B.1-3 presents a generalized decision tree for selecting grades for future activity data for energy industries. This decision tree applies in general for each of energy industries activities. Grade 1 is not recommended for energy industries.
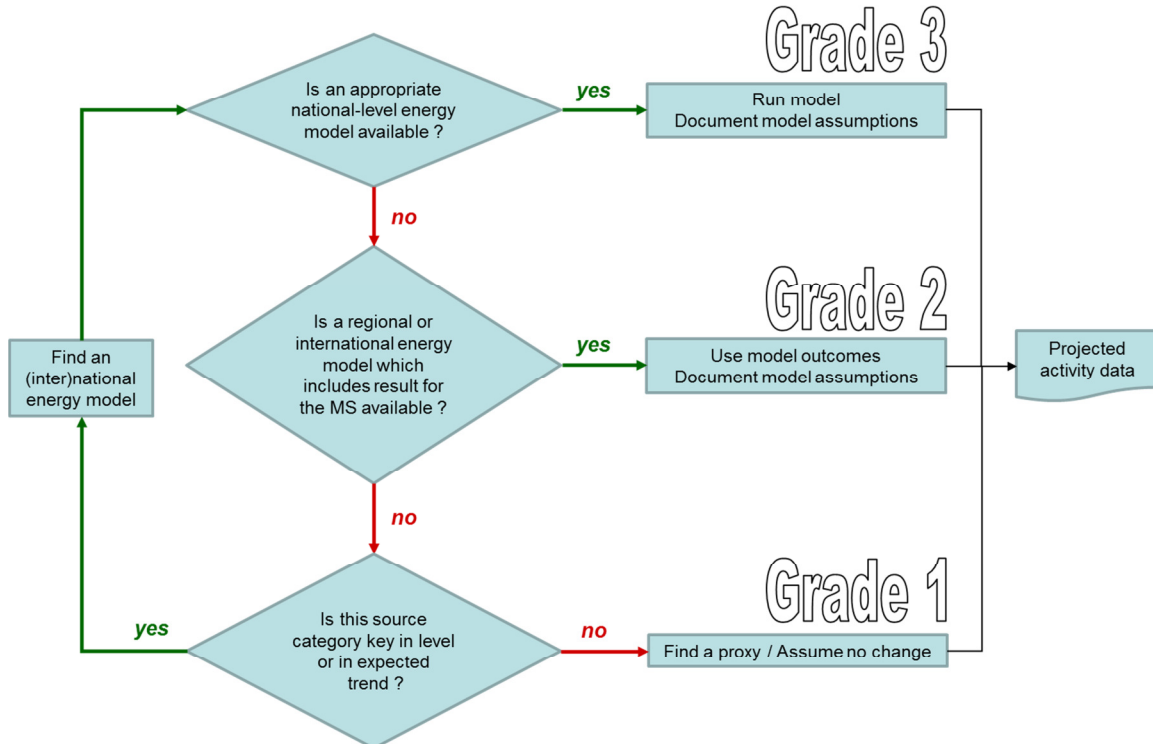
Figure B.1-3 Generalised decision tree for future activity data for energy industries activities.

Activity data projections should take into account the country's projected electricity demand and supply balance including any assumptions on future export/import of electricity. For the purpose of projecting GHG emissions, the principle that emissions from the point of generation should be counted regardless of where the electricity is consumed should be applied (i.e. emissions from the production of surplus electricity that is exported to foreign countries is still counted in the home country where it was originally generated.

1.3.2.1   Grade 1

As described in 1.A. Fuel Combustion section 1.2.2.3.

1.3.2.2   Grade 2

As described in 1.A. Fuel Combustion section1.2.2.4.

1.3.2.3   Grade 3

As described in 1.A. Fuel Combustion section 1.2.2.5.

1.3.3   Emission Factor projections

1.3.3.1   Grades and Decision Tree

Figure B.1-4 presents a generalized decision tree for selecting grades for future emission factors for energy industries. This decision tree applies in general for each of the energy industries activities.
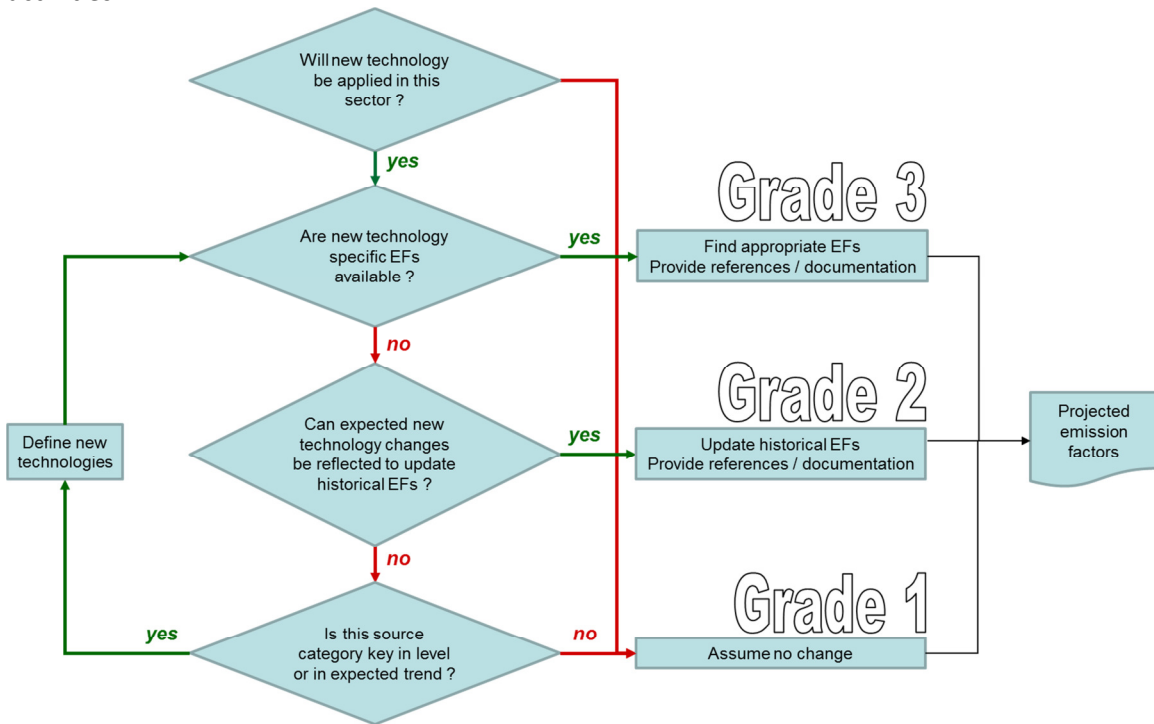
Figure B.1-4 Generalised decision tree for future emission factors for energy industries activities.

1.3.3.2   Grade 1

As described in 1.A. Fuel Combustion section 1.2.3.2.

1.3.3.3   Grade 2

As described in 1.A. Fuel Combustion section 1.2.3.3.

1.3.3.4   Grade 3

As described in 1.A. Fuel Combustion section 1.2.3.4, the Grade 3 approach includes technology-specific emission factors. This approach is relevant particularly where CCS is concerned and the methodology should relate to plant-by-plant forecasts of levels of CO_2 recovery. As set out in the

2006 IPCC Guidelines, the effect of CCS on emissions should always be estimated at the Grade 3 level, preferably for each specific CCS capture, transport and storage facility.

1.3.4   Policies and Measures

The projections developed should directly incorporate or be checked against legislative and other limits on emissions and/or lead to changes in overall energy demand and supply balance. It is good practice to ensure that these effects are taken into account in the proper source category and transparently documented in the national projections report. It is recommended that Member States set out clearly (e.g. in a tabular format) how each of the policies and measures has been taken into account in the projections (see also General Guidance – Part A Chapter A.2: Policies and Measures).

In some cases, there may be potential cross-sectoral effects of policies and measures (PAMs). For instance, a transportation policy aiming to increase the use of rail would lead to an increase in electricity demand. Therefore it is good practice to carefully review existing PAMS and take into account their potential effects on the activity and emission factor projections.

Table below lists the European Directives and voluntary programmes that are directly relevant to the energy industries. It is recommended to check PAM interactions (which are parent and which child PAMs see General Guidance – Part A Chapter A.0: Compiling an Emission Projection: A harmonized Approach, section 0.6 Policies and measures interactions. In addition to the European-level PAMs, there may be national PAMs that would have direct or indirect impacts on the sector, therefore it is good practice to consider these effects are taken into account and transparently document in the projections.

Table 6 Policies and Measures and related parameters affected by implementation of particular PAM in Energy Industries sector.

Sector	Description	Legislation	Parameters/Variables
Energy supply industries	*Directives:*		
	Industrial Emissions Directives	Directive 2010/75EC	*Emission ceilings for air pollutants,* *Emission factors,* *Energy production,* *Final energy consumption by sector by fuel type,* *Fuel efficiency* *Share of different technologies*
	Recast of the Energy performance of buildings	Directive 2010/31/EU	*Electricity consumption,* *Emission factors,* *Energy efficiency,* *Final energy consumption by sector by fuel type*
	Labelling and standard product information of the consumption of energy and other resources by energy related products (recast)	Directive 2010/30/EU	*Electricity consumption,* *Energy efficiency,* *Final energy consumption by*

Sector	Description	Legislation	Parameters/Variables
			sector by fuel type, *Share of different forms of energy*
	Biofuels directive (RES)	Directive 2009/28/EC	*Consumption of renewable energy for cooling,* *Consumption of renewable energy for heating,* *Energy efficiency,* *Final energy consumption by sector by fuel type,* *Fuel specification,* *Share of renewables in electricity generation*
	Amending Emissions Trading Scheme to improve and extend the greenhouse gas emission allowance trading scheme of the Community	Directive 2009/29/EC	*Electricity consumption,* *Emission factors,* *Final energy consumption by sector by fuel type,* *Share of different forms of energy*
	Geological storage of CO_2	Directive 2009/31/EC	*Electricity consumption,* *Emission factors,* *Final energy consumption by sector by fuel type,* *Share of different forms of energy*
	Recast of the Ecodesign requirements for energy-using products	Directive 2009/125/EC	*Electricity consumption,* *Emission factors,* *Energy efficiency,* *Final energy consumption by sector by fuel type*
	Framework for the setting of Ecodesign requirements for energy-using products	Directive 2008/28/EC	*Electricity consumption,* *Energy efficiency,* *Final energy consumption by sector by fuel type*
	Integrated pollution prevention and control (IPPC) recast	Directive 2008/1/EC	*Emission factors*
	End-use efficiency and energy services	Directive 2006/32/EC	*Electricity consumption,* *Energy efficiency,* *Final energy consumption by sector by fuel type*
	Ecodesign requirements for energy-using products	Directive 2005/32/EC	*Electricity consumption,* *Emission factors,* *Energy efficiency,* *Final energy consumption by sector by fuel type*
	Promotion of cogeneration	Directive 2004/8/EC	*Electricity consumption,* *Energy efficiency,* *Final energy consumption by*

Sector	Description	Legislation	Parameters/Variables
			sector by fuel type
	Kyoto Protocol	Directive 2004/101/EC	*Emission factors*
	Shifting the balance between modes of transport, in particular towards rail	Directive 2004/49/EC	*Electricity consumption*
	Energy labelling of household appliances (friges and freezers)	Directive 2003/66/EC	*Electricity consumption, Energy efficiency, Final energy consumption by sector by fuel type*
	Common rules for the internal market in natural gas	Directive 2003/55/EC	*Electricity consumption, Final energy consumption by sector by fuel type, Share of different forms of energy*
	Emissions Trading Scheme (ETS Directive)	Directive 2003/87/EC	*Electricity consumption, Emission factors, Energy efficiency, Final energy consumption by sector by fuel type, Share of different forms of energy*
	Taxation of energy products and electricity	Directive 2003/96/EC	*Electricity consumption, Final energy consumption by sector by fuel type, Fuel price, Share of different forms of energy*
	Internal electricity market	Directive 2003/54/EC	*Electricity consumption, Final energy consumption by sector by fuel type, Share of different forms of energy*
	Energy labelling of household appliances (air conditioners)	Directive 2002/31/EC	*Electricity consumption, Energy efficiency, Final energy consumption by sector by fuel type*
	Energy labelling of household appliances (electric ovens)	Directive 2002/40/EC	*Electricity consumption, Energy efficiency, Final energy consumption by sector by fuel type*
	Energy performance of buildings	Directive 2002/91/EC	*Electricity consumption, Emission factors, Energy efficiency, Final energy consumption by sector by fuel type*
	Electricity production from renewable energy sources	Directive 2001/77/EC	*Consumption of renewable energy for cooling,*

Sector	Description	Legislation	Parameters/Variables
			Consumption of renewable energy for heating, *Share of renewables in electricity generation,* *Share of renewables in energy production*
	Emissions from large combustion plants	Directive 2001/80/EC	*Emission ceilings for air pollutants*
	National Emission Ceilings for certain pollutants (NEC Directive)	Directive 2001/81/EC	*Emission ceilings for air pollutants*
	Energy efficiency requirements for ballasts for fluorescent lighting	Directive 2000/55/EC	*Electricity consumption,* *Energy efficiency,* *Emission factors,* *Final energy consumption by sector by fuel type*
	Energy labelling of household appliances (dish washers)	Directive 99/9/EC	*Electricity consumption,* *Energy efficiency,* *Final energy consumption by sector by fuel type*
	Energy labelling of household appliances (lamps)	Directive 98/11/EC	*Electricity consumption,* *Energy efficiency,* *Final energy consumption by sector by fuel type*
	Energy labelling of household appliances (washer-driers)	Directive 96/60/EC	*Electricity consumption,* *Energy efficiency,* *Final energy consumption by sector by fuel type*
	Energy labelling of household appliances (washing machines)	Directive 96/89/EC	*Electricity consumption,* *Energy efficiency,* *Final energy consumption by sector by fuel type*
	Labelling and standard product information of the consumption of energy and other resources by household appliances	Directive 92/75/EC	*Electricity consumption,* *Energy efficiency,* *Final energy consumption by sector by fuel type*
	Efficiency requirements for new hot-water boilers fired with liquid or gaseous fuels	Directive 92/42/EEC	*Electricity consumption,* *Emission factors,* *Energy efficiency,* *Final energy consumption by sector by fuel type*
	Emissions from large combustion plants (LCP Directive)	Directive 88/609/EEC	*Energy production,* *Final energy consumption by sector by fuel type,* *Share of different technologies*
	Decision:		
	Effort Sharing Decision	Decision 406/2009/EC	*Electricity consumption,* *Final energy consumption by*

Sector	Description	Legislation	Parameters/Variables
			sector by fuel type, *Share of different forms of energy*
	Regulations:		
	Shifting the balance between modes of transport, in particular towards rail	Regulation 881/2004	*Electricity consumption*
	Energy-efficiency labelling for office equipment recast	Regulation 106/2008	*Electricity consumption,* *Emission factors,* *Energy efficiency,* *Final energy consumption by sector by fuel type*
	Community energy efficiency labelling programme for office equipment	Regulation 2422/2001	*Electricity consumption,* *Emission factors,* *Energy efficiency,* *Final energy consumption by sector by fuel type*
	Community eco-management and audit scheme (EMAS)	Regulation 761/2001	*Energy efficiency,* *Final energy consumption by sector by fuel type*
	Regulations implementing Directive 2005/32/EC:		
	Ecodesign requirements for simple set-top boxes	Regulation 107/2009	*Electricity consumption,* *Emission factors,* *Energy efficiency,* *Final energy consumption by sector by fuel type*
	Ecodesign requirements for standby and offoff mode electric power consumption	Regulation 1275/2008	
	Ecodesign requirements for non-directional household lamp	Regulation 244/2009	
	Ecodesign requirements for fluorescent lamps	Regulation 245/2009	
	Ecodesifn requirements for external power supplies	Regulation 278/2009	
	Ecodesign requirements for electric motors	Regulation 640/2009	
	Ecodesign requirements for circulators	Regulation 641/2009	
	Ecodesign requirements for television	Regulation 642/2009	
	Ecodesign requirements for freezers and refrigerators	Regulation 643/2009	
	Others:		
	Energy-efficiency labelling programmes for office equipment	2006/1005/EC	*Electricity consumption,* *Energy efficiency,* *Final energy consumption by sector by fuel type*

In addition, there are policies and measures that are indirectly relevant to the energy industries. These include:

- o Efficiency requirements for new hot-water boilers fired with liquid or gaseous fuels (Directive 92/42/EEC);
- o Labelling and standard product information of the consumption of energy and other resources by household appliances (Directive 92/75/EC);
- o Energy efficiency requirements for ballasts for fluorescent lighting (Directive 2000/55/EC);
- o Energy performance of buildings Directive (Decision 2002/91/EC);
- o Energy labelling of household appliances (Directive 2002/31/EC for air conditioners, Directive 2002/40/EC for electric ovens, Directive 2003/66/EC for refrigerators and freezers, Directive 96/60/EC for washer-driers, Directive 96/89/EC for washing machines, Directive 98/11/EC for lamps and Directive 99/9/EC for dishwashers);
- o Ecodesign requirements for energy-using products (Directive 2005/32/EC);
- o End-use efficiency and energy services (Directive 2006/32/EC);
- o Framework for setting of Ecodesign requirements for energy-using products (Directive 2008/28/EC);
- o Energy efficiency labelling programmes for office equipment (Regulation 106/2008);
- o European Energy Programme for Recovery (Regulation 2009/663/EC); and
- o Community eco-management and audit scheme (Regulation 761/2001).

Indicators for projections to monitor and evaluate progress with PAMs include energy-related CO2 intensity of industry (t/EUR million) and specific CO2 emissions of public and autoproducer power plants (t/TJ)[3].

1.3.5   Source Specific QA/QC

It is important to ensure that resulting emission projections have similar verification and QA/QC as applied to the historic inventory.

A "general" QA/QC (described in General Guidance – Part A Chapter A.8: Quality Assurance and Quality Control (QA/QC) for Projections) should be undertaken to ensure the quality (TCCCA) of the MS GHG projections from energy industries (see also 1.A. Fuel Combustion section 1.2.5)

Issues to take into consideration in addition to the general QA/QC guidelines include:

- o The projections should be estimated using appropriate national assumptions on implementation of PAMs. These PAMs are put in place in order for Member States to achieve legislative and other limits on emissions. These include EU-level commitments (such as the EU ETS and ESD) as well as national and/or regional targets (such as carbon budgets/caps for countries, regions or sectors). For instance, Member States would determine what set of emission mitigation

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[3]   Based on the Decision 2005/166/EC.

actions would be implemented as a part of complying with the ESD, and these
activities should be the basis of the emissions projections. It is not recommended
that these targets would be automatically met without planned mitigation
activities and the forecast of emissions is 'back-casted';

o Checking input (e.g. fuel consumption) and output (e.g. electricity generation and
emission projections) against those used and produced by international models
such as PRIMES/GAINS, and accounting for any divergences;

o Checking against the historical time series for activity data and emission factors as
well as overall emissions.

o It is good practice to conduct these QA/QC activities within the internal GHG
projections team but it could be supplemented by independent reviews by
experts. This would provide assurance on the methods, assumptions and data
sources used in the projected estimates of GHG emissions.

1.4 Combustion in Manufacturing Industry and Construction (IPCC 1.A.2)

1.4.1 Source description

This emissions source comprises of primarily CO_2 emissions from fuels combusted by the
manufacturing industries & construction sector.

The 2006 IPCC Guidelines subdivide the manufacturing industry & construction sector using the
International Standard Industrial Classification (ISIC), which is a classification developed by the
United Nations, as follows:

Table 7 Detailed sector split for Combustion in Manufacturing Industry and Construction.

IPCC 2006 source category		Description	IPCC 1996	Re-port
1A2	Manufacturing Industries and Construction	Emissions from combustion of fuels in industry. Also includes combustion for the generation of electricity and heat for own use in these industries. Emissions from fuel combustion in coke ovens within the iron and steel industry should be reported under 1 A 1 c and not within manufacturing industry. Emissions from the industry sector should be specified by sub-categories that correspond to the International Standard Industrial Classification of all Economic Activities (ISIC). Energy used for transport by industry should not be reported here but under Transport (1 A 3). Emissions arising from off-road and other mobile machinery in industry should, if possible, be broken out as a separate subcategory. For each country, the emissions from the largest fuel-consuming industrial categories ISIC should be reported, as well as those from significant emitters of pollutants. A suggested list of categories is outlined below.	1A2	☑
1A2a	Iron and Steel	ISIC Group 271 and Class 2731.	1A2a	☑
1A2b	Non-Ferrous Metals	ISIC Group 272 and Class 2732.	1A2b	☑
1A2c	Chemicals	ISIC Division 24.	1A2c	☑
1A2d	Pulp, Paper and Print	ISIC Divisions 21 and 22.	1A2d	☑

IPCC 2006 source category		Description	IPCC 1996	Report
1A2e	Food Processing, Beverages and Tobacco	ISIC Divisions 15 and 16. Includes products such as glass ceramic, cement, etc.	1A2e	☑
1A2f	Non-Metallic Minerals	ISIC Division 26.	1A2f	
1A2g	Transport Equipment	ISIC Divisions 34 and 35.	1A2f	
1A2h	Machinery	Includes fabricated metal products, machinery and equipment other than transport equipment. ISIC Divisions 28, 29, 30, 31 and 32.	1A2f	
1A2i	Mining (excluding fuels) and Quarrying	ISIC Divisions 13 and 14.	1A2f	
1A2j	Wood and Wood Products	ISIC Division 20.	1A2f	
1A2k	Construction	ISIC Division 45.	1A2f	
1A2l	Textile and Leather	ISIC Divisions 17, 18 and 19.	1A2f	
1A2 m	Non-specified Industry:	Any manufacturing industry/construction not included above or for which separate data are not available. Includes ISIC Divisions 25, 33, 36 and 37.	1A2f	☑

Source: IPCC (2006)

The last column of the table indicates whether or not emissions and activity data are to be reported in the CRF tables. In the 1996 Guidelines, the source categories 1A2f to 1A2m are reported together under the heading *1A2f Other Industries (please Specify)*. The European Commissions' Reporting Guideline for Projections and National Programmes and European Environment Agency Air Pollutant Emissions Inventory Guidebook follows the 1996 subdivision of the sector. In cases where sector-specific emission source data is not specific, 1A2f "Other" category is used to take into account this non-categorised source of emissions.

1.4.2   Activity data projections

Activity data projections should be based on historic activity data and expected changes in the specific sector in the projection period. Activity data for this sector includes fuel consumption and economic activity driving the fuel consumption such as expansion or closure of manufacturing facilities and efficiency improvements expected to occur in the industry.

As a starting point for activity data projections, the most recent fuel consumption data and production activities data such as production volume, value added or revenue in the given sector may be used and compared to historical activity data for the years 2000, 2005 and 2010 to ensure consistency.

1.4.2.1   Grades and Decision Tree

A wide variety of different modelling approaches and datasets are available and in use at an EU level and by individual Member States. The proposed approach to projecting future activity data depends on the available information. Figure B.1-5 presents a generalized decision tree for

selecting grades for future activity data for combustion in manufacturing industry and construction.
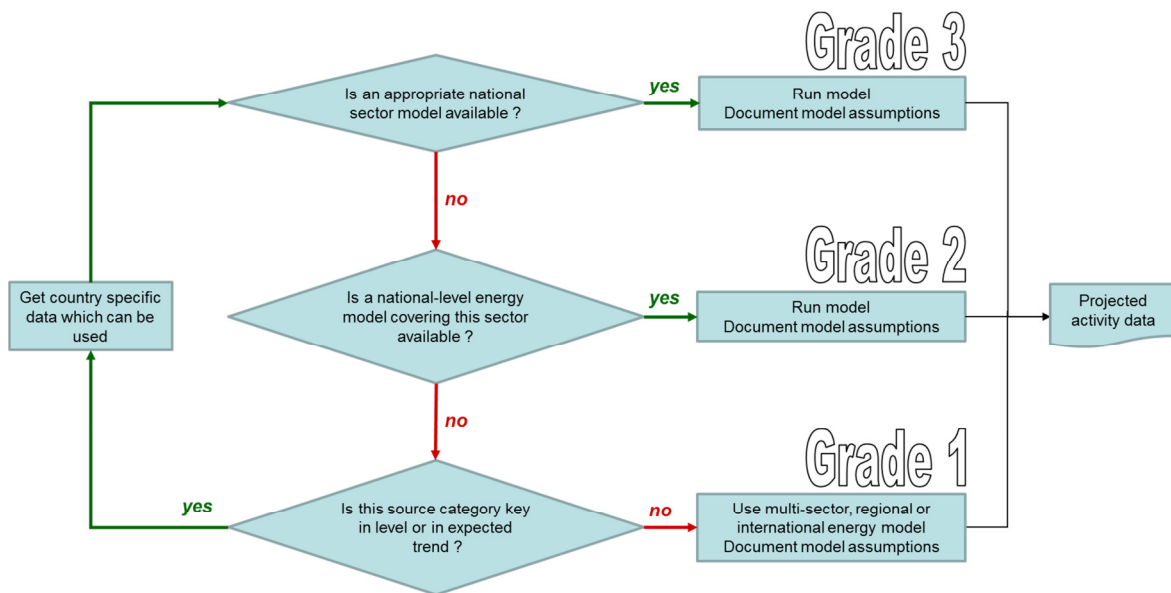
Figure B.1-5 Generalised decision tree for future activity data for combustion in manufacturing industry and construction activities.

1.4.2.2   Grade 1

Where the MS-level energy model or existing database is insufficient to project robust future fuel consumption data in the individual manufacturing industries & construction subsectors (i.e., 1A2a to 1A2f), the results of a regional or international energy model such as the PRIMES or World Energy Model can be used (see section1.2.2.3).

- o   The PRIMES model splits the industry sector into nine subsectors: (1) iron and steel; (2) non-ferrous metals; (3) chemicals; (4) building materials; (5) paper and pulp; (6) food, drink and tobacco; (7) engineering; (8) textiles; and (9) other industrial sectors. For each of these subsectors, the PRIMES model projects energy demand, value added and sectoral production.
- o   The World Energy Model splits the industry sector into five subsectors: (1) iron and steel; (2) chemical and petrochemical; (3) non-metallic minerals; (4) paper, pulp and printing, and (5) other industry, which aggregates non-ferrous metals, transport equipment, machinery, mining and quarrying, food and tobacco, wood and wood products, construction, textile and leather, and non-specified. For each of these subsectors, World Energy Model projects energy demand and CO_2 emissions[4].

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[4] CO_2 emissions are calculated by multiplying energy demand by an implied CO_2 content factor. Implied CO_2 content factors for coal, oil and gas differ between sectors and regions, reflecting the product mix.

Whichever source is used, the data should be linked to/check against MS level activity data from the emissions inventory, in order to ensure consistency. If any inconsistencies are apparent (e.g. baseline activity data differs significantly between the model and MS inventory), a simple approach would be to take the percentage changes from the external energy model and apply these to the data used in the national inventory.

It is not good practice to use a Grade 1 method for categories which are key sources and/or are expected to become a key source category.

1.4.2.3   Grade 2

If a subsector model is not available but a national-level energy model covering the combustion in manufacturing industry and construction exists then the last can be used for activity data projections. Grade 2 approach includes some more country specific data which should be used if available and should be appropriately reported.

1.4.2.4   Grade 3

If projection of future fuel consumption at the individual subsector level is available at the MS level, then this can be used for activity data for calculating emissions projections. Potential source of information could be sector-specific models, trade associations or individual companies within the sector. If projection of future production activities in the individual subsector is available at the MS level, then the growth rate from this projection can be applied to the most recent year's fuel consumption data to project future fuel consumption for the sector.

In order to ensure consistency of the activity data projection with the rest of emission projection, the general assumptions including macroeconomic drivers and policies and measures incorporated in the projection scenario for in the model that generated sector-specific activity data projection should be checked against the general assumptions used in the MS-level energy model.

1.4.3   Emission Factor projections

1.4.3.1   Grades and Decision Tree

Figure B.1-6 presents a generalized decision tree for selecting grades for future emission factors for combustion in manufacturing industry and construction. This decision tree applies in general for each of the combustion in manufacturing industry and construction activities.
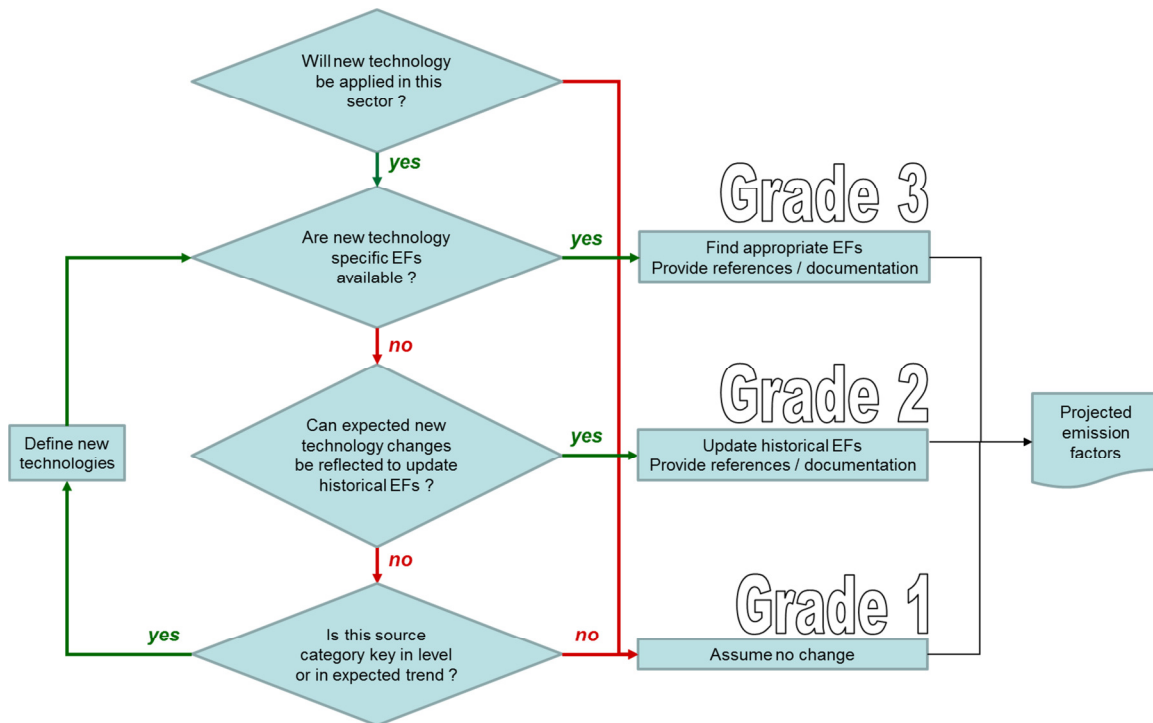
Figure B.1-6 Generalised decision tree for future emission factors combustion in manufacturing industry and construction activities.

1.4.3.2   Grade 1

Where no data are available on emission factors for the manufacturing industries & construction subsectors at the Member State level, the default emission factor values in the 2006 IPCC Inventory Guidelines or the most recent emission factor in the national GHG inventory can be used.

For manufacturing industries & construction, the default emission factors are listed in Table 2.3 (pg 2.18-2.19) in Chapter 2: Stationary Combustion. The IPCC Emission Factor Database (EFDB) also allows users to search for default emission factors on the web: http://www.ipcc-nggip.iges.or.jp/EFDB/find_ef_main.php.

1.4.3.3   Grade 2

Grade 2 projections are expected to take account of future technology changes thus future changes to emission factors. Grade 2 emission factors are extrapolated by MS from the historic values, using information on the expected changes in technologies and practices relevant for the emissions in some or all source categories.

As with the Emission Inventory Guidelines, the Grade 2 approach is to use country-specific emission factors derived from measurement (or calculation). These may include national emission factors and/or regional emission factors.

It is good practice that such emission factors are based on a sufficient number of sources to provide a good representation of the average conditions in the Member State for the source type, taking into

account fuel type and composition, type and size of the combustion unit, firing conditions, load, type of control technologies and maintenance level.

1.4.3.4   Grade 3

The Grade 3 approach includes technology-specific emission factors, as with the IPCC Emission Inventory Guidelines. Such factors are generally more appropriate where non-CO_2 greenhouse gas emissions are concerned. The 2006 IPCC Inventory Guidelines provide examples of uncontrolled emission factors for methane and nitrous oxide by technology, fuel type and configuration.

Emission factors are extrapolated by MS from the historic values, using information on existing sources of emissions, the expected changes in technologies and practices relevant for the emissions in some or all source categories.

It is good practice that these emission factors are based on a sufficient number of sources to provide a good representation of the average conditions in the Member State for the source type, taking into account fuel type and composition, type and size of the combustion unit, firing conditions, load, type of control technologies and maintenance level.

1.4.4   Policies and Measures

1.4.4.1   General

The projections developed should directly incorporate or be checked against legislative and other limits on emissions and/or lead to changes in overall energy demand and supply balance. It is good practice to ensure that these effects are taken into account in the proper source category and transparently documented in the national projections report. It is recommended that Member States set out clearly (e.g. in a tabular format) how each of the policies and measures has been taken into account in the projections.

In some cases, there may be potential cross-sectoral effects of policies and measures (PAMs). For instance, a transportation policy aiming to increase the use of rail would lead to an increase in electricity demand. Therefore it is good practice to carefully review existing PAMS and take into account their potential effects on the activity and emission factor projections.

Table below lists the European Directives that are directly relevant to the manufacturing industry and construction. In addition to the European-level policies and measures, there may be national policies and measures that would have direct or indirect impacts on the sector, therefore it is good practice to consider these effects are taken into account and transparently document in the projections.

The projections developed should either directly incorporate or be checked against legislative and other limits on emissions. It is recommended that Member States set out clearly (e.g. in a tabular format) how each of the policies and measures has been taken into account in the projections.

Table 8   **Policies and Measures and related parameters affected by implementation of particular PAM in Industrial Combustion sector.**

Sector	Description	Legislation	Parameters/Variables
Industrial Combustion	*Directives:*		
	Industrial Emissions Directives	Directive 2010/75EC	*Emission ceilings for air pollutants,* *Emission factors,* *Energy production,* *Final energy consumption by sector by fuel type,* *Fuel efficiency* *Share of different technologies*
	Amending Emissions Trading Scheme to improve and extend the greenhouse gas emission allowance trading scheme of the Community	Directive 2009/29/EC	*Electricity consumption,* *Emission factors,* *Final energy consumption by sector by fuel type,* *Share of different forms of energy*
	Integrated pollution prevention and control (IPPC) recast	Directive 2008/1/EC	*Emission factors*
	End-use efficiency and energy services	Directive 2006/32/EC	*Electricity consumption,* *Energy efficiency,* *Final energy consumption by sector by fuel type*
	Kyoto Protocol	Directive 2004/101/EC	*Emission factors*
	Promotion of cogeneration	Directive 2004/8/EC	*Electricity consumption,* *Energy efficiency,* *Final energy consumption by sector by fuel type*
	Taxation of energy products and electricity	Directive 2003/96/EC	*Electricity consumption,* *Final energy consumption by sector by fuel type,* *Fuel price,* *Share of different forms of energy*
	Emissions Trading Scheme (ETS Directive)	Directive 2003/87/EC	*Electricity consumption,* *Emission factors,* *Energy efficiency,* *Final energy consumption by sector by fuel type,* *Share of different forms of energy*
	National Emission Ceilings for certain pollutants (NEC Directive)	Directive 2001/81/EC	*Emission ceilings for air pollutants*
	Emissions from large combustion plants	Directive 2001/80/EC	*Emission ceilings for air pollutants*
	Emissions from large combustion	Directive 88/609/EEC	*Energy production,*

Sector	Description	Legislation	Parameters/Variables
	plants (LCP Directive)		*Final energy consumption by sector by fuel type,* *Share of different technologies*
	Decision:		
	Effort Sharing Decision	Decision 406/2009/EC	*Electricity consumption,* *Final energy consumption by sector by fuel type,* *Share of different forms of energy*

In addition, there are policies and measures that are indirectly relevant to the manufacturing industry and construction. These would include:

- o Efficiency requirements for new hot-water boilers fired with liquid or gaseous fuels (Directive 92/42/EEC);
- o Labelling and standard product information of the consumption of energy and other resources by household appliances (Directive 92/75/EC);
- o Energy efficiency requirements for ballasts for fluorescent lighting (Directive 2000/55/EC);
- o Energy performance of buildings Directive (Decision 2002/91/EC);
- o Energy labelling of household appliances (Directive 2002/31/EC for air conditioners, Directive 2002/40/EC for electric ovens, Directive 2003/66/EC for refrigerators and freezers, Directive 96/60/EC for washer-driers, Directive 96/89/EC for washing machines, Directive 98/11/EC for lamps and Directive 99/9/EC for dishwashers);
- o Ecodesign requirements for energy-using products (Directive 2005/32/EC);
- o End-use efficiency and energy services (Directive 2006/32/EC);
- o Framework for setting of Ecodesign requirements for energy-using products (Directive 2008/28/EC);
- o Energy efficiency labelling programmes for office equipment (Regulation 106/2008);
- o European Energy Programme for Recovery (Regulation 2009/663/EC); and
- o Community eco-management and audit scheme (Regulation 761/2001).

Indicators for projections to monitor and evaluate progress with PAMs include energy-related CO_2 intensity for selected industries (t/EUR million) and specific CO2 emissions for selected industries (t emissions/t product).

1.4.4.2   ETS and non-ETS sector split

Some of the emission sources in this sector are currently covered by the EU ETS Phase II, and more will be covered in the EU ETS Phase III beginning 2013. Under the Effort Sharing Decision (ESD), MS are committed to reducing emissions from non-EU ETS covered sources.

For options on how to split emissions from EU ETS covered sources and non-covered sources, please see section 1.A. Fuel Combustion section 1.2.4.2.

1.4.5   Source Specific QA/QC

It is important to ensure that resulting emission projections have similar verification and QA/QC as applied to the historic inventory.

A "general" QA/QC (described in General Guidance – Part A Chapter A.8: Quality Assurance and Quality Control (QA/QC) for Projections) should be undertaken to ensure the quality (TCCCA) of the MS GHG projections from combustion in manufacturing industry and construction (see also 1.A. Fuel Combustion section section 1.2.5).

Issues to take into consideration in addition to the general QA/QC guidelines include:

- o   The potential difference in the sectoral breakdown in the information that is available to the MS and the categories specified by this guideline (based on 1996 IPCC Guidelines). This may be due to availability of information or specific design of the model used in projecting GHG emissions from this sector. It is good practice to first check whether the sub-sectoral information available at the MS level matches the International Standard Industrial Classification of all Economic Activities (ISIC) used by IPCC and recommended by this Guideline (i.e. 1A2a/Iron and Steel, 1A2b/Non-Ferrous Metals, 1A2c/Chemicals, 1A2d/Pulp, Paper and Print, 1A2e/Food Processing, Beverages and Tobacco and 1A2f/Others). National Accounting Matrix with Environmental Accounts (NAMEA) could also be used. If it is unclear whether certain emission sources corresponds to a specific sub-category of industrial industries and construction, then it is good practice to assign them in 1A2f "Others" category and provide a description of the emission sources.
- o   In some cases, the model used in projecting GHG emissions from manufacturing industries and construction may combine emissions from fuel combustion and process emissions in the output. For the projections, the fuel combustion emissions and process emissions should be disaggregated. This can be done either applying the historical proportion (based on the most recent inventory data) to the projections or by estimating non-process emissions based on the amount of fuel consumed by the Member State.
- o   It is good practice to check consistency with activity data and other relevant assumptions (e.g. specific technology uptake rates) on process emissions to ensure that the basic assumptions made in projecting fuel combustion emissions from this sector are consistent with those made in projecting process emissions from the same sources.
- o   It is good practice to conduct these QA/QC activities within the internal GHG projections team but it could be supplemented by independent reviews by experts. This would provide assurance on the methods, assumptions and data sources used in the projected estimates of GHG emissions.

1.5   Transport (IPCC 1.A.3)

1.5.1   Introduction

Mobile sources produce direct greenhouse gas emissions of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) from the combustion of various fuel types, as well as several other pollutants such as carbon monoxide (CO), Non-methane Volatile Organic Compounds (NMVOCs), sulphur dioxide (SO_2), particulate matter (PM) and oxides of nitrogen (NOx), which cause or contribute to local or regional air pollution. This chapter covers good practice in the development of estimates for the direct greenhouse gases CO_2, CH_4, and N_2O . Greenhouse gas emissions from mobile combustion and evaporation of fuel are most easily estimated by major transport activity, i.e., road, off-road, air, railways, and water-borne navigation (Table 9).

Table 9 Detailed sector split for Transport.

IPCC 2006 source category		Description	Re-port
1A3	Transport	Emissions from the combustion and evaporation of fuel for all transport activity (excluding military transport), regardless of the sector, specified by sub-categories below. Emissions from fuel sold to any air or marine vessel engaged in international transport (1 A 3 a i and 1 A 3 d i) should as far as possible be excluded from the totals and subtotals in this category and should be reported separately.	☑
1A3a	Civil Aviation	Emissions from international and domestic civil aviation, including take-offs and landings. Comprises civil commercial use of airplanes, including: scheduled and charter traffic for passengers and freight, air taxiing, and general aviation. The international/domestic split should be determined on the basis of departure and landing locations for each flight stage and not by the nationality of the airline. Exclude use of fuel at airports for ground transport which is reported under 1 A 3 e Other Transportation. Also exclude fuel for stationary combustion at airports; report this information under the appropriate stationary combustion category.	☑
1A3b	Road Transportation	All combustion and evaporative emissions arising from fuel use in road vehicles, including the use of agricultural vehicles on paved roads.	☑
1A3c	Railways	Emissions from railway transport for both freight and passenger traffic routes.	☑
1A3d	Water-borne Navigation	Emissions from fuels used to propel water-borne vessels, including hovercraft and hydrofoils, but excluding fishing vessels. The international/domestic split should be determined on the basis of port of departure and port of arrival, and not by the flag or nationality of the ship.	☑
1A3e	Other Transportation	Combustion emissions from all remaining transport activities including pipeline transportation, ground activities in airports and harbours, and off-road activities not otherwise reported under 1 A 4 c Agriculture or 1 A 2. Manufacturing Industries and Construction. Military transport should be reported under 1 A 5 (see 1 A 5 Non-specified).	☑

Source: IPCC (2006)

1.5.2   Policies and Measures

A number of specific policies and measures will have an effect on GHG emissions from transport sector in the future. Table 10 presents the relevant EU legislation. It is recommended to check PAM interactions (which are parent and which child PAMs) as per General Guidance – Part A Chapter A.0: Compiling an Emission Projection: A harmonized Approach, section 0.6 Policies and measures interactions.

Table 10 Policies and Measures and related parameters affected by implementation of particular PAM in Transport sector.

Policy area	Description	Legislation	Parameters/Variables
Cross cutting	*Directives:*		
	Biofuels directive	Directive 2009/28/EC	*Energy efficiency, Final energy consumption by sector by fuel type, Fuel specification, Share of biofuels in transport, Share of renewables in electricity generation*
	Taxation of energy products and electricity	Directive 2003/96/EC	*Electricity consumption, Final energy consumption by sector by fuel type, Fuel price, Share of different forms of energy*
	EU Emissions trading scheme	Directive 2003/87/EC	*Electricity consumption, Emission factors, Energy efficiency, Final energy consumption by sector by fuel type, Share of different forms of energy*
	National Emission Ceilings for certain pollutants (NEC Directive)	Directive 2001/81/EC	*Emission ceilings for air pollutants*
	Decision:		
	Effort Sharing Decision	Decision 406/2009/EC	*Electricity consumption, Final energy consumption by sector by fuel type, Share of different forms of energy*
Transport	*Directives:*		
	Promotion of clean and energy efficient road transport vehicles	Directive 2009/33/EC	*Emission factors, Fuel specification*

Policy area	Description	Legislation	Parameters/Variables
	Fuel Quality Directive	Directive 2009/30/EC	*Emission factors,* *Fuel specification*
	Amending Directive 2003/87/EC so as to include aviation activities in the scheme for greenhouse gas emission allowance	Directive 2008/101/EC	*Final energy consumption by sector by fuel type,* *Shares of different forms of energy*
	Development of the Community's railways	Directive 2007/58/EC	*Electricity consumption,* *Fuel switch in transport,* *Fuel use per transport mode,* *Kilometers driven per transport mode,* *Modal shift in transport*
	Mobile Air Conditioning Directive	Directive 2006/40/EC	*Fuel efficiency,* *Fuel use per transport mode,* *Share of gases in personal cars*
	Euro vignette	Directive 2006/38/EC	*Share of freight transport per mode*
	Shifting the balance between modes of transport, in particular towards rail	Directive 2004/51/EC Directive 2004/50/EC Directive 2004/49/EC	*Electricity consumption,* *Fuel switch in transport,* *Fuel use per transport mode,* *Kilometers driven per transport mode,* *Modal shift in transport*
	Biofuel Directive	Directive 2003/30/EC	*Final energy consumption by sector by fuel type,* *Fuel switch in transport,* *Share of biofuels in transport*
	Shifting the balance between modes of transport, in particular towards rail	Directive 2001/14/EC Directive 2001/13/EC Directive 2001/12/EC	*Electricity consumption,* *Fuel switch in transport,* *Fuel use per transport mode,* *Kilometers driven per transport mode,* *Modal shift in transport*
	Labelling of new passenger car	Directive 1999/94/EC	*Fuel efficiency*
	Regulations:		
	Labelling of tyres	Regulation 1222/2009	*Emission factors,* *Fuel efficiency*
	Regulation Euro VI for heavy duty vehicles	Regulation 2009/598/EC	*Emission factors*
	Strategy for cars CO2	Regulation 443/2009	*Emission factors*
	Regulation EURO 5 and 6	Regulation 2007/715/EC	*Emission factors*

Policy area	Description	Legislation	Parameters/Variables
	Marco Polo II	Regulation 1692/2006	*Electricity consumption, Fuel switch in transport, Fuel use per transport mode, Kilometers driven per transport mode, Modal shift in transport*
	Marco Polo Programme	Regulation 1382/2003	
	Shifting the balance between modes of transport, in particular towards rail	Regulation 881/2004	*Electricity consumption, Fuel switch in transport, Fuel use per transport mode, Kilometers driven per transport mode, Modal shift in transport*
	Others:		
	Integrated European railway area (2nd + 3rd Railway package)	COM(2002)18 final	*Electricity consumption, Fuel switch in transport, Fuel use per transport mode, Kilometers driven per transport mode, Modal shift in transport, Share of different forms of energy*
	ACEA Agreement Voluntary agreement to reduce specific CO2 emissions from cars	1999/125/EC	*Emission factors, Fuel efficiency*
	Voluntary agreement to reduce specific CO2 emissions from cars	KAMA, JAMA	
	Regulation EURO 5 and 6	Regulation 2007/715/EC	*Emission factors*
	Regulation Euro VI for heavy duty vehicles	Regulation 2009/595/EC	*Emission factors*

1.5.3   Civil Aviation (IPCC 1.A.3.a)

1.5.3.1   Source description

Emissions from aviation come from the combustion of jet fuel (jet kerosene and jet gasoline) and aviation gasoline (a fuel used only in small piston engine aircraft, and which generally represents less than 1 percent of fuel used in aviation).

Aircraft engine emissions are roughly composed of about 70 percent CO_2 , a little less than 30 percent H_2O, and less than 1 percent each of NOx, CO, SOx , NMVOC, particulates, and other trace components including hazardous air pollutants. Little or no N_2O emissions occur from modern gas turbines. Methane (CH_4) may be emitted by gas turbines during idle and by older technology

engines, but recent data suggest that little or no CH_4 is emitted by modern engines.
Emissions depend on the number and type of aircraft operations; the types and efficiency of the
aircraft engines; the fuel used; the length of flight; the power setting; the time spent at each stage of
the flight; and, to a lesser degree, the altitude at which exhaust gases are emitted.

For the purpose of these guidelines (as for 2006 IPCC Guidelines for National Greenhouse gas
Inventories), operations of aircraft are divided into:

    o   Landing/Take-Off (LTO) cycle
    o   Cruise

Generally, about 10 percent of aircraft emissions of all types, except hydrocarbons and CO, are
produced during airport ground level operations and during the LTO cycle. The bulk of aircraft
emissions (90 percent) occur at higher altitudes. For hydrocarbons and CO, the split is closer to 30
percent local emissions and 70 percent at higher altitudes (IPCC, 2006).

This source category (see also Table 11) includes emissions from all civil commercial use of airplanes,
including civil and general aviation (e.g. agricultural airplanes, private jets or helicopters). Emissions
from military aviation are not included in this source category.

The total Civil Aviation source category covers emissions from international[5] and domestic civil
aviation, including take-offs and landings. The category comprises civil commercial use of airplanes,
including: scheduled and charter traffic for passengers and freight, air taxiing, and general aviation.
The international/domestic split should be determined on the basis of departure and landing
locations for each flight stage and not by the nationality of the airline.
Exclude use of fuel at airports for ground transport and also fuel for stationary combustion at
airports.

For the purpose of GHG projections (as for the emissions inventories), a distinction is made between
domestic and international aviation. All emissions from fuels used for international aviation
(bunkers) and multilateral operations pursuant to the UNFCCC reporting guidelines are to be
excluded from national totals.

Table 11 Detailed sector split for Civil Aviation.

IPCC 2006 source category		Description	Report
1A3a	Civil Aviation	Emissions from international and domestic civil aviation, including take-offs and landings. Comprises civil commercial use of airplanes, including: scheduled and charter traffic for passengers and freight, air taxiing, and general aviation. The international/domestic split should be determined on the basis of departure and landing locations for each flight stage and not by the nationality of the airline. Exclude use of fuel at airports for ground transport which is reported under 1 A 3 e Other Transportation. Also exclude fuel for stationary combustion at airports; report this information under the appropriate stationary combustion category.	☑

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[5] Emissions from international flights are reported as international bunkers

IPCC 2006 source category		Description	Re-port
1A3ai	International Aviation (International Bunkers)	Emissions from flights that depart in one country and arrive in a different country. Include take-offs and landings for these flight stages. Emissions from international military aviation can be included as a separate sub-category of international aviation provided that the same definitional distinction is applied and data are available to support the definition.	6
1A3aii	Domestic Aviation	Emissions from civil domestic passenger and freight traffic that departs and arrives in the same country (commercial, private, agriculture, etc.), including take-offs and landings for these flight stages. Note that this may include journeys of considerable length between two airports in a country (e.g. San Francisco to Honolulu). Exclude military, which should be reported under 1 A 5 b.	☑

Source: IPCC (2006)

1.5.3.2   Activity data projections

Activity data for civil aviation may include:

- o   GDP (absolute and growth, per sector)
- o   Population (absolute numbers and growth rate and base year value)
- o   Final energy consumption in domestic aviation (PJ per fuel)
- o   Proportional technology split
- o   Modal split (passenger and freight)
- o   Passenger aviation kilometers (Mkm)
- o   Freight tonne kilometres by air transport (Mtkm)

Grades and Decision Tree

As described in 1.A.2 Combustion in Manufacturing Industry and Construction section 1.4.2 the proposed approach to projecting future activity data dependent on the available information. Figure B.1-7 presents a generalized decision tree for selecting grades for future activity data for civil aviation. This decision tree applies for each of the transport modes.

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6   International Bunkers are memo item in the reporting and are not included in the national total.
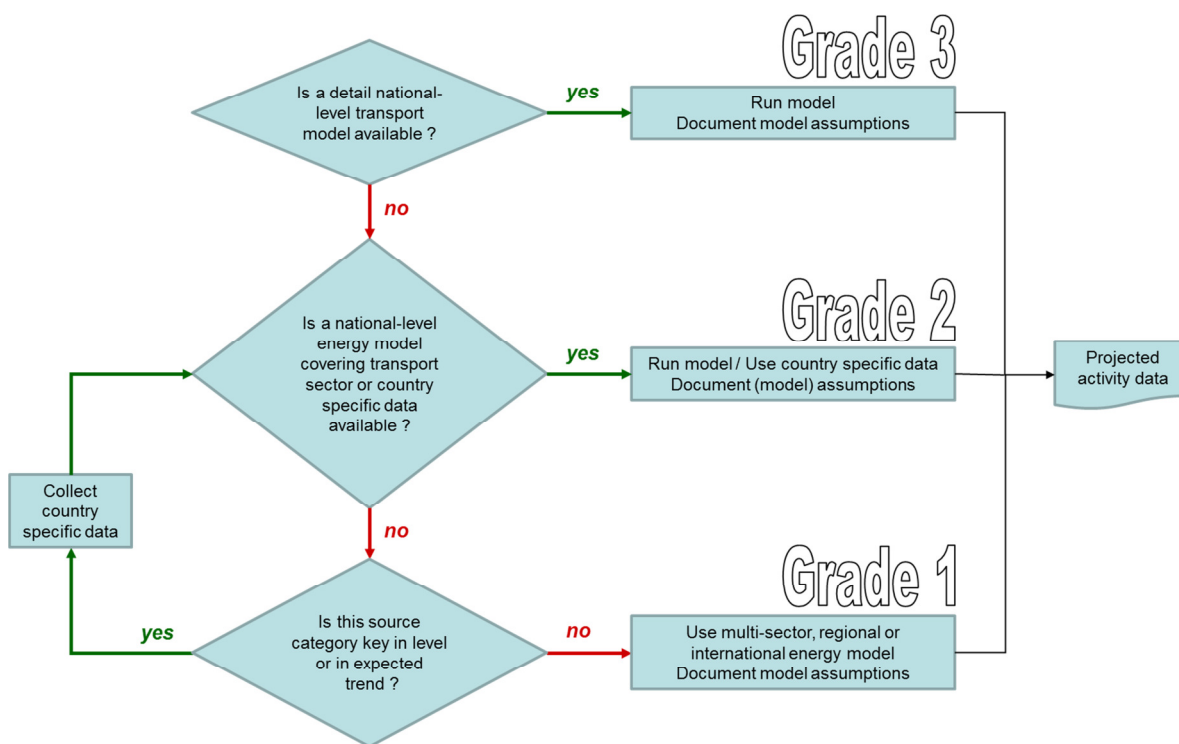
Figure B.1-7 Generalised decision tree for future activity data for all transport modes.

Grade 1

As described in 1.A.2 Combustion in Manufacturing Industry and Construction section 1.4.2.2.

In Grade 1, the projection of activity data in the civil aviation sector would be derived from an available multi-sector, regional or international energy model which includes results for the Member States.

At present, the European Commission uses the PRIMES model to project greenhouse gas (GHG) emissions from fuel combustion in the European Union. Under the Grade 1 approach, one could use the detailed activity projections of the PRIMES model. The PRIMES model's outputs include full detailed EUROSTAT Energy Balance sheets per country and per year, energy demand per country and per year, detailed energy balance including transport activity, modes/means and vehicles, etc. For further details on the PRIMES model please refer to Annex B.1.II for more information.

Another multi-sector energy model is the World Energy Model by the International Energy Agency. Transport demand is modelled in detail by mode and fuel. For further details on the WEO model please refer to Annex B.1.III.

Where data from such models are not provided at the required level of disaggregation for reporting purposes, it may be necessary to apportion activity data using a simplified approach such as pro-rata using data from the historical inventory.

Whichever source is used, the data should be linked to/check against MS level activity data from the emissions inventory, in order to ensure consistency. If any inconsistencies are apparent (e.g. baseline

activity data differs significantly between the model and MS inventory), a simple approach would be to take the percentage changes from the external energy model and apply these to the data used in the national inventory.

Grade 1 approach is not recommended for a key sources, both key in level and in expected trend.

Grade 2

As described in 1.A.2 Combustion in Manufacturing Industry and Construction section 1.4.2.3.

If a national-level energy model is available and this model covers energy use in transport sector it should be used to estimate the projection of activity data in civil aviation sector. If such a model does not exist but there are country specific data available then these data should be used in projecting future activities for transport sector. In both cases the appropriate documentation should be reported.

Grade 3

As described in 1.A.2 Combustion in Manufacturing Industry and Construction section 1.4.2.4.

If a detailed national-level transport model is available it should be used for activity data for civil aviation. The underlying information, e.g. model assumption should be appropriately reported.

1.5.3.3   Emission Factor projections

Grades and Decision Tree

1.A. Fuel Combustion section 1.2.3 introduces Emission Factor projections.

Figure B.1-8 presents a generalized decision tree for selecting grades for future emission factors for civil aviation. This decision tree applies in general for each of the transport modes.
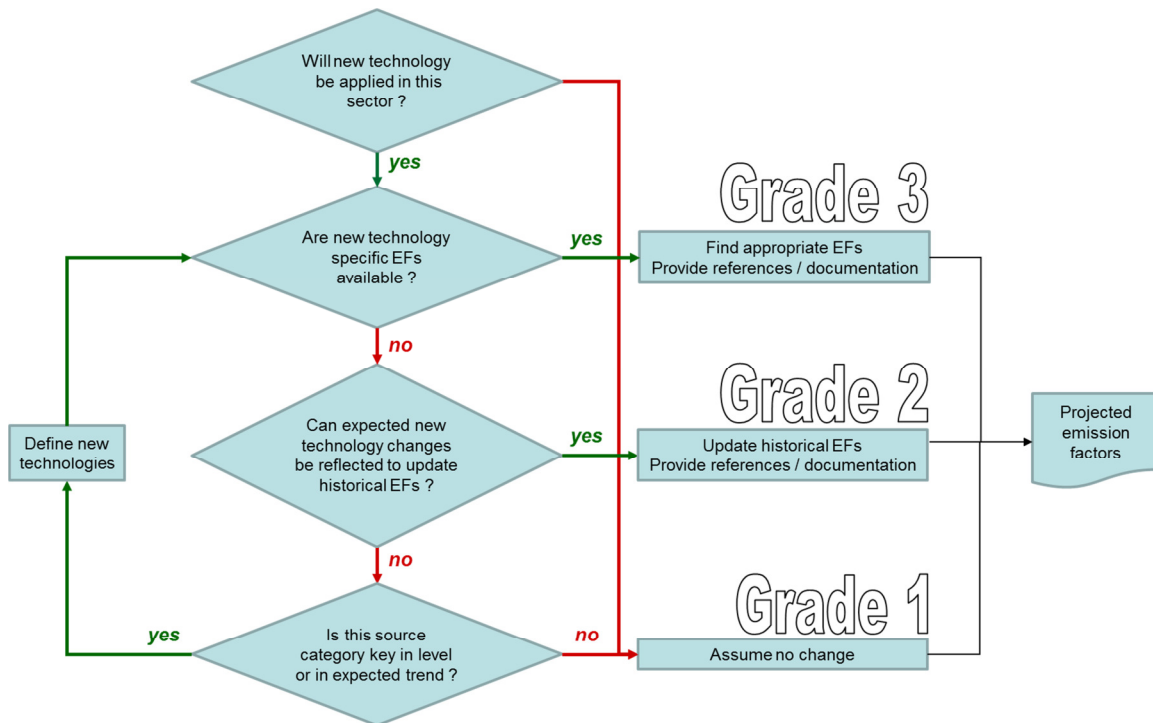
Figure B.1-8 Generalised decision tree for future emission factors for transport activities.

Grade 1

As described in 1.A. Fuel Combustion section 1.2.3.2.

Grade 2

As described in 1.A. Fuel Combustion section 1.2.3.3.

Grade 3

As described in 1.A. Fuel Combustion section 1.2.3.4

1.5.3.4   Policies and Measures

PAMs for transport sector are listed in the 1.A. Fuel Combustion section 1.5.2.

In 1.A. Fuel Combustion section 1.5.4.4 an example of PAM, DIRECTIVE 2009/28/EC on the promotion of the use of energy from renewable sources, is introduced.

1.5.3.5   ETS and non-ETS split

In the GHG projections only domestic civil aviation need to be included in the national total emissions and the projections will need to meet the following requirements:

       o   GHG projections should not differ too much from the historical data.

- o The methodology should be transparent and appropriately reported.
- o GHG projections should be estimated taking into account the caps[7] set down by the Commission governing the inclusion of aviation emissions within Phase III of the EU-ETS.

Airlines joined the EU ETS scheme in 2012. All flights arriving or departing from EU airports are covered by the EU ETS, regardless of the nationality of the aircraft operator. EU MS will be responsible for ensuring compliance with the requirements of the legislation by those aircraft operators to which they issue an operating licence and whose emissions in 2006 were mostly attributable to that MS.

Only commercial aircraft operators that fly fewer than 243 flights for three consecutive four-month periods, emit less than 10,000 tonnes of CO_2 a year, or operate aircraft weighing less than 5,700 kilograms will be exempt from the scheme.

There is a difficulty for estimating the share of the domestic civil aviation in the emissions by the EU ETS as reported by the MS. The civil aviation emission (covered in the MS projections) are based on a territory approach (flights between airports within the MS, independent of the flight operator).

ETS emissions are determined on an operator based approach, so they cover more emissions (as reported to the UNFCC) as all flights from and to a MS airport to airports in another MS are included. In MS' inventories these emission are included in the aviation bunkers. There is no information in the ETS on the attribution of the emissions to individual MS territories.

Only by analysis of very detailed flight data a MS would be able to attribute ETS emission to their own territory. At the moment Eurostat is working on a database which includes data on the CO_2 emissions of the flights between all European airports. These data could be used in such a detailed analysis.

As a default value it is good practice to assume that all or high percentages of national and international emissions of kerosene consumption are included in EU-ETS, since mostly small aircrafts are excluded from EU-ETS, whose kerosene consumption is small. It is good practice to assume that all emissions from aviation gasoline are excluded from EU-ETS since it is mostly used in small aircraft types which are excluded in EU-ETS.

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7   For 2012, the EU will set a cap on airlines' emissions, measured in tonnes of CO_2, set at 97% of the baseline level (the baseline being an average of annual emissions between 2004 and 2006;). From 2013 to 2020, this cap will fall to 95% of the baseline. About 82% of the cap will be issued as free emission allowances in the form of EU Aviation Allowances (EUAAs--that is, EUAs issued to the aviation sector) and allocated to airlines free of charge. A further 15% of the cap will be in the form of allowances that are to be auctioned, while the remaining 3% will be held for new entrants (http://www.environmental-finance.com/download.php?files/pdf/4d663c478efb8/Airline%20Carbon%20Costs%20take%20Off.pdf)

1.5.3.6 Source Specific QA/QC

It is important to ensure that resulting emission projections have similar verification and QA/QC as applied to the historic inventory.

A "general" QA/QC approach (described in General Guidance – Part A Chapter A.8: Quality Assurance and Quality Control (QA/QC) for Projections) should be undertaken to ensure the quality (TCCCA) of the MS GHG projections from civil aviation (see also 1.A. Fuel Combustion section 1.2.5).

It is good practice to check / compare GHG projections from the civil aviation sector against the historical trends for AD and EFs. In case of significant differences it is good practice to explain it. The European Environmental Agency provides a useful dataset[8] which presents emissions and passenger/freight volume for each transportation mode for Europe. Estimates go to 2020 but the data are only available from 2003 onwards and are available for EU15.

The second step is to apply sector specific QA/QC. It is good practice to:

- o Ensure that all remaining civil aviation activities are included: 1A5b Mobile (aviation component) and 1A5c Multilateral Operations (aviation component)[9].
- o check whether applied methods use input data (GDP, population, fuel burned in civil aviation, etc.) that is consistent with national economic, energy and activity projections used elsewhere in the projected emissions estimates.
- o ensure consistency between the outcomes of the MS-energy model and MS-specific model. Consistency should be maintained between final energy consumption in the civil aviation sector and energy consumption used as input to the estimates. It is good practice to check the outcomes against international models/sources, such as: the centrally run energy models, PRIMES, TREMOVE, Eurostat or WEO.
- o reference all data sources within the spread sheets / databases so that the input data is traceable.
- o ensure transparency in the underlying methodology, assumptions and other relevant information of the MS-energy model and MS-specific model by appropriately reporting.

1.5.4 Road Transportation (IPCC 1.A.3.b)

1.5.4.1 Source description

The mobile source category (see also Table 12) Road Transportation includes all types of light-duty vehicles such as automobiles and light trucks, and heavy-duty vehicles such as articulated trucks and buses, and on-road motorcycles (including mopeds, scooters, and three-wheelers). These vehicles operate on different types of gaseous and liquid fuels.

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[8] http://acm.eionet.europa.eu/databases/TRENDS/TRENDS_EU15_data_Sep03.xls

[9] (IPCC, 2006)

Table 12 Detailed sector split for Road Transport.

IPCC 2006 source category		Description	Re-port
1A3b	Road Transportation	All combustion and evaporative emissions arising from fuel use in road vehicles, including the use of agricultural vehicles on paved roads.	☑
1A3bi	Cars	Emissions from automobiles so designated in the vehicle registering country primarily for transport of persons and normally having a capacity of 12 persons or fewer.	
1A3bi	Passenger Cars With 3-way Catalysts	Emissions from passenger car vehicles with 3-way catalysts.	
1A3bi	Passenger Cars Without 3-way Catalysts	Passenger car emissions from vehicles without 3-way catalysts.	
1A3bii	Light-duty Trucks	Emissions from vehicles so designated in the vehicle registering country primarily for transportation of light-weight cargo or which are equipped with special features such as four-wheel drive for off-road operation. The gross vehicle weight normally ranges up to 3500-3900 kg or less.	
1A3bii	Light-duty Trucks With 3-way Catalysts	Emissions from light duty trucks with 3-way catalysts.	
1A3bii	Light-duty Trucks Without 3-way Catalysts	Emissions from light duty trucks without 3-way catalysts.	
1A3biii	Heavy-duty Trucks and Buses	Emissions from any vehicles so designated in the vehicle registering country. Normally the gross vehicle weight ranges from 3500-3900 kg or more for heavy duty trucks and the buses are rated to carry more than 12 persons.	
1A3biv	Motorcycles	Emissions from any motor vehicle designed to travel with not more than three wheels in contact with the ground and weighing less than 680 kg.	
1A3bv	Evaporative Emissions from Vehicles	Evaporative emissions from vehicles (e.g. hot soak, running losses) are included here. Emissions from loading fuel into vehicles are excluded.	
1A3bvi	Urea-based Catalysts	CO_2 emissions from use of urea-based additives in catalytic converters (non-combustive emissions).	

Source: IPCC (2006)

Emissions of CO_2 are best calculated on the basis of the amount and type of fuel combusted (fuel sold) and its carbon content. Emissions of CH_4 and N_2O are more difficult to estimate accurately because emission factors depend on vehicle technology, fuel and operating characteristics. CH_4 and N_2O emissions are significantly affected by the distribution of emission controls in the fleet.

1.5.4.2 Activity data projections

Activity data for road transport sector may include:

- o GDP (absolute and growth, per sector)
- o Population (absolute numbers and growth rate and base year value)
- o Final energy consumption in road transport (PJ per fuel)

- o Proportional technology split
- o Modal split (passenger and freight)
- o Passenger vehicle kilometres driven per fuel and technology type (Mkm)
- o Freight road transport per fuel and technology type (Mtkm)

Grades and Decision Tree

As described in 1.A.2 Combustion in Manufacturing Industry and Construction section 1.4.2 the proposed approach to projecting future activity data dependent on the available information. Figure B.1-7 presents a generalized decision tree for selecting grades for future activity data for transport sector. This decision tree applies for each of the transport modes, including road transport.

Grade 1

As described in 1.A.3.a Civil Aviation section 1.5.3.2 Part: Grade 1

Grade 1 assumes that vehicle type split over the subcategories remains the same over time.

Grade 2

As described in 1.A.3.a Civil Aviation section 1.5.3.2 Part: Grade 2

Some of the activity data, such as: transport demand, modal shifts or vehicle stock can be derived from TREMOVE model[10].

Grade 3

As described in 1.A.3.a Civil Aviation section 1.5.3.2 Part: Grade 3

1.5.4.3   Emission Factor projections

1.A. Fuel Combustion section 1.2.3 introduces Emission Factor projections.

Figure B.1-8 presents a generalized decision tree for selecting grades for future emission factors for transport activities. This decision tree applies for each of the transport modes.

Grade 1

As described in 1.A. Fuel Combustion section 1.2.3.2.

Grade 2

As described in 1.A. Fuel Combustion section 1.2.3.3.

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  http://www.tmleuven.be/methode/tremove/home.htm

Grade 3

As described in 1.A. Fuel Combustion section 1.2.3.4

1.5.4.4   Policies and Measures

PAMs for transport sector are listed in the 1.A. Fuel Combustion section 1.5.2.

Many of the listed transport policies affect GHG emissions mainly by reducing energy/fuel consumption and increasing efficiency.

The following paragraph outlines an example of how to include a PAM in GHG projection estimation for the sector:

DIRECTIVE 2009/28/EC on the promotion of the use of energy from renewable sources is a cross-cutting PAM which also influence transport sector. It aims at promoting energy from renewable sources and sets mandatory national targets for the overall share of energy from renewable sources in transport. Member States should ensure that a minimum proportion of biofuels and other renewable fuels is placed on their markets. As a result final consumption of energy from renewable sources in transport will increase and will lead to proportionally lower consumption of diesel and petrol so proportionally lower GHG emission. The Directive specifies the rules for calculating the greenhouse gas impact of biofuels, bio liquids and their fossil fuel comparators. These rules should be used by MS to calculate the GHG emission saving (%) from the use of biofuels and bio liquids. Each MS shall ensure that the share of energy from renewable sources in gross final energy consumption in particular year is at least its national overall target for the share of energy from renewable sources in that year as set in the Directive.

1.5.4.5   Treatment of alternative fuels

The Renewable Energy Directive includes a specific target for transport sector, i.e. that in 2020, at least 10% of all transport fuels (petrol, diesel, biofuels for road/rail transport, and electricity) must be derived from renewable sources. This not only concerns biofuels (such as biodiesel and bioethanol), but also renewable electricity and hydrogen may count towards achieving the target. It is good practice that projections on fuel use for road transport reflect the actual use of renewable sources for the different sectors.

It is good practice that the use of battery electric vehicles or the plug-in rechargeable type are properly reported and the consistency of the projected fuel economy is ensured.

1.5.4.6   Source Specific QA/QC

It is important to ensure that resulting emission projections have similar verification and QA/QC as applied to the historic inventory.

A "general" QA/QC approach (described in General Guidance – Part A Chapter 8.A: Quality Assurance and Quality Control (QA/QC) for Projections) should be undertaken to ensure the quality (TCCCA) of the MS GHG projections from road transport (see also 1.A. Fuel Combustion section section1.2.5).

The second step is to apply sector specific QA/QC. It is good practice to:

- o check whether applied methods use input data (GDP, population, fuel burned in road transport, number or vehicles, etc.) that is consistent with national economic, energy and activity projections used elsewhere in the projected emissions estimates.
- o ensure consistency between kilometres driven and fuel sold
- o ensure that the energy systems as assumed in the MS projections will be consistent with different energy subcategories. E.g., introduction of electric transport in relation to the effects on power generation and further downstream the refineries, since the oil product range will move away from gasoline and diesel towards other product, possibly as feed-stocks in the chemical industry.
- o ensure consistency between the outcomes of the MS-energy model and MS-specific models. Consistency should be maintained between final energy consumption in the road transport sector and energy consumption used as input to the estimates. It is good practice to check the outcomes against international models/sources, such as: the centrally run energy models, PRIMES, TREMOVE, Eurostat or WEO.
- o reference all data sources within the spread sheets / databases so that the input data is traceable.
- o ensure transparency in the underlying methodology, assumption and other relevant information of the MS-energy model and MS-specific model by appropriately reporting.

1.5.5   Railways (IPCC 1.A.3.c)

1.5.5.1   Source description

This source category include emissions from railway transport for both freight and passenger traffic routes. Railway locomotives generally are one of three types: diesel, electric, or steam. Diesel locomotives generally use diesel engines in combination with an alternator or generator to produce the electricity required to power their traction motors.

Electric locomotives are powered by electricity generated at stationary power plants as well as other sources. The corresponding emissions are covered under the Stationary Combustion (1.A.1).

Steam locomotives are now generally used for very localized operations, primarily as tourist attractions and their contribution to greenhouse gas emissions is correspondingly small.

Table 13 Sector description of Rail Transport.

IPCC 2006 source category		Description	Re-port
1A3c	Railways	Emissions from railway transport for both freight and passenger traffic routes.	☑

Source: IPCC (2006)

1.5.5.2   Activity data projections

Activity data for rail transport sector may include:

- o   GDP (absolute and growth, per sector)
- o   Population (absolute numbers and growth rate and base year value
- o   Final energy consumption in rail transport (PJ per fuel)
- o   Proportional technology split
- o   Modal split (passenger and freight)
- o   Passenger rail kilometres (Mkm)
- o   Freight tonne kilometres by rail (Mtkm)

Grades and Decision Tree

As described in 1.A.2 Combustion in Manufacturing Industry and Construction section 1.4.2 the proposed approach to projecting future activity data dependent on the available information. Figure B.1-7 presents a generalized decision tree for selecting grades for future activity data for transport sector. This decision tree applies for each of the transport modes, including railway transport.

Grade 1

As described in 1.A.3.a Civil Aviation section 1.5.3.2 Part: Grade 1

Grade 2

As described in 1.A.3.a Civil Aviation section 1.5.3.2 Part: Grade 2

Some of the activity data, such as: transport demand, modal shifts can be derived from TREMOVE model[10].

Grade 3

As described in 1.A.3.a Civil Aviation section 1.5.3.2 Part: Grade 3

1.5.5.3   Emission Factor projections

1.A. Fuel Combustion section 1.2.3 introduces Emission Factor projections.

Figure B.1-8 presents a generalized decision tree for selecting grades for future emission factors for transport activities. This decision tree applies for each of the transport modes.

Grade 1

As described in 1.A. Fuel Combustion section 1.2.3.2.

Grade 2

As described in 1.A. Fuel Combustion section 1.2.3.3.

Grade 3

As described in 1.A. Fuel Combustion section 1.2.3.4

1.5.5.4   Policies and Measures

PAMs for transport sector are listed in the 1.A. Combustion section 1.5.2.

There are PAMs (i.e. first and second Railway Packages (2001, 2004)) aimed at shifting the balance between modes of transport, in particular towards rail. The purpose of these PAMs is to ensure the development and improvement of the Community's railways and improved access to the market for rail transport services. They aim to lead to increased demand for (high speed) railway. Member States need to ensure consistency in the shift in transport modes and in the balance of diesel vs electric in projected energy use for the sector.

1.5.5.5   Source Specific QA/QC

It is important to ensure that resulting emission projections have similar verification and QA/QC as applied to the historic inventory.

A "general" QA/QC approach (described in General Guidance – Part A Chapter A.8: Quality Assurance and Quality Control (QA/QC) for Projections) should be undertaken to ensure the quality (TCCCA) of the MS GHG projections from railways (see also 1.A. Fuel Combustion section 1.5.2).

The second step is to apply sector specific QA/QC. It is good practice to:

   o   check whether applied methods use input data (GDP, population, fuel burned in rail transport, etc) that is consistent with national economic, energy and activity projections used elsewhere in the projected emissions estimates.
   o   ensure consistency between the outcomes of the MS-energy model and MS-specific model. Consistency should be maintained between final energy consumption in the rail transport sector and energy consumption used as input to the estimates. It is good practice to check the outcomes against international models/sources, such as: the centrally run energy models, PRIMES, TREMOVE, Eurostat or WEO.
   o   ensure consistency between emission projections from rail transport and those reported under power generation sector.
   o   reference all data sources within the spreadsheets / databases so that the input data is traceable.
   o   ensure transparency the underlying methodology, assumption and other relevant information of the Member-State-energy model and Member-State-specific model by appropriately reporting.

1.5.6   Water-borne Navigation (IPCC 1.A.3.d)

1.5.6.1   Source description

This source category (see also Table 14) covers all water-borne transport from recreational craft to large ocean-going cargo ships that are driven primarily by large, slow and medium speed diesel engines and occasionally by steam or gas turbines. It includes hovercraft and hydrofoils, but excludes fishing vessels.

The international/domestic split should be determined on the basis of port of departure and port of arrival, and not by the flag or nationality of the ship.

Table 14 Detailed sector split for Water-borne Navigation.

IPCC 2006 source category		Description	Re-port
1A3d	Water-borne Navigation	Emissions from fuels used to propel water-borne vessels, including hovercraft and hydrofoils, but excluding fishing vessels. The international/domestic split should be determined on the basis of port of departure and port of arrival, and not by the flag or nationality of the ship.	☑
1A3di	International Water-borne Navigation (International Bunkers)	Emissions from fuels used by vessels of all flags that are engaged in international water-borne navigation. The international navigation may take place at sea, on inland lakes and waterways and in coastal waters. Includes emissions from journeys that depart in one country and arrive in a different country. Exclude consumption by fishing vessels (see Other Sector - Fishing). Emissions from international military water-borne navigation can be included as a separate sub-category of international water-borne navigation provided that the same definitional distinction is applied and data are available to support the definition.	
1A3dii	Domestic Water-borne Navigation	Emissions from fuels used by vessels of all flags that depart and arrive in the same country (exclude fishing, which should be reported under 1 A 4 c iii, and military, which should be reported under 1 A 5 b). Note that this may include journeys of considerable length between two ports in a country (e.g. San Francisco to Honolulu).	☑

Source: IPCC (2006)

1.5.6.2   Activity data projections

Activity data for water-borne navigation sector include:

- o   GDP (absolute and growth, per sector)
- o   Population (absolute numbers and growth rate and base year value)
- o   Final energy consumption in water-borne navigation (PJ per fuel)
- o   Proportional technology split
- o   Modal split (passenger and freight)
- o   Passenger water-borne navigation kilometers (Mkm)
- o   Freight tonne kilometres by navigation (Mtkm)

Grades and Decision Tree

As described in 1.A.2 Combustion in Manufacturing Industry and Construction section 1.4.2 the proposed approach to projecting future activity data dependent on the available information. Figure B.1-7 presents a generalized decision tree for selecting grades for future activity data for transport sector. This decision tree applies for each of the transport modes, including water-borne navigation transport.

Grade 1

As described in 1.A.3.a Civil Aviation section 1.5.3.2 Part: Grade 1

Grade 2

As described in 1.A.3.a Civil Aviation section 1.5.3.2 Part: Grade 2

Some of the activity data, such as: transport demand, modal shifts be derived from TREMOVE model[10].

Grade 3

As described in 1.A.3.a Civil Aviation section 1.5.3.2 Part: Grade 3

1.5.6.3   Emission Factor projections

1.A. Fuel Combustion section 1.2.3 introduces Emission Factor projections.

Figure B.1-8 presents a generalized decision tree for selecting grades for future emission factors for transport activities. This decision tree applies for each of the transport modes.

Grade 1

As described in 1.A. Fuel Combustion section 1.2.3.2.

Grade 2

As described in 1.A. Fuel Combustion section 1.2.3.3.

Grade 3

As described in 1.A. Fuel Combustion section 1.2.3.4

1.5.6.4   Policies and Measures

PAMs for transport sector are listed in the 1.A. Fuel Combustion 1.5.2.

In 1.A. Fuel Combustion section 1.5.4.4 an example of PAM, DIRECTIVE 2009/28/EC on the promotion of the use of energy from renewable sources, is introduced.

1.5.6.5   Source Specific QA/QC

It is important to ensure that resulting emission projections have similar verification and QA/QC as applied to the historic inventory.

A "general" QA/QC approach (described in General Guidance – Part A Chapter A.8: Quality Assurance and Quality Control (QA/QC) for Projections) should be undertaken to ensure the quality (TCCCA) of the MS GHG projections from water-borne navigation (see also 1.A. Fuel Combustion section 1.2.5).

The second step is to apply sector specific QA/QC. It is good practice to:

- o Ensure that all remaining water-borne navigation activities are included: 1A5b Mobile (water-borne navigation component) and 1A5c Multilateral Operations (water-borne navigation component).
- o check whether applied methods use input data (GDP, population, fuel burned in water-borne navigation, etc) that is consistent with national economic, energy and activity projections used elsewhere in the projected emissions estimates.
- o ensure accurate GHG emission allocation between national and international water-borne navigation.
- o ensure consistency between the outcomes of the MS-energy model and MS-specific model. Consistency should be maintained between final energy consumption in the water-borne navigation sector and energy consumption used as input to the estimates. It is good practice to check the outcomes against international models/sources, such as: the centrally run energy models, PRIMES, TREMOVE, Eurostat or WEO.
- o reference all data sources within the spreadsheets / databases so that the input data is traceable.
- o ensure transparency in the underlying methodology, assumption and other relevant information of the MS-energy model and MS-specific model by appropriately reporting.

1.5.7   Other Transportation (IPCC 1.A.3.e)

This source category (see also Table 15) covers all other transportation.

Table 15 Detailed sector split for other Transportation.

IPCC 2006 source category		Description	Re-port
1A3e	Other Transportation	Combustion emissions from all remaining transport activities including pipeline transportation, ground activities in airports and harbours, and off-road activities not otherwise reported under 1 A 4 c Agriculture or 1 A 2. Manufacturing Industries and Construction. Military transport should be reported under 1 A 5 (see 1 A 5 Non-specified).	☑

| 1A3ei | Pipeline Transport | Combustion related emissions from the operation of pump stations and maintenance of pipelines. Transport via pipelines includes transport of gases, liquids, slurry and other commodities via pipelines. Distribution of natural or manufactured gas, water or steam from the distributor to final users is excluded and should be reported in 1 A 1 c ii or 1 A 4 a. | |
| 1A3eii | Off-road | Combustion emissions from Other Transportation excluding Pipeline Transport. | |

Source: IPCC (2006)

1.5.8   Source specific QA/QC

Ensure that all remaining transport activities are included: other transportation (1A3e), fishing (mobile activities) (1A4ciii) and activities not otherwise reported (1A5a,b)

1.6   Other Combustion (IPCC 1.A.4)

1.6.1   Source description

This source category (see also Table 16) covers all GHG emissions from other combustion activities, including the Residential sector and Commercial/Institutional sector.

Table 16 Detailed sector split for Other Combustion.

IPCC 2006 source category		Description	Re-port
1A4	Other Sectors	Emissions from combustion activities as described below, including combustion for the generation of electricity and heat for own use in these sectors.	☑
1A4a	Commercial/Institutional	Emissions from fuel combustion in commercial and institutional buildings; all activities included in ISIC Divisions 41,50, 51, 52, 55, 63-67, 70-75, 80, 85, 90-93 and 99.	☑
1A4b	Residential	All emissions from fuel combustion in households.	☑
1A4c	Agriculture Forestry Fishing Fish Farms	Emissions from fuel combustion in agriculture, forestry, fishing and fishing industries such as fish farms. Activities included in ISIC Divisions 01, 02 and 05. Highway agricultural transportation is excluded.	☑
1A4ci	Stationary	Emissions from fuels combusted in pumps, grain drying, horticultural greenhouses and other agriculture, forestry or stationary combustion in the fishing industry.	
1A4cii	Off-road Vehicles and Other Machinery	Emissions from fuels combusted in traction vehicles on farm land and in forests.	
1A4ciii	Fishing (mobile combustion)	Emissions from fuels combusted for inland, coastal and deep-sea fishing. Fishing should cover vessels of all flags that have refuelled in the country (include international fishing).	

Source: IPCC (2006)

1.6.2   Policies and Measures

A number of specific policies and measures will have an effect on GHG emissions from residential and commercial and institutional sector in the future Table 17 presents the EU legislation. It is recommended to check PAM interactions (see General Guidance – Part A Chapter A.0: Compiling an Emission Projection: A harmonized Approach, section 0.6 Policies and measures interactions).

Table 17 Policies and Measures and related parameters affected by implementation of particular PAM in Other Combustion sector.

Policy area	Description	Legislation	Parameters/Variables
Cross cutting	*Directives:*		
	Biofuels directive	Directive 2009/28/EC	*Energy efficiency, Final energy consumption by sector by fuel type, Fuel specification, Share of biofuels in transport, Share of renewables in electricity generation*
	EU Emissions trading scheme	Directive 2003/87/EC	*Electricity consumption, Emission factors, Energy efficiency, Final energy consumption by sector by fuel type, Share of different forms of energy*
	National Emission Ceilings for certain pollutants (NEC Directive)	Directive 2001/81/EC	*Emission ceilings for air pollutants*
	Decision:		
	Effort Sharing Decision	Decision 406/2009/EC	*Electricity consumption, Final energy consumption by sector by fuel type, Share of different forms of energy*
Energy	*Directives:*		
	Labelling and standard product information of the consumption of energy and other resources by energy related products (recast)	Directive 2010/30/EU	*Electricity consumption, Energy efficiency, Final energy consumption by sector by fuel type, Share of different forms of energy*
	Framework for the setting of Ecodesign requirements for	Directive 2008/28/EC	*Electricity consumption, Energy efficiency,*

Policy area	Description	Legislation	Parameters/Variables
	energy-using products		*Final energy consumption by sector by fuel type*
	Promotion of cogeneration	Directive 2004/8/EC	*Electricity consumption, Energy efficiency, Final energy consumption by sector by fuel type*
	Taxation of energy products and electricity	Directive 2003/96/EC	*Electricity consumption, Final energy consumption by sector by fuel type, Fuel price, Share of different forms of energy*
	Electricity production from renewable energy sources	Directive 2001/77/EC	*Consumption of renewable energy for cooling, Consumption of renewable energy for heating, Share of renewables in electricity generation, Share of renewables in energy production*
	Energy efficiency requirements for ballasts for fluorescent lighting	Directive 2000/55/EC	*Electricity consumption, Energy efficiency, Emission factors, Final energy consumption by sector by fuel type*
	Labelling and standard product information of the consumption of energy and other resources by household appliances	Directive 92/75/EC	*Electricity consumption, Energy efficiency, Final energy consumption by sector by fuel type*
	Efficiency requirements for new hot-water boilers fired with liquid or gaseous fuels	Directive 92/42/EEC	*Electricity consumption, Emission factors, Energy efficiency, Final energy consumption by sector by fuel type*
	Others:		
	Energy-efficiency labelling programmes for office equipment	2006/1005/EC	*Electricity consumption, Energy efficiency, Final energy consumption by sector by fuel type*
Residential and Commercial	*Directives:*		
	Recast of the Energy performance of buildings	Directive 2010/31/EU	*Electricity consumption, Emission factors,*

Policy area	Description	Legislation	Parameters/Variables
			Energy efficiency, *Final energy consumption by sector by fuel type*
	Recast of the Ecodesign requirements for energy-using products	Directive 2009/125/EC	*Electricity consumption,* *Emission factors,* *Energy efficiency,* *Final energy consumption by sector by fuel type*
	End-use efficiency and energy services	Directive 2006/32/EC	*Electricity consumption,* *Energy efficiency,* *Final energy consumption by sector by fuel type*
	Ecodesign requirements for energy-using products	Directive 2005/32/EC	*Electricity consumption,* *Emission factors,* *Energy efficiency,* *Final energy consumption by sector by fuel type*
	Energy labelling of household appliances (fridges and freezers)	Directive 2003/66/EC	*Electricity consumption,* *Energy efficiency,* *Final energy consumption by sector by fuel type*
	Energy performance of buildings	Directive 2002/91/EC	*Electricity consumption,* *Emission factors,* *Energy efficiency,* *Final energy consumption by sector by fuel type*
	Energy labelling of household appliances (electric ovens)	Directive 2002/40/EC	*Electricity consumption,* *Energy efficiency,* *Final energy consumption by sector by fuel type*
	Energy labelling of household appliances (air conditioners)	Directive 2002/31/EC	*Electricity consumption,* *Energy efficiency,* *Final energy consumption by sector by fuel type*
	Energy labelling of household appliances (dish washers)	Directive 99/9/EC	*Electricity consumption,* *Energy efficiency,* *Final energy consumption by sector by fuel type*
	Energy labelling of household appliances (lamps)	Directive 98/11/EC	*Electricity consumption,* *Energy efficiency,* *Final energy consumption by sector by fuel type*
	Energy labelling of household appliances (washing machines)	Directive 96/89/EC	*Electricity consumption,* *Energy efficiency,* *Final energy consumption by sector by fuel type*
	Energy labelling of household	Directive 96/60/EC	*Electricity consumption,*

Policy area	Description	Legislation	Parameters/Variables
	appliances (washer-driers)		*Energy efficiency, Final energy consumption by sector by fuel type*
	Regulations:		
	Energy-efficiency labelling for office equipment recast	Regulation 106/2008	*Electricity consumption, Emission factors, Energy efficiency, Final energy consumption by sector by fuel type*
	Community energy efficiency labelling program for office equipment	Regulation 2422/2001	*Electricity consumption, Emission factors, Energy efficiency, Final energy consumption by sector by fuel type*
	Community eco-management and audit scheme (EMAS)	Regulation 761/2001	*Energy efficiency, Final energy consumption by sector by fuel type*
	Regulations implementing Directive 2005/32/EC:		
	Ecodesign requirements for simple set-top boxes	Regulation 107/2009	*Electricity consumption, Emission factors, Energy efficiency, Final energy consumption by sector by fuel type*
	Ecodesign requirements for standby and offoff mode electric power consumption	Regulation 1275/2008	
	Ecodesign requirements for non-directional household lamp	Regulation 244/2009	
	Ecodesign requirements for fluorescent lamps	Regulation 245/2009	
	Ecodesifn requirements for external power supplies	Regulation 278/2009	
	Ecodesign requirements for electric motors	Regulation 640/2009	
	Ecodesign requirements for circulators	Regulation 641/2009	
	Ecodesign requirements for television	Regulation 642/2009	
	Ecodesign requirements for freezers and refrigerators	Regulation 643/2009	
Other Combustion	Community eco-management and audit scheme (EMAS)	Regulation 761/2001	*Energy efficiency, Final energy consumption by sector by fuel type*

Policy area	Description	Legislation	Parameters/Variables
	Emission by engines to power agricultural or forestry	Directive 2000/25/EC	

1.6.3   Commercial/Institutional (IPCC 1.A.4.a)

1.6.3.1   Source description

Emissions from fuel combustion in commercial and institutional buildings (1.A.4.a).

1.6.3.2   Activity data projections

Activity data for commercial / institutional sector may include:

- o   GDP (absolute and growth, per sector)
- o   Final energy consumption in commercial / institutional (PJ per fuel)
- o   Number of employees in commercial / institutional sector
- o   Gross value-added (GVA)– services (Value Bln EUR, EC95)

Grades and Decision Tree

As described in 1.A.2 Combustion in Manufacturing Industry and Construction section 1.4.2 the proposed approach to projecting future activity data dependent on the available information. Figure B.1-9 presents a generalized decision tree for selecting grades for future activity data for commercial/institutional sector. This decision tree applies also for combustion in residential sector.
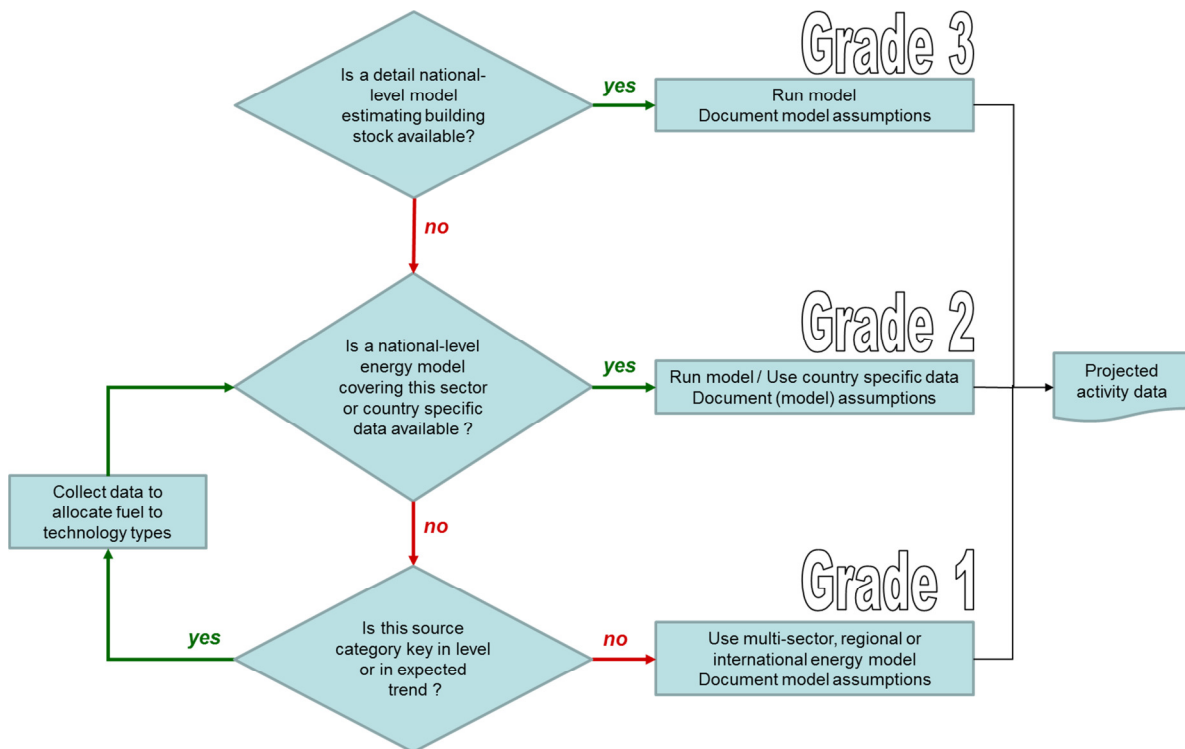
**Figure B.1-9 Generalised decision tree for future activity data for other combustion,
commercial/institutional sector.**

Grade 1

As described in Combustion in Manufacturing Industry and Construction section 1.4.2.2.

In Grade 1, the projection of activity data in the commercial/instittutional sector would be derived from an available multi-sector, regional or international energy model which includes results for the Member States. At present, the European Commission uses the PRIMES model to project greenhouse gas (GHG) emissions from fuel combustion in the European Union. Under the Grade 1 approach, one could use the detailed activity projections of the PRIMES model.

Another multi-sector energy model is the World Energy Model by the International Energy Agency.

Whichever source is used, the data should be linked to/check against MS level activity data from the emissions inventory, in order to ensure consistency. If any inconsistencies are apparent (e.g. baseline activity data differs significantly between the model and MS inventory), a simple approach would be to take the percentage changes from the external energy model and apply these to the data used in the national inventory.

Grade 1 approach is not recommended for a key sources, both key in level and in expected trend.

Grade 2

As described in Combustion in Manufacturing Industry and Construction section 1.4.2.3

If a national-level energy model is available and this model covers energy use in commercial/institutional sector it should be used to estimate the projection of activity data in this sub- sector. If such a model does not exist but there are country specific data available then these data should be used in projecting future activities for this sub- sector. In both cases the appropriate documentation should be reported.

Grade 3

As described in Combustion in Manufacturing Industry and Construction section 1.4.2.4.

If a detailed national-level transport model is available it should be used for activity data for commercial/institutional sector. The underlying information, e.g. model assumption should be appropriately reported (see also section 1.2.2.5).

1.6.3.3   Emission Factor projections

1.A. Fuel Combustion section 1.2.3 introduces Emission Factor projections.

Figure B.1-2 presents a generalized decision tree for selecting grades for future emission factors for fuel combustion. This decision tree applies in general for each of the fuel combustion activities, including commercial/institutional sector

Grade 1

As described in 1.A. Fuel Combustion section 1.2.3.2.

Grade 2

As described in 1.A. Fuel Combustion section 1.2.3.3.

Grade 3

As described in 1.A. Fuel Combustion section 1.2.3.4

1.6.3.4   Policies and Measures

PAMs for commercial / institutional sector are listed in the 1.A. Fuel Combustion section 1.6.2.

An example of how to include a PAM in the GHG projection estimation for the sector is provided in the following paragraph:

Direcitive 2002/91/EC on Energy performance of buildings

The projected building stock consists of different type of buildings. Each type of building has its own emission factor/ energy consumption. The energy efficiency directive will lead to reduced fuel consumption/emission factors per building type. In cases where the projection is to show the influence of this type of policy, it is good practice to use these building specific values and EFs to estimate GHG projections upon implementation of the energy efficiency measures.

1.6.3.5   Source Specific QA/QC

It is important to ensure that resulting emission projections have similar verification and QA/QC as applied to the historic inventory.

A "general" QA/QC approach (described in General Guidance – Part A Chapter A.8: Quality Assurance and Quality Control (QA/QC) for Projections) should be undertaken to ensure the quality (TCCCA) of the MS GHG projections from commercial and institutional sector (see also 1.A. Fuel Combustion section 1.2.5).

The second step is to apply sector specific QA/QC. It is good practice to:

- o check whether applied methods use input data (GDP, number of employees, etc) that is consistent with national economic, energy and activity projections used elsewhere in the projected emissions estimates.
- o ensure consistency between the outcomes of the MS-energy model and MS-specific model when used for this sector Consistency should be maintained between final energy consumption in commercial / institutional sector and energy consumption used as input to the estimates.
- o check the outcomes against international models/sources, such as: the centrally run energy models, PRIMES, Eurostat or WEO.
- o reference all data sources within the spreadsheets / databases so that the input data is traceable.
- o ensure transparency in the underlying methodology, assumption and other relevant information of the MS-energy model and MS-specific model by appropriately reporting.

1.6.4   Residential (IPCC 1.A.4.b)

1.6.4.1   Source description

In the residential sector, energy is consumed as input in processes that provide services to the households, such as space heating, water heating, cooking, cooling, lighting and other needs.

1.6.4.2   Activity data projections

Activity data for residential sector may include:

- o GDP (absolute and growth, per sector)
- o Population (absolute numbers and growth rate and base year value)
- o Final energy consumption in households (PJ per fuel)
- o Building stock (number of households, households size, stock of permanently occupied dwellings, etc.)

Grades and Decision Tree

As described in 1.A.2 Combustion in Manufacturing Industry and Construction section 1.4.2 the proposed approach to projecting future activity data dependent on the available information. Figure B.1-9 presents a generalized decision tree for selecting grades for future activity data for other combustion which includes residential sector.

Grade 1

As described in Commercial/Institutional section 1.6.3.2 Part: Grade 1

Grade 2

As described in Commercial/Institutional section 1.6.3.2 Part: Grade 2

Grade 3

As described in Commercial/Institutional section 1.6.3.2 Part: Grade 3

1.6.4.3   Emission Factor projections

1.A. Fuel Combustion section 1.2.3 introduces Emission Factor projections.

Figure B.1-2 presents a generalized decision tree for selecting grades for future emission factors for fuel combustion. This decision tree applies in general for each of the fuel combustion activities, including commercial/institutional sector

Grade 1

As described in 1.A. Fuel Combustion section 1.2.3.2.

Grade 2

As described in 1.A. Fuel Combustion section 1.2.3.3.

Grade 3

As described in 1.A. Fuel Combustion section 1.2.3.4

1.6.4.4   Policies and Measures

PAMs for commercial / institutional sector are listed in the 1.A. Fuel Combustion section 1.6.2.

An example how to include a PAM in the GHG projection estimation for the residential sector is provided in the following paragraph:

<u>DIRECTIVE 2006/32/EC on energy end-use efficiency and energy services</u> is a PAM which aims at improving energy end-use efficiency and contributing to the reduction of primary energy consumption in the residential sector. As a result energy savings and more energy-efficient technologies could be used. These will lead to lower energy consumption and new, depending on the new technologies, emission factors. Examples of energy efficiency measures include:

- o decreasing the fuel input into the residences for heating and cooling through:

✓ domestic generation of renewable energy sources, whereby the amount of purchased energy is reduced (e.g. solar thermal applications, domestic hot water, solar-assisted space heating and cooling)

✓ alternative heat sources (e.g. heat pumps, new efficient boilers, installation/efficient update of district heating/ cooling systems)

✓ insulation and ventilation (e.g. wall cavity and roof insulation, double/triple glazing of windows, passive heating and cooling);

✓ hot water (e.g. installation of new devices, direct and efficient use in space heating, washing machines);

o decreasing electricity use and hence emissions in power plants through:

✓ lighting (e.g. new efficient bulbs and ballasts, digital control systems, use of motion detectors for lighting systems in commercial buildings);

✓ cooking and refrigeration (e.g. new energy efficient devices, heat recovery systems);

✓ other equipment and appliances (e.g. combined heat and power appliances, new efficient devices, time control for optimised energy use, stand-by loss reduction, installation of capacitors to reduce reactive power, transformers with low losses);

With this, the implementation of this Directive will lead to reduced activity data in both the residential sector and in power plants. It is good practice to ensure in this type of analyses that these effects are taken into account in the proper source category and transparently documented in the national projections report.

1.6.4.5   Source Specific QA/QC

It is important to ensure that resulting emission projections have similar verification and QA/QC as applied to the historic inventory.

A "general" QA/QC approach (described in General Guidance – Part A Chapter A.8: Quality Assurance and Quality Control (QA/QC) for Projections) should be undertaken to ensure the quality (TCCCA) of the MS GHG projections from residential sector (see also 1.A. Fuel Combustion section 1.2.5).

The second step is to apply sector specific QA/QC. It is good practice to:

- o check whether applied methods use input data (GDP, population, number of buildings, etc) that is consistent with national economic, energy and activity projections used elsewhere in the projected emissions estimates.

o   ensure consistency the outcomes of the MS-energy model and MS-specific model.
    Consistency should be maintained between final energy consumption in the
    residential sector and energy consumption used as input to the estimates. It is
    good practice to check the outcomes against international models/sources, such
    as: the centrally run energy models, PRIMES, Eurostat or WEO.
o   reference all data sources within the spread sheets / databases so that the input
    data is traceable.
o   ensure transparency in the underlying methodology, assumption and other
    relevant information of the MS-energy model and MS-specific model by
    appropriately reporting.

1.6.5   Source specific QA/QC

It is good practice to ensure the quality of the MS GHG projections by checking: "Completeness": the
missing sources/fuels, "Accuracy": errors in application of assumptions or biased assumptions,
"Comparability": miss allocation of estimates to subsectors, "Consistency": inconsistency in the time
series (including historic to projected) or between approaches for different pollutants/categories.

It is good practice to check / compare GHG projections from the residential sector against the
historical trends for AD and EFs. Where significant differences exist it is good practice to explain
them.

Ensure "Completeness" by checking whether all remaining combustion activities from:

o   1.A.4.c   Agriculture Forestry Fishing Fish Farms
o   1.A.4.c.i   Stationary
o   1.A.4.c.i.i   Off-road Vehicles and Other Machinery
o   1.A.4.c.i.i.i   Fishing (mobile combustion)

are included.

1.7   Fugitive emissions (IPCC 1.B)

1.7.1   Source description

This emissions source comprises of fugitive emissions, including CH_4 and CO_2, from fuel extraction,
processing, storage and transport to the point of final use. The 2006 IPCC guidelines subdivide the
manufacturing industry and construction sector using the International Standard Industrial
Classification as follows:

Table 18 Detailed sector split for Fugitive emissions.

IPCC 2006 source category		Description	Report
1B	Fugitive Emissions from Fuels	Includes all intentional and unintentional emissions from the extraction, processing, storage and transport of fuel to the point of final use.	☑

IPCC 2006 source category		Description	Report
1B1	Solid Fuels	Includes all intentional and unintentional emissions from the extraction, processing, storage and transport of fuel to the point of final use.	☑
1B1a	Coal Mining and Handling	Includes all fugitive emissions from coal.	☑
1B1ai	Underground Mines	Includes all emissions arising from mining, post-mining, abandoned mines and flaring of drained methane.	
1B1ai	Mining	Includes all seam gas emissions vented to atmosphere from coal mine ventilation air and degasification systems.	
1B1ai	Post-mining Seam Gas Emissions	Includes methane and CO_2 emitted after coal has been mined, brought to the surface and subsequently processed, stored and transported.	
1B1ai	Abandoned Underground Mines	Includes methane emissions from abandoned underground mines.	
1B1ai	Flaring of Drained Methane or Conversion of Methane to CO_2	Methane drained and flared, or ventilation gas converted to CO_2 by an oxidation process should be included here. Methane used for energy production should be included in Volume 2, Energy, Chapter 2 'Stationary Combustion'.	
1B1aii	Surface Mines	Includes all seam gas emissions arising from surface coal mining.	
1B1aii	Mining	Includes methane and CO_2 emitted during mining from breakage of coal and associated strata and leakage from the pit floor and high wall.	
1B1aii	Post-mining Seam Gas Emissions	Includes methane and CO_2 emitted after coal has been mined, subsequently processed, stored and transported.	
1B1b	Uncontrolled Combustion, and Burning Coal Dumps	Includes fugitive emissions of CO_2 from uncontrolled combustion in coal.	☑
1B1c	Solid Fuel Transformation	Fugitive emissions arising during the manufacture of secondary and tertiary products from solid fuels.	☑
1B2	Oil and Natural Gas	Comprises fugitive emissions from all oil and natural gas activities. The primary sources of these emissions may include fugitive equipment leaks, evaporation losses, venting, flaring and accidental releases.	☑
1B2a	Oil	Comprises emissions from venting, flaring and all other fugitive sources associated with the exploration, production, transmission, upgrading, and refining of crude oil and distribution of crude oil products.	☑
1B2ai	Venting	Emissions from venting of associated gas and waste gas/vapour streams at oil facilities.	
1B2aii	Flaring	Emissions from flaring of natural gas and waste gas/vapour streams at oil facilities.	
1B2aiii	All Other	Fugitive emissions at oil facilities from equipment leaks, storage losses, pipeline breaks, well blowouts, land farms, gas migration to the surface around the outside of wellhead casing, surface casing vent bows, biogenic gas formation from tailings ponds and any other gas or vapour releases not specifically accounted for as venting or flaring.	
1B2aiii	Exploration	Fugitive emissions (excluding venting and flaring) from oil well drilling, drill stem testing, and well completions.	

IPCC 2006 source category		Description	Report
1B2aiii	Production and Upgrading	Fugitive emissions from oil production (excluding venting and flaring) occur at the oil wellhead or at the oil sands or shale oil mine through to the start of the oil transmission system. This includes fugitive emissions related to well servicing, oil sands or shale oil mining, transport of untreated production (i.e , well effluent, emulsion, oil shale and oilsands) to treating or extraction facilities, activities at extraction and upgrading facilities, associated gas re-injection systems and produced water disposal systems. Fugitive emission from upgraders are grouped with those from production rather than those from refining since the upgraders are often integrated with extraction facilities and their relative emission contributions are difficult to establish. However, upgraders may also be integrated with refineries, co-generation plants or other industrial facilities and their relative emission contributions can be difficult to establish in these cases.	
1B2aiii	Transport	Fugitive emissions (excluding venting and flaring) related to the transport of marketable crude oil (including conventional, heavy and synthetic crude oil and bitumen) to upgraders and refineries. The transportation systems may comprise pipelines, marine tankers, tank trucks and rail cars. Evaporation losses from storage, filling and unloading activities and fugitive equipment leaks are the primary sources of these emissions.	
1B2aiii	Refining	Fugitive emissions (excluding venting and flaring) at petroleum refineries. Refineries process crude oils, natural gas liquids and synthetic crude oils to produce final refined products (e.g., primarily fuels and lubricants). Where refineries are integrated with other facilities (for example, upgraders or co-generation plants) their relative emission contributions can be difficult to establish.	
1B2aiii	Distribution of Oil Products	This comprises fugitive emissions (excluding venting and flaring) from the transport and distribution of refined products, including those at bulk terminals and retail facilities. Evaporation losses from storage, filling and unloading activities and fugitive equipment leaks are the primary sources of these emissions.	
1B2aiii	Other	Fugitive emissions from oil systems (excluding venting and flaring) not otherwise accounted for in the above categories. This includes fugitive emissions from spills and other accidental releases, waste oil treatment facilities and oilfield waste disposal facilities.	
1B2b	Natural Gas	Comprises emissions from venting, flaring and all other fugitive sources associated with the exploration, production, processing, transmission, storage and distribution of natural gas (including both associated and non-associated gas).	☑
1B2bi	Venting	Emissions from venting of natural gas and waste gas/vapour streams at gas facilities.	
1B2bii	Flaring	Emissions from flaring of natural gas and waste gas/vapour streams at gas facilities.	
1B2biii	All Other	Fugitive emissions at natural gas facilities from equipment leaks, storage losses, pipeline breaks, well blowouts, gas migration to the surface around the outside of wellhead casing, surface casing vent bows and any other gas or vapour releases not specifically accounted for as venting or flaring.	

IPCC 2006 source category		Description	Report
1B2biii	Exploration	Fugitive emissions (excluding venting and flaring) from gas well drilling, drill stem testing and well completions.	
1B2biii	Production	Fugitive emissions (excluding venting and flaring) from the gas wellhead through to the inlet of gas processing plants, or, where processing is not required, to the tie-in points on gas transmission systems. This includes fugitive emissions related to well servicing, gas gathering, processing and associated waste water and acid gas disposal activities.	
1B2biii	Processing	Fugitive emissions (excluding venting and flaring) from gas processing facilities.	
1B2biii	Transmission and Storage	Fugitive emissions from systems used to transport processed natural gas to market (i.e., to industrial consumers and natural gas distribution systems). Fugitive emissions from natural gas storage systems should also be included in this category. Emissions from natural gas liquids extraction plants on gas transmission systems should be reported as part of natural gas processing (Sector 1.B.2.b.iii.3). Fugitive emissions related to the transmission of natural gas liquids should be reported under Category 1.B.2.a.iii.3.	
1B2biii	Distribution	Fugitive emissions (excluding venting and flaring) from the distribution of natural gas to end users.	
1B2biii	Other	Fugitive emissions from natural gas systems (excluding venting and flaring) not otherwise accounted for in the above categories. This may include emissions from well blowouts and pipeline ruptures or dig-ins.	
1B3	Other Emissions from Energy Production	Other fugitive emissions for example, from geo thermal energy production, peat and other energy production not included in 1.B.2.	☑

Source: IPCC (2006)

Primary sources of fugitive emissions from coal mining and handling process include ventilation air and degasification systems for underground mines, surface mining area, abandoned mines and flaring of drained methane. Closed or abandoned mines continue to emit GHGs for some time after the mine has been decommissioned.

Primary sources of fugitive emissions from oil and natural gas systems include equipment leaks, evaporation losses, venting, flaring and accidental releases.

The last column of the table indicates whether or not emissions and activity data are to be reported in the CRF tables.

1.7.2   Coal mines – In Operation (IPCC 1.B.1)

1.7.2.1   Activity data projections

Activity data projections would be based on historic activity data and expected changes in the specific sector in the projection period. Activity data for this sector includes projection of raw coal production from both underground and surface mines (1B1ai and 1B1aii, respectively), taking into account future expansion or closure of the working mines and changes expected in the methane degasification systems.

Another activity data for this sector is the amount of CH_4 recovered and utilised, which is subtracted from the estimated future emissions, which would be calculated using projected coal production data and emission factor.

As a starting point for activity data projection, the most recent raw coal production data should be used and compared to historical activity data for the years 2000, 2005 and 2010 to ensure consistency.

Grades and decision tree

Figure B.1-10 presents a generalized decision tree for selecting grades for future activity data for coal mines-in operation.

Figure B.1-10 Generalised decision tree for future activity data for coal mines-in operation activities.

Grade 1

When future projection of coal production activities at the national level or individual mines is not available, it is good practice to use the most recent raw coal production data from underground and surface mines and apply the expected growth in the coal production sector in the MS. This will allow the MS to estimate future raw coal production data. Potential sources of information include the PRIMES model or the World Energy Model if the national-level data is insufficient or unavailable.

If raw coal production data is not available, MS can use the amount of saleable coal considering that raw coal production equals the amount of saleable coal if coal is not sent to a coal preparation plant or washery for upgrading. If coal is upgraded, the amount of non-saleable coal that has been rejected is typically around 20 percent of the weight of raw coal feed.

If there is no data on expected growth in the coal production sector, then it is good practice to assume that the most recent coal production would be held constant for the projection period.

If data on CH_4 recovery and utilisation is not available, then apply the 2006 IPCC Inventory Guideline's default efficiency of the CH_4 drainage systems (i.e. the fraction of gas drained, typically 30 to 50 percent) for calculation of GHG emissions.

Grade 2

Under the Grade 2 approach, activity data projections would be based on future projection of the coal production activities and CH_4 recovery & utilisation information at the MS level. This may be estimated by applying pro-rata figure to the MS specific baseline activity data from the historical inventory. Potential sources of information include governmental bodies involved in the coal sector, coal production companies, trade associations, or academic institutions that may provide MS-level activity data.

Grade 3

Under the Grade 3 approach, activity data projections would be based on projection of coal production activities and CH_4 recovery and utilisation information for individual mines expected to be in operation during the projection period. Projection of coal production activities would reflect various drivers including accessible reserves, planned closures, coal demand, etc. CH_4 recovery and utilisation projection would take into account changes expected in utilisation methods and efficiency of degasification systems. Potential sources of information include individual coal mines, companies, or trade associations that may have site-specific information.

1.7.2.2 Emissions factor projections

In general, emission factor for operating coal mines is held constant along the time series but varies by coal type. The emission factor depends on the depth of the mine as the gas content of coal increases with depth. It also depends on the type of mines, geology of the coal seams, and mine ventilation methods. It is good practice to separate emission factors for underground mines and surface mines given the difference in depth of the mine and exposure area of the coal extracted.

Grades and decision tree

Figure B.1-11 presents a generalized decision tree for selecting grades for future emission factors for coal mines-in operation.
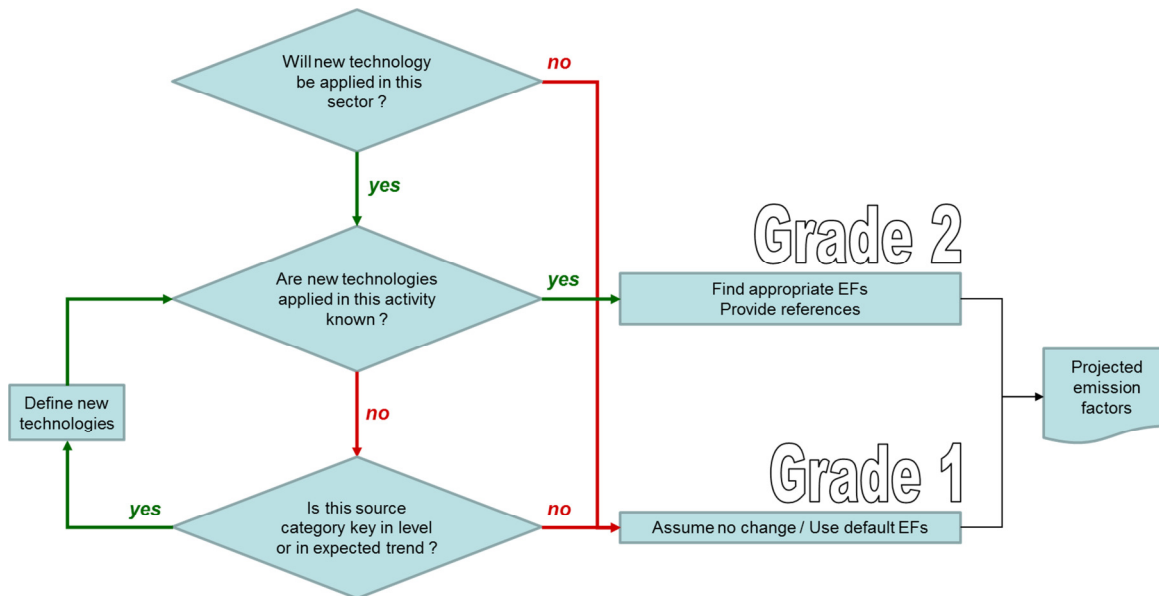
Figure B.1-11 Generalised decision tree for future emission factors for coal mines-in operation activities.

Grade 1

If there is no up to date emission factor from the national inventory, it is good practice to use the default emissions factors from 2006 IPCC Guidelines. The IPCC default emission factors are based on the range of measured deep mine data from a sample group of coal-producing countries. Low-end default emission factor is for mines with average depths of less than 200 m, and high-end default emission factor is for mines with average depths of greater than 400 m.

For underground mines in operation, 2006 IPCC Guideline suggests the following emission factors:

- o   Low CH_4 Emission Factor   = 10 m^3 tonne^{-1};
- o   Average CH_4 Emission Factor   = 18 m^3 tonne^{-1}; and
- o   High CH_4 Emission Factor   = 25 m^3 tonne^{-1}.

For surface mines in operation, 2006 IPCC Guideline suggests the following emission factors:

- o   Low CH_4 Emission Factor   = 0.3 m^3 tonne^{-1};
- o   Average CH_4 Emission Factor   = 1.2 m^3 tonne^{-1}; and
- o   High CH_4 Emission Factor   = 2.0 m^3 tonne^{-1}.

Grade 2

Under the Grade 2 approach, emission factor reported in the most recent MS GHG inventory would be used. In some cases, the emission factor is calculated using actual measurement of CH_4 emissions from gassy mines and coal production data submitted to national authority by mine operators, plus basin-specific assumptions for non-gassy mines. For GHG projection period, the MS-specific emission factor would be held constant, assuming that there is no major change in the overall profile of operating mines in the MS.

The emission factor is likely to change over time as different number and types of mines come into operation or cease operation. Depending on the data available at the MS level or individual mines, it may be possible to take these changes into account and increase or decrease the emission factors for the sector during the GHG projection period.

1.7.3   Coal mines – Post-mining (IPCC 1.B.1)

1.7.3.1   Activity data projections

Activity data projections would be based on historic activity data and expected changes in the specific sector in the projection period. Activity data for this sector includes projection of numbers of abandoned coal mines from both underground and surface mines (1B1ai and 1B1aii, respectively), taking into account future closure of the working mines. If changes in characteristics of the closed mines including gas reserve decay rate and flooding rates are available, it is good practice to reflect this information in emission projections. Another activity data for this sector is the amount of CH_4 recovered and utilised, which is subtracted from the estimated future emissions calculated using projected coal production data and emission factor.

As a starting point for activity data projection, the most recent number of abandoned mines and the estimated reserve of CH_4 in the closed mines should be used.

Grades and decision tree

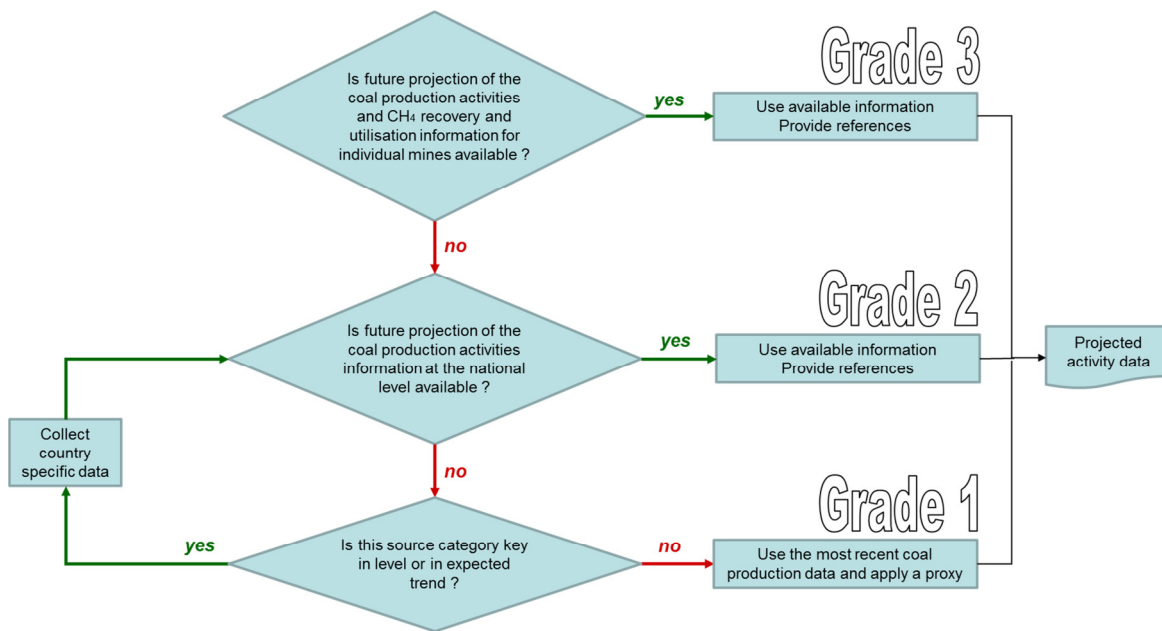Figure B.1-12 presents a generalized decision tree for selecting grades for future activity data for coal mines-post-mining.
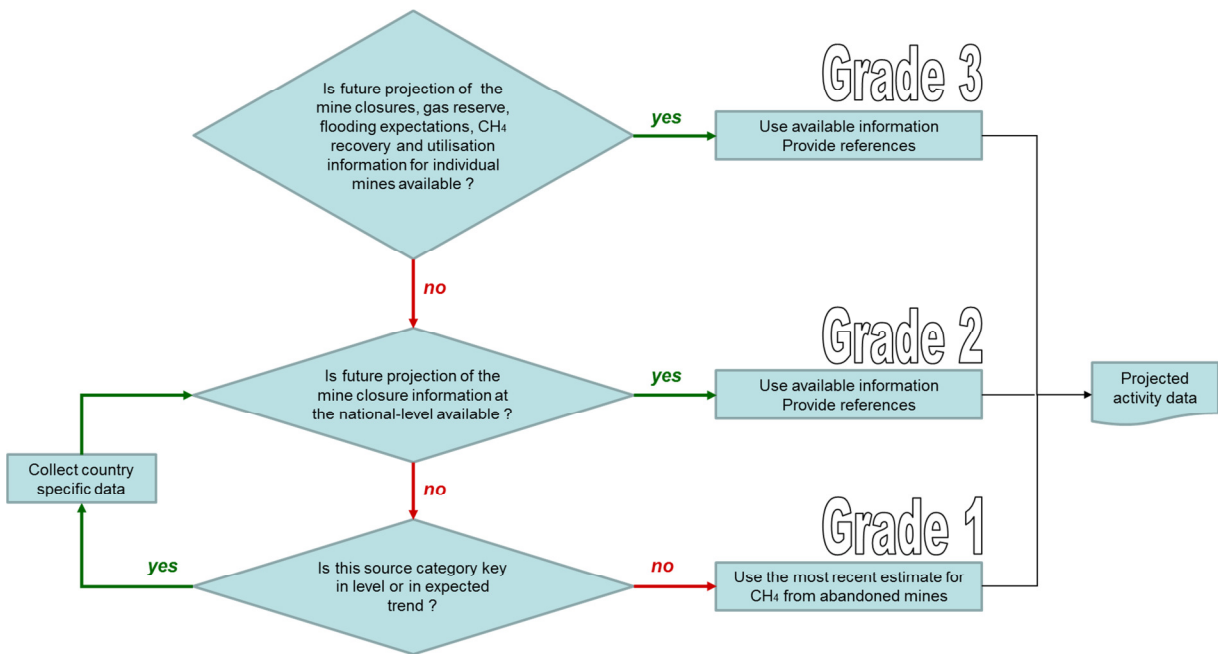
Figure B.1-12 Generalised decision tree for future activity data for coal mines-post-mining activities.

Grade 1

If there is no data on the expected closure of currently operating mines or characteristics of currently closed mines, apply the most recent estimate for CH_4 emissions from abandoned mines from the national GHG inventory and hold constant for the projection period.

Grade 2

Using the available information on the expected closure dates for mines currently in operation, it is good practice to estimate the expected number of closed mines for the projection period. A national average for CH_4 reserve, decay rate, and flooding rate would be applied to estimate CH_4 emissions from these mines.

Grade 3

An inventory of closed mines, expected closures and known gas reserves estimates of individual mines in the MS would be used for forecasting physical properties of individual mines and eventually for aggregated MS-level emission projections. Gas reserve decay rate would be based on historic data. Future projection of CH_4 recovered and utilised should subtracted from the future emissions estimate.

1.7.3.2   Emissions factor projections

Grades and decision tree

Figure B.1-13 presents a generalized decision tree for selecting grades for future emission factors for coal mines-post-mining.
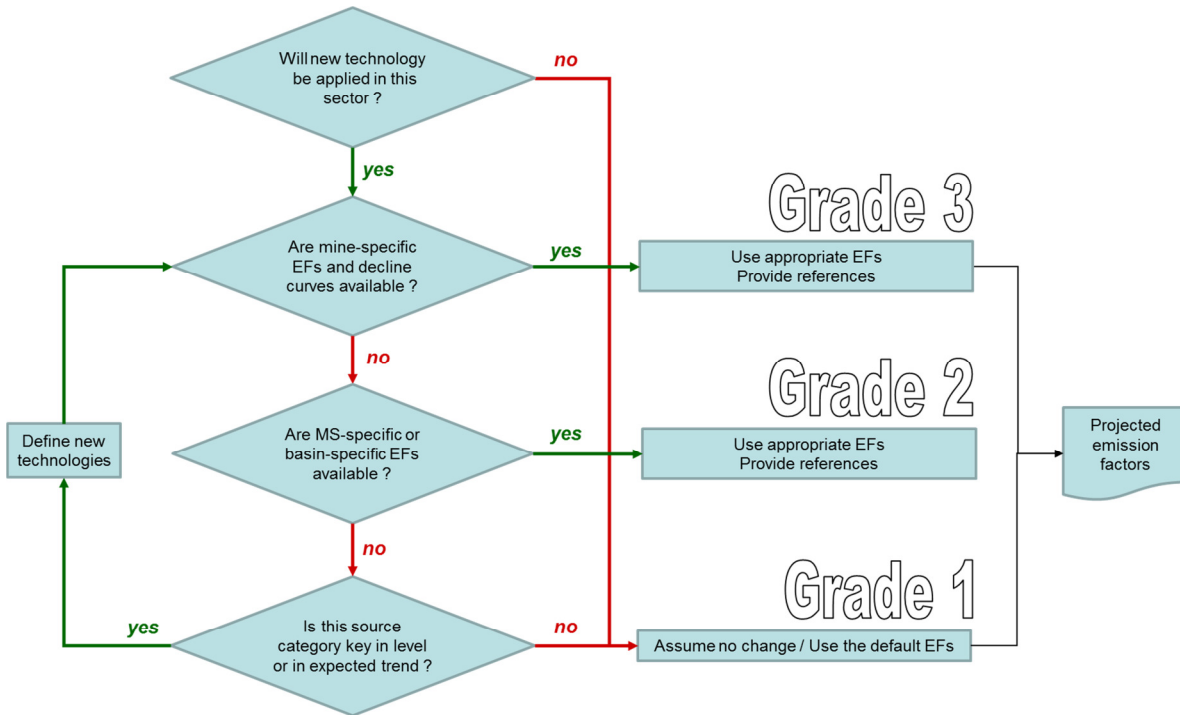
Figure B.1-13 Generalised decision tree for future emission factors for coal mines-post-mining activities.

Grade 1

If the absence of mine- or MS-specific emission factors, it is good practice to use the default global average emissions factors from 2006 IPCC Guidelines. The IPCC default emission factors are based on the total number of coal mines closed, adjusted for the fraction considered gassy. Mines that were non-gassy during operation are presumed to have negligible emissions. The 2006 IPCC Guideline Table 4.1.6 details emission factors specific for year (only up to 2016) and interval of mine closure. Considering that the emission factors decrease from 2012 to 2016 following a linear trend downwards, it would be reasonable to use the emission factors for the years after 2016 that continue to decrease following this trend.

Table 19 Emission factor from abandoned underground mines per interval of mine closure (million M^3 CH$_4$/mine)

Project year	Interval of mine closure				
	1901-1925	1926-1950	1951-1975	1976-2000	2001-Present
2012	0.247	0.286	0.353	0.507	0.763
2013	0.246	0.284	0.350	0.496	0.730
2014	0.244	0.283	0.346	0.487	0.701
2015	0.243	0.281	0.343	0.478	0.675
2016	0.242	0.279	0.340	0.469	0.652

If information on flooding expectation is insufficient, it is good practice to assume that all closed mines are not flooded.

Grade 1

The emission factors would be estimated using general characteristics of the coal mines in the MS. If the MS has a model which takes into account the characteristics of the mines (e.g., interval since closure of the mine, gassiness of the mines, coal type, etc.), then emission factors used in the model may be used for projections. If there are known changes in the general characteristics of the mines at the MS level due to mine closures or openings, it is advised that the emission factors used for the projections also change to best reflect these expected changes in coal mines in the MS.

Grade 2

Based on the regression between the mine-specific gas reserves and flow rate from these mines, a single-value long-term emission factor can be determined. It is good practice to check this emission factor against the historic value for consistency.

1.7.4   Oil and Gas (IPCC 1.B.2)

1.7.4.1   Activity data projections

Activity data projections should be based on historic activity data and expected changes in the specific sector in the projection period. Activity data for this sector is production activity for individual segments of oil & gas production. These segments for the oil sector are venting, flaring, exploration, production and upgrading, transport, refining, distribution, and other. These segments for gas sector are venting, flaring, exploration, production, processing, transmission and storage, distribution, and other. Activity data needed for emission projections in a given segment should include oil and gas throughputs and gas compositions being processed at each segment level. As a starting point for activity data projection, it is good practice to use the most recent activity data.

Grades and decision tree

Figure B.1-14 presents a generalized decision tree for selecting grades for future activity data for oil and gas.
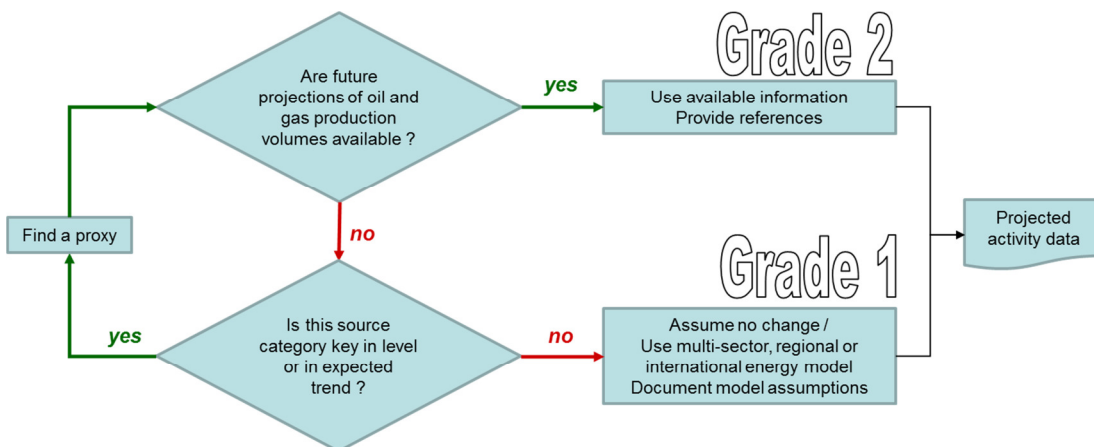
Figure B.1-14 Generalised decision tree for future activity data for oil and gas activities.

Grade1

If the fugitive emissions from the national GHG inventory and historical oil and gas production data do not show considerable changes in recent years, the most recent emissions can be used and held constant. The PRIMES model or the World Energy Model may have information regarding the future activity level in the oil and gas sector.

Grade 2

For each source, reported fugitive emissions can be compared to historical production data in order to determine a correlation. This relationship can be applied to a projection of oil and gas production at the national level for future years to derive activity data in the sector.

1.7.4.2   Emissions factor projections

Grades and decision tree

Figure B.1-15 presents a generalized decision tree for selecting grades for future emission factors for oil and gas activities.
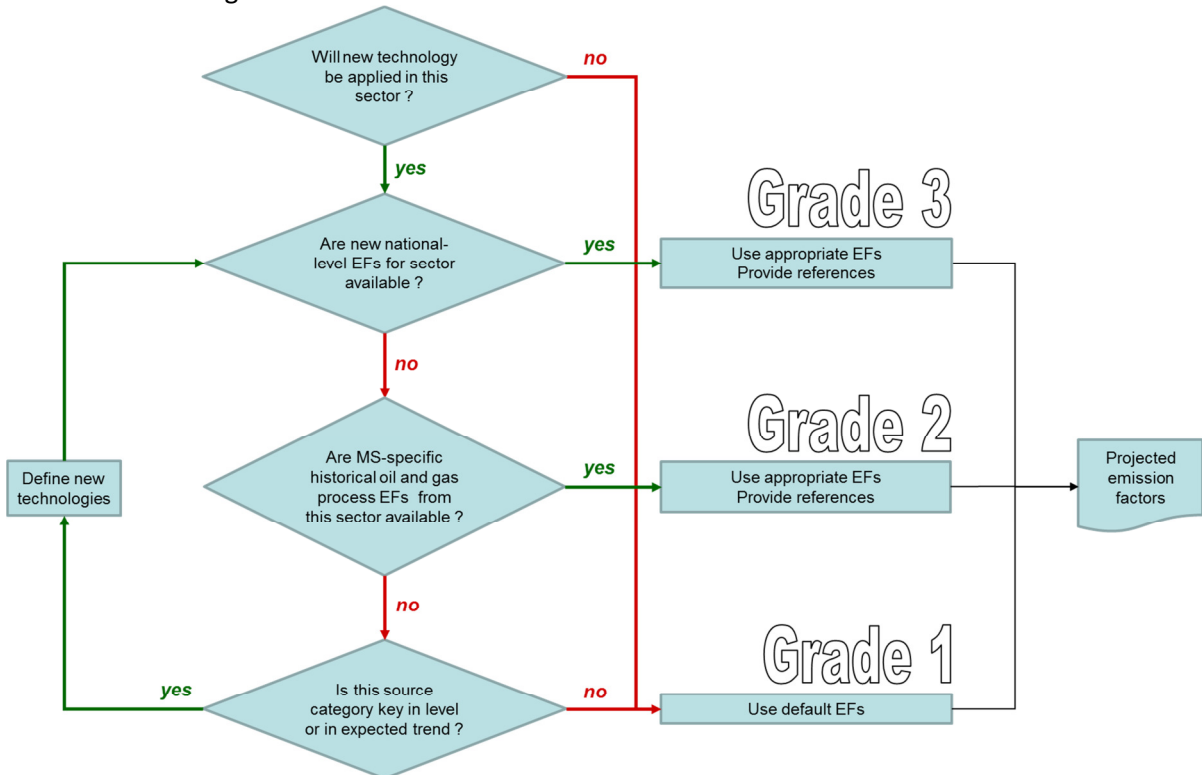
Figure B.1-15 Generalised decision tree for future emission factors for oil and gas activities.

Grade 1

In the absence of data on historical emission factors from the oil and gas process, it is good practice to use the default emission factors from Table 4.2.4 and 4.2.5 of the 2006 IPCC Inventory Guidelines.

Grade 2

Using the historical oil and gas production activities and fugitive emissions from the sector at the MS level, emissions factor expressed in units of mass emissions per unit volume of oil or gas throughput can be calculated. This can be held constant for the future years.

Grade 3

If there are known policies and programmes specifically targeting to reduce fugitive emissions from this sector and data is available on these potential structural changes to the source categories is available at the MS-level, this can be taken into account to estimate the emission factors. Factors which might prompt a change in the emission factors over time include:

- o changes to venting or flaring practices (i.e. replace vending with flaring, reductions in CH_4 emission due to capture and utilisation).
- o changes to emission control technologies applied within industrial source types (e.g. improved leak detection and repair programme).
- o structural changes that lead to changes in emission factors indirectly such as replacement of old cast iron gas distribution pipes with plastic pipes.

1.7.5   Policies and Measures

The projections developed should directly incorporate or be checked against legislative and other limits on emissions and/or lead to changes in overall energy demand and supply balance. It is good practice to ensure that these effects are taken into account in the proper source category and transparently documented in the national projections report. It is recommended that Member States set out clearly (e.g. in a tabular format) how each of the policies and measures has been taken into account in the projections.

In some cases, there may be potential cross-sectoral effects of policies and measures (PAMs). For instance, a transportation policy aiming to increase the use of rail would lead to an increase in electricity demand. Therefore it is good practice to carefully review existing PAMS and take into account their potential effects on the activity and emission factor projections.

Table below lists the European Directives that are directly relevant to the fugitive emissions from fuel, covering coal, oil and gas industries. In addition to the European-level policies and measures, there may be national policies and measures that would have direct or indirect impacts on the sector, therefore it is good practice to consider these effects are taken into account and transparently document in the projections.

The projections developed should either directly incorporate or be checked against legislative and other limits on emissions. It is recommended that Member States set out clearly (e.g. in a tabular format) how each of the policies and measures has been taken into account in the projections.

Table 20 Policies and Measures and related parameters changed via implementation of particular PAM for Fugitive Emissions sector.

Sector	Description	Legislation	Parameters/Variables
Fugitive Emissions from Fuels	*Directives:*		
	Industrial Emissions Directives	Directive 2010/75EC	*Emission ceilings for air pollutants,* *Emission factors,* *Energy production,* *Final energy consumption by sector by fuel type,* *Fuel efficiency* *Share of different technologies*
	Amending Emissions Trading Scheme to improve and extend the greenhouse gas emission allowance trading scheme of the Community	Directive 2009/29/EC	*Electricity consumption,* *Emission factors,* *Final energy consumption by sector by fuel type,* *Share of different forms of energy*
	Integrated pollution prevention and control (IPPC) recast	Directive 2008/1/EC	*Emission factors*
	Emissions Trading Scheme (ETS Directive)	Directive 2003/87/EC	*Electricity consumption,* *Emission factors,* *Energy efficiency,* *Final energy consumption by sector by fuel type,* *Share of different forms of energy*
	Emissions from large combustion plants (LCP Directive)	Directive 88/609/EEC	*Energy production,* *Final energy consumption by sector by fuel type,* *Share of different technologies*
	National Emission Ceilings for certain pollutants (NEC Directive)	Directive 2001/81/EC	*Emission ceilings for air pollutants*
	Emissions from large combustion plants	Directive 2001/80/EC	*Emission ceilings for air pollutants*
	Regulation:		
	Community eco-management and audit scheme (EMAS)	Regulation 761/2001	*Energy efficiency,* *Final energy consumption by sector by fuel type*

In addition, there are policies and measures that are indirectly relevant to fugitive emissions from fuel, covering coal, oil and gas industries, such as European Energy Programme for Recovery (Regulation 2009/663/EC).

Indicators for projections to monitor and evaluate progress with PAMs include energy-related CO_2 @ intensity for selected industries (t/EUR million) and specific CO_2 emissions for selected industries (t emissions/t product).

1.7.6 Source specific QA/QC

It is important to ensure that resulting emission projections have similar verification and QA/QC as applied to the historic inventory.

A "general" QA/QC (described in General Guidance – Part A Chapter A.8: Quality Assurance and Quality Control (QA/QC) for Projections) should be undertaken to ensure the quality (TCCCA) of the MS GHG projections (see also 1.A. Fuel Combustion section 1.2.5).

Issue to take into consideration in addition to the general QA/QC guidelines include:

- o Fugitive emissions from coal, oil and gas industries should share the same activity data with Industrial process emissions (2.A to 2.F). Also for some source categories, direct linking of activity data is recommended.

MS vary greatly in the number and type of fugitive emission sources. As with other sectors, it is good practice to specify which fugitive emission source is categorised under the suggested 2006 IPCC Source Categories and how the activity data and emission factors are estimated. In addition, the projections should be checked against the inventory data to see if they are consistent with each other.

It is good practice to conduct these QA/QC activities within the internal GHG projections team but it could be supplemented by independent reviews by experts. This would provide assurance on the methods, assumptions and data sources used in the projected estimates of GHG emissions.

Annex B.1.I   Link to EUROSTAT Energy Statistics

B.1.I.1   EUROSTAT Products and Indicators

All EU Member States report energy statistics to EUROSTAT in a well-defined format and set of definitions of both the fuel types (**products** as these are called in the energy statistics) and activities (also called **indicators** in the energy statistics). For a transparent reporting of energy related greenhouse gas emissions it is good practice to directly link to these EUROSTAT definitions and practices. This would very much support (time series) consistency between retrospective energy statistics and prospective energy sector projections.

Table 21 Relevant "Products" (fuels) and "Indicators" in EUROSTAT.

Relevant "Products" (fuels) and "Indicators" in EUROSTAT

This table lists all the detailed fuel as combusted in all sectors of the economy, with a direct link to the IPCC 1996 and 2006 source categories, as presently used in the greenhouse gas reporting to UNFCCC under the Convention and under the Kyoto Protocol. These data provide the "output" indicators from the **Economy** part and as the input indicators for the **Technology** part of the projection model (see General Guidance – Part A Chapter A.3 Modelling Projection, section 3.5 Technology module).

For each of the relevant source categories / fuel combinations in the Member State's projected inventory the tables above provide a EUROSTAT definition that will provide the required historic activity data. The sectoral chapters in these guidelines will provide guidance on how to project these activity data towards the specific years of the projection.

B.1.I.2   IPCC Fuels and EUROSTAT Products

The EUROSTAT products need to be interpreted as the ***Fuels*** defined by the IPCC Guidelines. These IPCC definitions are essentially the same in both the IPCC 1996 and the IPCC 2006 Guidelines. The link is provided in the table below.

Table 22 EUROSTAT "Products" (fuels) and fuels as defined by IPCC.

English Description		Comments (IPCC 2006 Guidelines, Volume 2, chapter 1 — table 1.1 definitions of fuel types used in the 2006 guidelines)	Product code	Product Name
LIQUID (Crude oil and petroleum products)				
Crude Oil		Crude oil is a mineral oil consisting of a mixture of hydrocarbons of natural origin, being yellow to black in colour, of variable density and viscosity. It also includes lease condensate (separator liquids) which are recovered from gaseous hydrocarbons in lease separation facilities.	3290	Other Petroleum Products
Orimulsion		A tar-like substance that occurs naturally in large reserves in Venezuela. Orimulsion can be burned directly or refined into light petroleum products.	3290	Other Petroleum Products
Natural Gas Liquids (NGLs)		NGLs are the liquid or liquefied hydrocarbons produced in the manufacture, purification and stabilisation of natural gas. These are those portions of natural gas which are recovered as liquids in separators, field facilities, or gas processing plants. NGLs include but are not limited to ethane, propane, butane, pentane, natural gasoline and condensate. They may also include small quantities of non-hydrocarbons.	3290	Other Petroleum Products
Gasoline	Motor Gasoline	This is light hydrocarbon oil for use in internal combustion engines such as motor vehicles, excluding aircraft. Motor gasoline is distilled between 35°C and 215°C and is used as a fuel for land based spark ignition engines. Motor gasoline may include additives, oxygenates and octane enhancers, including lead compounds such as TEL (Tetraethyl lead) and TML (Tetramethyl lead).	3230	Motor Spirit
	Aviation Gasoline	Aviation gasoline is motor spirit prepared especially for aviation piston engines, with an octane number suited to the engine, a freezing point of -60°C, and a distillation range usually within the limits of 30°C and 180°C.	3230	Motor Spirit
	Jet Gasoline	This includes all light hydrocarbon oils for use in aviation turbine power units. They distil between 100°C and 250°C. It is obtained by blending kerosenes and gasoline or naphthas in such a way that the aromatic content does not exceed 25% in volume, and the vapour pressure is between 13.7 kPa and 20.6 kPa. Additives can be included to improve fuel stability and combustibility.	3230	Motor Spirit
Jet Kerosene		This is medium distillate used for aviation turbine power units. It has the same distillation characteristics and flash point as kerosene (between 150°C and 300°C but not generally above 250°C). In addition, it has particular specifications (such as freezing point) which are established by the International Air Transport Association (IATA).	3240	Kerosenes - Jet Fuels
Other Kerosene		Kerosene comprises refined petroleum distillate intermediate in volatility between gasoline and gas/diesel oil. It is a medium oil distilling between 150°C and 300°C.	3240	Kerosenes - Jet Fuels
Shale Oil		A mineral oil extracted from oil shale.	3290	Other Petroleum Products
Gas/Diesel Oil		Gas/diesel oil includes heavy gas oils. Gas oils are obtained from the lowest fraction from atmospheric distillation of crude oil, while heavy gas oils are obtained by vacuum redistillation of the residual from atmospheric distillation. Gas/diesel oil distils between 180°C and 380°C. Several grades are available depending on uses: diesel oil for diesel compression ignition (cars, trucks, marine, etc.), light heating oil for industrial and commercial uses, and other gas oil including heavy gas oils which distil between 380°C and 540°C and which are used as petrochemical feedstocks.	3260	Gas / Diesel Oil
Residual Fuel Oil		This heading defines oils that make up the distillation residue. It comprises all residual fuel oils, including those obtained by blending. Its kinematic viscosity is above 10 cSt at 80°C. The flash point is always above 50°C and the density is always more than 0.90 kg/l.	Select Code	
Liquefied Petroleum Gases		These are the light hydrocarbons fraction of the paraffin series, derived from refinery processes, crude oil stabilisation plants and natural gas processing plants comprising propane (C₃H₈) and butane (C₄H₁₀) or a combination of the two. They are normally liquefied under pressure for transportation and storage.	Select Code	
Ethane		Ethane is a naturally gaseous straight-chain hydrocarbon (C₂H₆). It is a colourless paraffinic gas which is extracted from natural gas and refinery gas streams.	Select Code	
Naphtha		Naphtha is a feedstock destined either for the petrochemical industry (e.g. ethylene manufacture or aromatics production) or for gasoline production by reforming or isomerisation within the refinery. Naphtha comprises material in the 30°C and 210°C distillation range or part of this range.	Select Code	
Bitumen		Solid, semi-solid or viscous hydrocarbon with a colloidal structure, being brown to black in colour, obtained as a residue in the distillation of crude oil, vacuum distillation of oil residues from atmospheric distillation. Bitumen is often referred to as asphalt and is primarily used for surfacing of roads and for roofing material. This category includes fluidised and cut back bitumen.	Select Code	
Lubricants		Lubricants are hydrocarbons produced from distillate or residue; they are mainly used to reduce friction between bearing surfaces. This category includes all finished grades of lubricating oil, from spindle oil to cylinder oil, and those used in greases, including motor oils and all grades of lubricating oil base stocks.	Select Code	
Petroleum Coke		Petroleum coke is defined as a black solid residue, obtained mainly by cracking and carbonising of petroleum derived feedstocks, vacuum bottoms, tar and pitches in processes such as delayed coking or fluid coking. It consists mainly of carbon (90% to 95%) and has a low ash content. It is used as a feedstock in coke ovens for the steel industry, for heating purposes, for electrode manufacture and for production of chemicals. The two most important qualities are "green coke"	Select Code	

EUROSTAT "Products" (fuels) and fuels as defined by IPCC

B.1.I.3   IPCC Source categories and EUROSTAT Indicators

The EUROSTAT products need to be interpreted as the ***Fuels*** defined by the IPCC Guidelines. These IPCC definitions are essentially the same in both the IPCC 1996 and the IPCC 2006 Guidelines.

Table 23 Relevant "Products" (fuels) and "Indicators" in EUROSTAT

Category Number and Name	Definitions	96 GLs Category	Gases	Indicator Code	Indicator Name
	Table 8.2				
	Classification and definition of categories of emissions and removals				
1 ENERGY	All GHG emissions arising from combustion and fugitive releases of fuels. Emissions from the non-energy uses of fuels are generally not included here, but reported under 2 Industrial Processes and Product Use.	1	CO_2, CH_4, N_2O, NOx, CO, $NMVOC$, SO_2	Select Code	
1 A **Fuel Combustion Activities**	Emissions from the intentional oxidation of materials within an apparatus that is designed to raise heat and provide it either as heat or as mechanical work to a process or for use away from the apparatus.	1A	CO_2, CH_4, N_2O, NOx, CO, $NMVOC$, SO_2	Not relevant	
1 A 1 *Energy Industries*	Comprises emissions from fuels combusted by the fuel extraction or energy-producing industries.	1A1	CO_2, CH_4, N_2O, NOx, CO, $NMVOC$, SO_2	Not	
1 A 1 a Main Activity Electricity and Heat Production	Sum of emissions from main activity producers of electricity generation, combined heat and power generation, and heat plants. Main activity producers (formerly know as public utilities) are defined as those undertakings whose primary activity is to supply the public. They may be in public or private ownership. Emissions from own on-site use of fuel should be included. Emissions from autoproducers (undertakings which generate electricity/heat wholly or partly for their own use, as an activity which supports their primary activity) should be assigned to the sector where they were generated and not under 1 A 1 a. Autoproducers may be in public or private ownership.	1A1a	CO_2, CH_4, N_2O, NOx, CO, $NMVOC$, SO_2	101001 Input to conventional thermal power stations	
1 A 1 a i Electricity Generation	Comprises emissions from all fuel use for electricity generation from main activity producers except those from combined heat and power plants.	1A1a i	CO_2, CH_4, N_2O, NOx, CO, $NMVOC$, SO_2	Not relevant	
1 A 1 a ii Combined Heat and Power Generation (CHP)	Emissions from production of both heat and electrical power from main activity producers for sale to the public, at a single facility; co-generation plant.	1A1a ii	CO_2, CH_4, N_2O, NOx, CO, $NMVOC$, SO_2	Not relevant	
1 A 1 a iii Heat Plants	Production of heat from main activity producers for sale by pipe network.	1A1a iii	CO_2, CH_4, N_2O, NOx, CO, $NMVOC$, SO_2	Not	
1 A 1 b Petroleum Refining	All combustion activities supporting the refining of petroleum products. Does not include evaporative emissions occurring at the refinery. These emissions should be reported separately under 1 B 2 a below.	1A1b	CO_2, CH_4, N_2O, NOx, CO, $NMVOC$, SO_2	Select Code	
1 A 1 c Manufacture of Solid Fuels and Other Energy	Combustion emissions from fuel use during the manufacture of secondary and tertiary products from solid fuels including production of charcoal. Emissions from own on-site fuel use should be included.	1A1c	CO_2, CH_4, N_2O, NOx, CO, $NMVOC$, SO_2	Select Code	
1 A 1 c i Manufacture of Solid Fuels	Emissions arising from fuel combustion for the production of coke, brown coal briquettes and patent fuel.	1A1c i	CO_2, CH_4, N_2O, NOx, CO, $NMVOC$, SO_2	Select Code	
1 A 1 c ii Other Energy Industries	Combustion emissions arising from the energy-producing industries own (on-site) energy use not mentioned above. This includes the emissions from own-energy use for the production of charcoal, bagasse, saw dust, cotton stalks and carbonizing of biofuels as well as fuel used for coal mining and oil and gas extraction. This category also includes emissions from pre-combustion processing for CO_2 capture and storage. Combustion emissions from pipeline transport should be reported under 1A3 e.	1A1c ii	CO_2, CH_4, N_2O, NOx, CO, $NMVOC$, SO_2	Select Code	
1 A 2 *Manufacturing Industries and Construction*	Emissions from combustion of fuels in industry including combustion for the generation of electricity and heat for own use in these industries. Emissions from fuel combustion in coke ovens within the iron and steel industry should be reported under 1 A 1 c and not within manufacturing industry. Emissions from the industry sector should be specified by sub-categories that correspond to the International Standard Industrial Classification of All Economic Activities (ISIC). Energy used for transport by industry should not be reported here but under Transport (1 A 3). Emissions arising from off-road and other mobile machinery in industry should, if possible, be broken out as a separate subcategory. For each country, the emissions from the largest fuel-consuming industrial categories (ISIC) should be reported, as well as those from significant emitters of pollutants. A suggested list of categories is	1A2	CO_2, CH_4, N_2O, NOx, CO, $NMVOC$, SO_2	Select Code	
1 A 2 a Iron and Steel	ISIC Group 271 and Class 2731	1A2a	CO_2, CH_4, N_2O, NOx, CO, $NMVOC$, SO_2	Select Code	
1 A 2 b Non-Ferrous Metals	ISIC Group 272 and Class 2732	1A2b	CO_2, CH_4, N_2O, NOx, CO, $NMVOC$, SO_2	Select Code	
1 A 2 c Chemicals	ISIC Division 24	1A2c	CO_2, CH_4, N_2O, NOx, CO, $NMVOC$, SO_2	Select Code	
1 A 2 d Pulp, Paper and Print	ISIC Divisions 21 and 22	1A2d	CO_2, CH_4, N_2O, NOx, CO, $NMVOC$, SO_2	Select Code	
1 A 2 e Food Processing,	ISIC Divisions 15 and 16	1A2e	CO_2, CH_4, N_2O, NOx, CO, $NMVOC$, SO_2	Select	
1 A 2 f Non-Metallic Minerals	Includes products such as glass ceramic, cement, etc. ISIC Division 26	1A2f	CO_2, CH_4, N_2O, NOx, CO, $NMVOC$, SO_2	Select Code	
1 A 2 g Transport Equipment	ISIC Divisions 34 and 35	1A2f	CO_2, CH_4, N_2O, NOx, CO, $NMVOC$, SO_2	Select Code	
1 A 2 h Machinery	Fabricated metal products, machinery and equipment other than transport equipment ISIC Divisions 28, 29, 30, 31 and 32	1A2f	CO_2, CH_4, N_2O, NOx, CO, $NMVOC$, SO_2	Select Code	
1 A 2 i Mining and Quarrying	ISIC Divisions 13 and 14	1A2f	CO_2, CH_4, N_2O, NOx, CO, $NMVOC$, SO_2	Select Code	

Relevant "Products" (fuels) and "Indicators" in EUROSTAT

Annex B.1.II   PRIMES Model

Within the European Union the Primes model of the E^{3}M Lab of the National Technical University of Athens is frequently used when projecting energy demand, energy transformation and energy supply for 35 countries in Europe, including the 27 EU Member States.

The PRIMES model is a modelling system that simulates a market equilibrium solution for energy supply and demand. The model determines the equilibrium by finding the prices of each energy form such that the quantity producers find best to supply matches the quantity consumers wish to use. The equilibrium is static (within each time period) but repeated in a time-forward path, under dynamic relationships.

The Primes model description provides details on the specific properties of the model, including a comparison with other energy models. The PRIMES modelling methodology is briefly summarized in the figure below.

Figure B.1-16 Primes modelling methodology
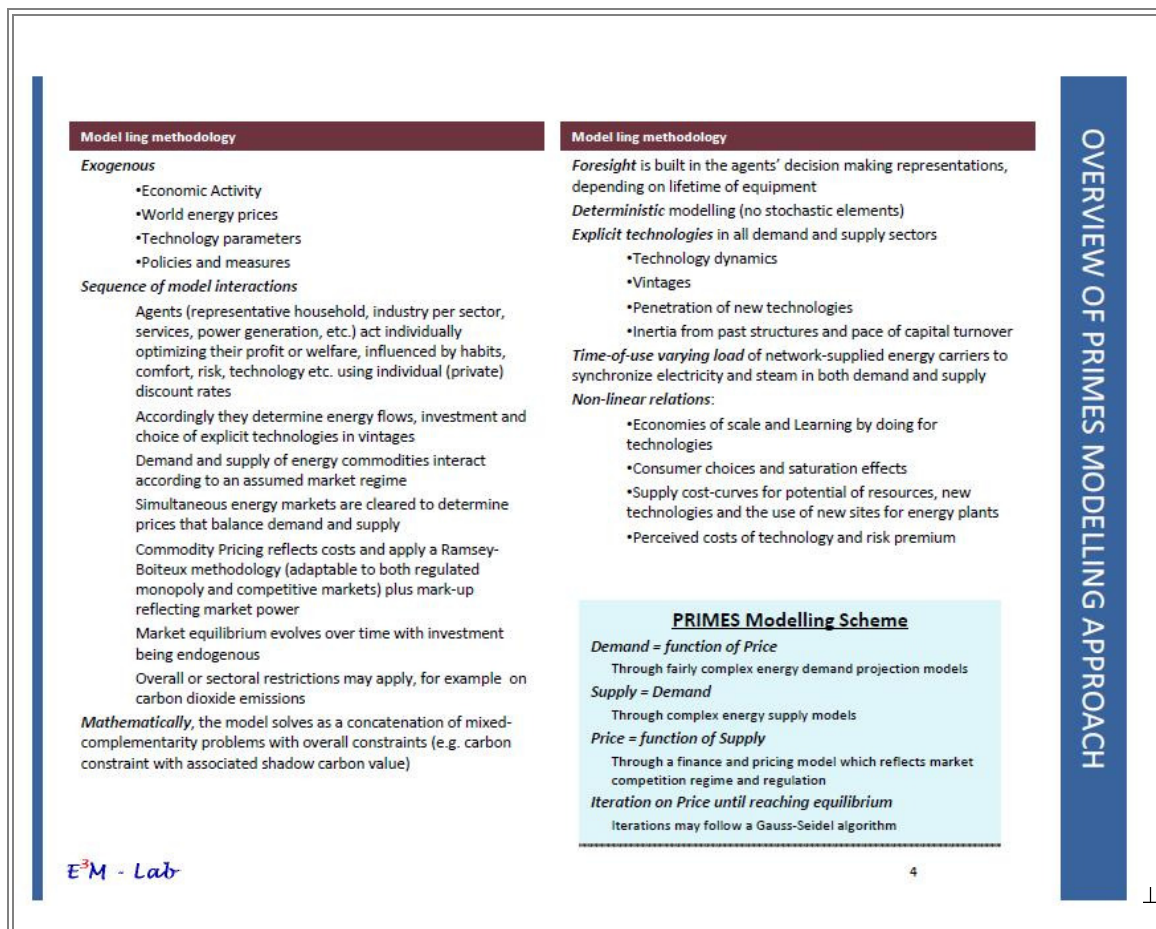
Primes modelling methodology

The model estimates the by fuel and by activity energy demand as a result of individual decisions by "agents" in an economic equilibrium model.

In order to run, the model needs information on Economic Activity, World energy prices, Technology parameters and Policies and measures. With this exogenous information PRIMES generates projected full detailed energy balances for each country in the model.

Parameters used in projecting energy use

Figure B.1-17 Primes main inputs and outputs.
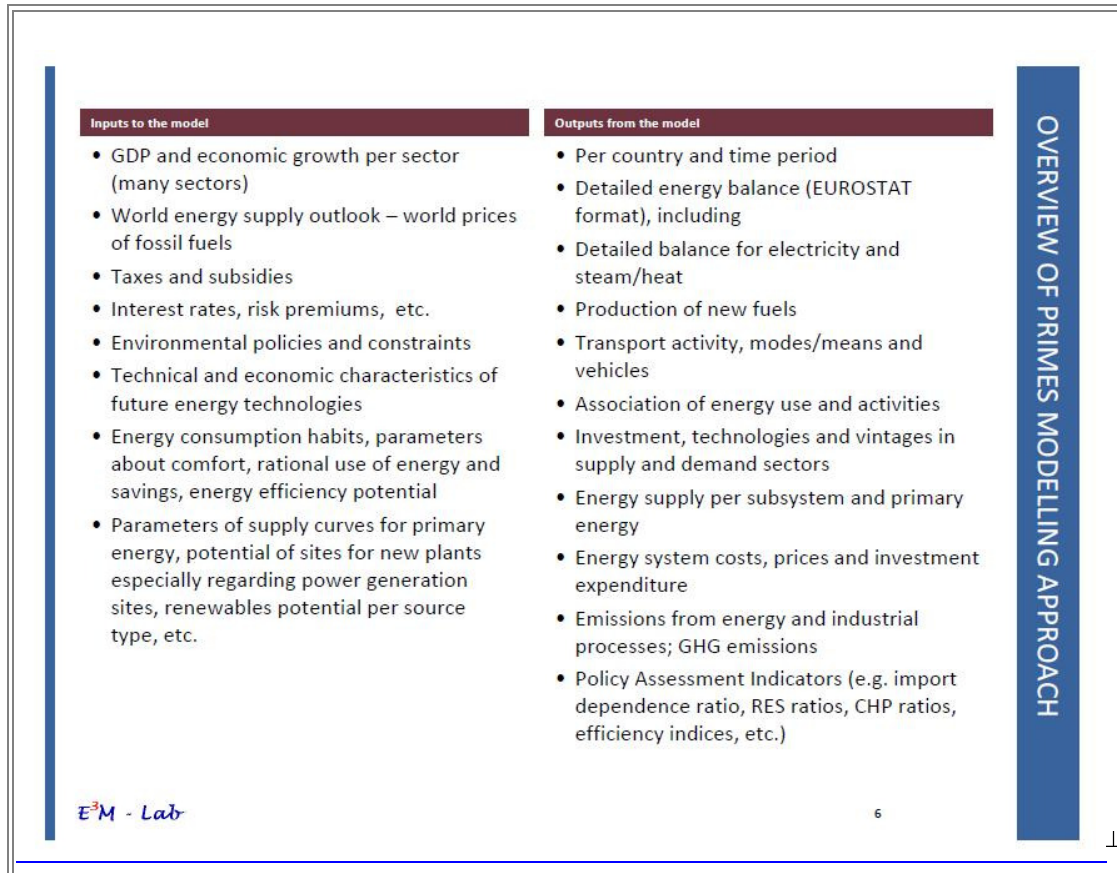
Primes main inputs and outputs

Annex B.1.III   World Energy Model

The World Energy Model is a mathematical model run and managed by the International Energy Agency (IEA) (IEA, 2011). It covers 25 regions and consists of six main modules: final energy consumption (with sub-models covering residential, services, agriculture, industry, transport and non-energy use); power generation and heat; refinery/petrochemicals and other transformation; fossil-fuel supply; CO_2 emissions and investment.

The model is designed to analyse:

- o Global energy prospects including trends in demand, supply availability and constraints, international trade and energy balances by sector and by fuel to 2035.
- o Environmental impact of energy use: CO_2 emissions from fuel combustion are derived from the detailed projections of energy consumption.
- o Effects of policy actions and technological changes: Alternative scenarios analyse the impact of policy actions and technological developments on energy demand, supply, trade, investments and emissions.
- o Investment in the energy sector: The model evaluates investment requirements in the fuel supply chain needed to satisfy projected energy demand to 2035. It also evaluates demand-side investment requirements in the alternative scenarios.

In the model, sector and end-use is modelled in detail as follows:

- o Industry is separated into five subsectors, allowing a more detailed analysis of trends and drivers in the industrial sector by fuel.
- o Residential energy demand is separated into five end-uses by fuel.
- o Services demand by fuel.
- o Transport demand is modelled in detail by mode and fuel.

Final energy demand at the sectoral level is modelled for each of the model regions, but not at such a disaggregated end-use level. Total final energy demand is the sum of energy consumption in each final demand sector. In each subsector or end-use, at least six types of energy are shown: coal, oil, gas, electricity, heat and renewables. Within each subsector or end-use, energy demand is estimated as the product of an energy intensity and an activity variable.

The model's regional definitions and grouping of regions in regard to the 27 Member States are as below:

- o European Union, including Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden and United Kingdom.
- o OECD Europe (comprising 3 regional models):

  ✓ France, Germany, Italy and the United Kingdom;

- ✓ Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, Greece, Hungary, Ireland, Luxembourg, Netherlands, Poland, Portugal, Slovak Republic, Slovenia , Spain, and Sweden; and
- ✓ Iceland, Norway, Switzerland and Turkey and Israel.

> o Eastern Europe/Eurasia (comprising 1 country model and 3 regional models):

- ✓ Bulgaria, Cyprus, Latvia, Lithuania, Malta, and Romania;
- ✓ Albania, Belarus, Bosnia and Herzegovina, Croatia, Gibraltar, the Former Yugoslav Republic of Macedonia, the Repulic of Moldova, Serbia (included Montenegro until 2004 and Kosovo until 1999) and Ukraine;
- ✓ Russia; and
- ✓ Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan.

B.2 Industrial Processes (IPCC sector 2)

2.1   Introduction

2.1.1   Source description

Table 24 Sector split for Industrial Processes.

IPCC 2006 source category		Description	Re-port
2	Industrial Processes and Product Use	Emissions from industrial processes and product use, excluding those related to energy combustion (reported under 1A), extraction, processing and transport of fuels (reported under 1B) and CO_2 transport, injection and storage (reported under 1C).	☑
2A	Mineral Industry		☑
2B	Chemical Industry		☑
2C	Metal Industry		☑
2D	Non-Energy Products from Fuels and Solvent Use	The use of oil products and coal-derived oils primarily intended for purposes other than combustion.	☑
2E	Electronics Industry		☑
2F	Product Uses as Substitutes for Ozone Depleting Substances		☑
2G	Other Product Manufacture and Use		☑
2H	Other		☑

Source: IPCC (2006)

2.2   General guidance for projections in this sector

For the projection of emissions from industrial processes (mainly CO_2, CH_4 and N_2O but also e.g. PFC from aluminium production or SF6 from Aluminium and Magnesium Foundries), it is good practice to split the projection into the projection of activity data (see 2. Industrial Processes section 2.2.1) and emission factors (see 2. Industrial Processes section 2.2.2), using activity data and emission factors of the most recent historic inventory year as starting point for projections. If this split is not possible because the data is not published due to confidential reasons, emission projections have to be calculated as a whole term (see 2. Industrial Processes section 2.2.3).

For subsectors which are identified to be key source categories at the moment of projection or in the future, it is good practice to apply higher grade methods of the sectoral guidances.

For the projection of F-Gases a broad range of individual chemical species of HFCs and PFCs and SF_6 has to be considered with different Global Warming Potentials (GWP). For F-gases, in addition to emissions which occur during the production process, also emissions from the stock of appliances have to be taken into account. These are emitted along the lifetime of each appliance and during disposal at the end of their lifetime. Therefore for the projection of emissions occurring from source categories 2.F the following emission sources have to be considered:

- o   Manufacturing emissions
- o   Lifetime emissions (resulting as leakage from the stock of appliances)
- o   Disposal emissions (emissions occurring at the end of lifetime from the stock of appliances which is disposed)

Detailed calculations have to include in most cases historical trends, which influence the stock of appliances. Effects of policies and measures can only affect emissions of new products or those occurring at the end of lifetime of the actual stock of appliances. Only manufacturing emissions are directly linked to the production data of each single year. Guidelines for the projection in this subsector are described in section 2.2.4.

2.2.1   Activity data projections

Activity data projections must be based on a historic starting point and scenarios developed, which show how the future may look like.

As a starting point for activity data projections, it is good practice to use the most recent activity data for the subsector provided by the country in its inventory submissions and to use the same level of detail (regarding the inclusion of gases and methodologies used).). It is good practice to report historical data for 2000, 2005, and 2010.

2.2.1.1   Grades and Decision Tree

Figure B.2-1 presents a generalized decision tree for selecting grades for future activity data for industrial processes. This decision tree applies for each of the industrial processes activities.
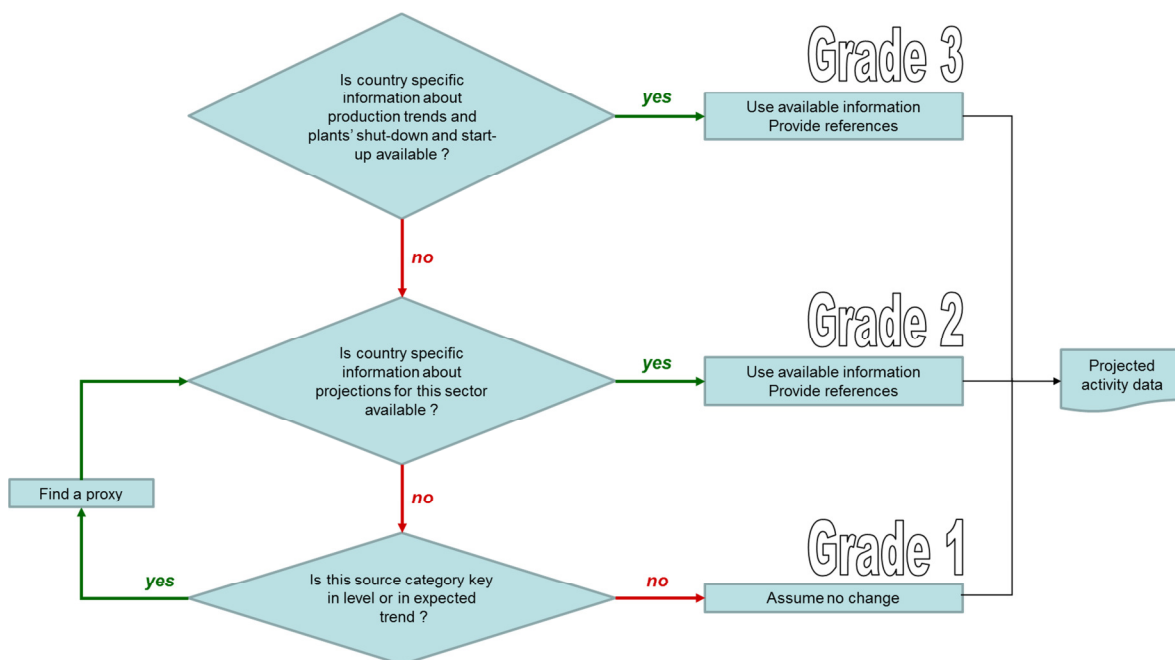
Figure B.2-1 Generalised decision tree for future activity data for industrial processes activities.

2.2.1.2   Grade 1

If the subsector is not a key source category it is good practice to use the most recent data and keep it constant.

2.2.1.3   Grade 2

If the subsector is a key category it is good practice to check if considerable changes can be observed in the activity data submitted in the last five years in the national GHG inventories which should be considered with an extrapolation of the trend or if it seems probable that they will change due to:

- o   economic development (GVA or GDP) or sectoral economic trends (projected output per sector)
- o   effects of policies and measures.

The size of the population generally influences industrial processes, but in most source categories the effects of its growth and decrease are small in relation to the effects of parameters mentioned above.

If this is the case, it is good practice to project changing activity data along the time series, calculating variations in production index (t/a) between the years with the same rate, which can be identified for the trend of the most important parameter.

For projections of economic development it is good practice to use European projections of national GVA or GDP. Only if national projections in good quality are available, it is good practice to use them instead, conducting also a sensitivity analysis with European projections of national GVA or GDP. For effects of PAMs it is good practice to use preferably national projections (e.g. from national ministries, economic research organizations and statistical offices), however if these are not available European projections should be used. For the projection of population development it is good practice to use European projections.

If no influences of the parameters mentioned are assumed to occur in the future, it is good practice to keep activity data constant.

2.2.1.4   Grade 3

If the subsector is a key category (actual emissions or trend), it is good practice to use national projections on the amount of production in future years or information about the shutdown or start-up of individual installations and their existing or expected production.

2.2.2   Emissions factor projections

Emission factors are dependent on the carbon content of process input and output. Stoichiometric relationships are constant, that is why for most industrial processes, emission factors are constant along the time series and only differ slightly between MS.

As a starting point for emission factor projection, it is good practice to use the most recent emission factor for the subsector provided by MS in their inventory submissions, related to the activity data of the subsector. It is good practice to report historical data for 2000, 2005, and 2010.

2.2.2.1   Grades and Decision Tree

Guidelines for emission factor projections adopt the Grade-based approach of the 2006 IPCC Emission Inventory Guidelines. Figure B.2-2 presents a generalized decision tree for selecting grades for future emission factors for industrial processes. This decision tree applies for each of the industrial processes activities.
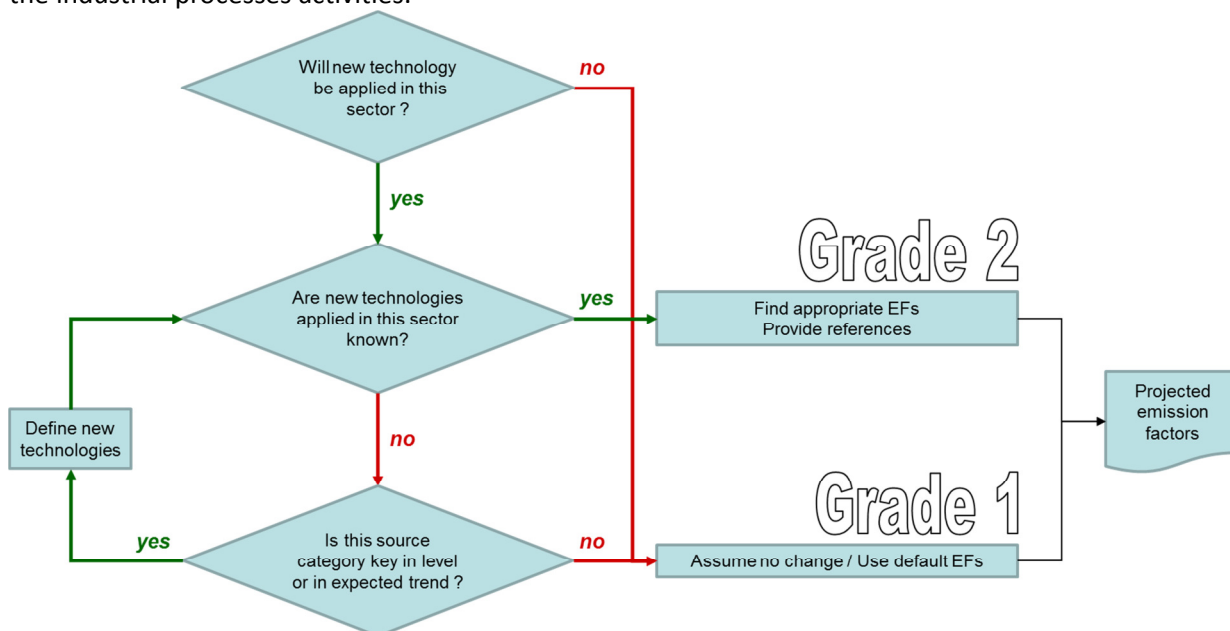
Figure B.2-2 Generalised decision tree for future emission factors for industrial processes activities.

2.2.2.2   Grade 1

If the subsector is not a key source category or if the emission factor has not changed considerably according to national GHG inventory data in the last five years, it is good practice to use the most recent data or a reasonable average value of (e.g. last five years) emission factors and keep these factors constant.

2.2.2.3   Grade 2

If the subsector is a key category it is good practice to check if considerable changes can be observed in the emission factors submitted in the last five years in the national GHG inventories which should be considered with an extrapolation of the trend or if it seems probable that they will change due to:

o   changes in process input or output or
o   technical developments such as the installation of abatement measures at the plants (e.g. recycling of cement kiln dust, installation of abatement technologies for N_2O)
o   effects of policies and measures.

If this is the case it is good practice to vary emission factors along the future time series, depending on projections of future development the influencing factors outlined. If no relevant changes can be observed or are anticipated, emission factors can be kept constant.

2.2.3   Projections in a whole term

As a starting point for emission projection, it is good practice to use the emission data for the source category provided by MS in their inventory submissions and to use the same level of detail (regarding the inclusion of gases and methodologies used). It is good practice to report historical data for 2000, 2005, and 2010.

2.2.3.1   Grades and Decision Tree

Figure B.2-3 presents a generalized decision tree to project direct emissions from industrial processes.
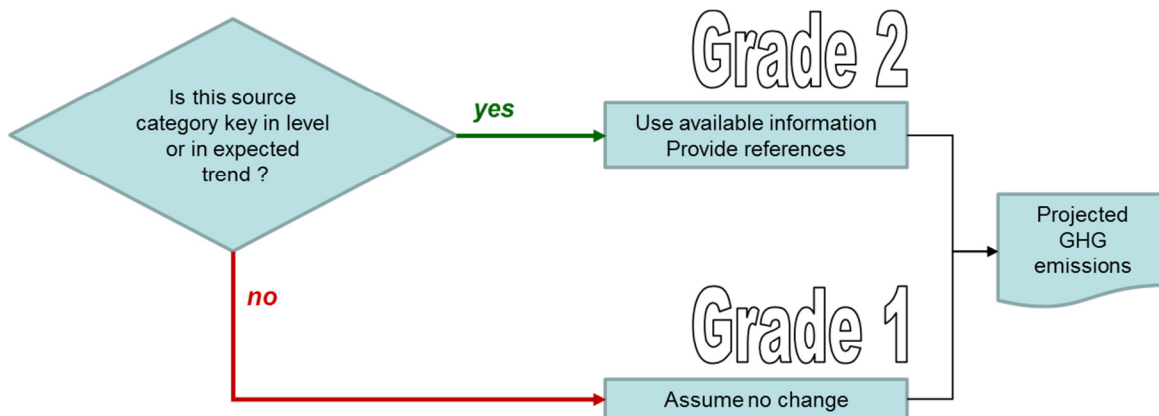
Figure B.2-3 Generalised decision tree for GHG emission projections from industrial processes activities.

2.2.3.2   Grade 1

If the subsector is not a key source it is good practice to use the most recent inventory data and keep it constant.

2.2.3.3   Grade 2

If the subsector is a key category (actual emissions or trend) it is good practice to check if considerable changes can be observed in the emission level submitted in the last five years in the national GHG inventory which should be considered with an extrapolation of the trend or if it seems probable that they will change due to:

      o   economic development (GVA or GDP) or
      o   technical development or
      o   population growth/decrease or
      o   plant opening/closure or
      o   effects of policies and measures.

It is good practice to calculate changes of emissions along the future time series which show the same trend as the most important influencing factor(s). If no relevant changes can be observed or are anticipated, emissions can be kept constant.

2.2.4   Emission projection for 2.F (taking into account emissions from stock)

It is good practice to use the most recent HFC data provided by MS in their GHG inventory submissions at the same level of sectoral detail as a starting point for emission projection, and to report historical data for 2000, 2005, and 2010.

Assumptions and methodologies which are proposed in the following guidelines for the projection of F-Gases are based on the recent F-Gas report for the EU Commission (Schwarz et al 2011)[11], which include projections on population (Population projections 2004-2050, Eurostat) and GDP (EC 2009)[12], together with a large number of detailed assumptions for all individual appliances which contain fluorinated gases. Two scenarios are described in this report: a without measures scenario and a with measures scenario, the latter includes all national and European policies and measures which came into force prior to the end of 2010.

2.2.4.1   Grades and Decision Tree

Figure B.2-1 and Figure B.2-2 present generalized decision trees for selecting grades for future activity data and emission factors for industrial processes. These decision trees apply for each of the industrial processes activities. Figure B.2-4 presents a decision tree for selecting grades for GHG emission projections from 2.F.

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[11]   Schwarz et al (2011): Preparatory study for a review of Regulation (EC) No. 842/2006 on certain fluorinated greenhouse gases", prepared for the EU Commission in the context of Service Contract No 070307/2009/548866/SER/C4, September 2011

[12]   EC (2009): European Commission, DG Economic and Financial Affairs: 2009 Ageing Report: Economic and budgetary projections for the EU-27 Member States (2008-2060). EUROPEAN ECONOMY 2|2009
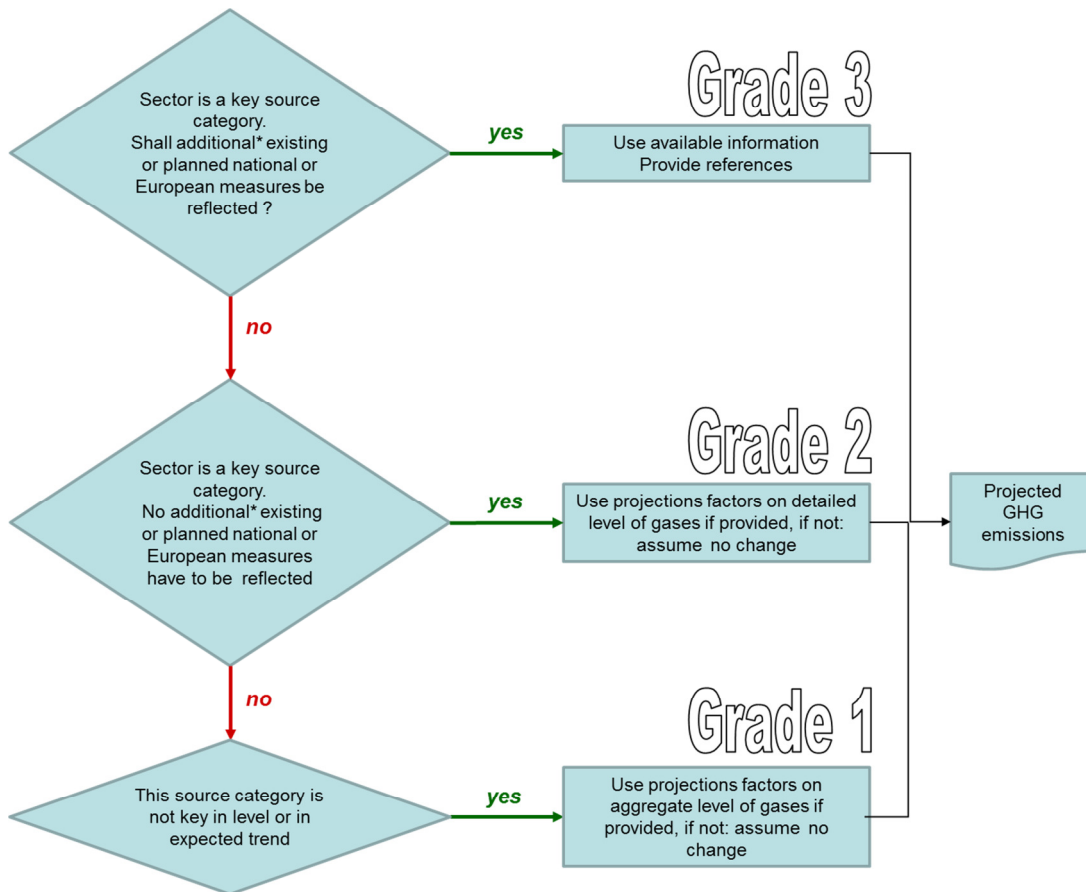
Figure B.2-4 Generalised decision tree for GHG emission projections from industrial processes activities.
* additional to those which came into force prior to the end of 2010 and which have been taken into account in Schwarz et al. 2010.

2.2.4.2   Grade 1

If the subsector is not a key source category it is good practice to use the most recent GHG inventory data for HFCs, PFCs and SF6 at the highest aggregation level (i.e. in t CO_2eq) for each individual subsector category. If it is not mentioned otherwise in subsectoral guidelines, it is good practice to keep emissions constant for the projection time series. For some subsectors a projection of the emission development at European level is provided in form of projection factors. These factors are based on assumptions and methodologies used in a recent F-Gas report for the EU Commission (Schwarz et al. 2011) and are the result of emission projections on national level in this report. It is good practice to use these projection factors for the scaling of most recent GHG data at the highest aggregation level.

Projection factors are given for most important subsectors. They reflect historical and projected developments of emissions from stock of emissions in a without measures scenario and a with measures scenario, the latter includes all national and European policies and measures which came into force prior to the end of 2010. This allows the projection of emissions from stock and the quantification of effects of existing policies and measures based on results of Schwarz et al. (2011).

2.2.4.3   Grade 2

If the subsector is a key source category, it is good practice to calculate emission projections at the level of each individual chemical species reported in most recent GHG inventory for the source category.

For some subsectors a projection of the emission development at European level is provided in form of projection factors. These factors are based on assumptions and methodologies used in a recent F-Gas report for the EU Commission (Schwarz et al. 2011) and are the result of emission projections on national level in this report. It is good practice to use these projection factors for the scaling of most recent GHG data on the level of each chemical species reported in this sector.

Projection factors are given for most important subsectors at the level of each gas. They reflect historical and projected developments of emissions from stock of emissions in a without measures scenario and a with measures scenario, the latter includes all national and European policies and measures which came into force prior to the end of 2010. This allows the projection of emissions from stock and the quantification of effects of existing policies and measures based on results of Schwarz et al. (2011), but also to take into account national circumstances related to the proportion of gases in each sector.

2.2.4.4   Grade 3

If the subsector is a key source category and the effects of additional policies and measures are to be quantified, it is good practice to calculate projections which include all emission sources occurring in the subsector (manufacturing, lifetime emissions from the stock and from disposal).

To calculate F-Gas emissions from one source of appliances for year n it is good practice to sum up all three types of emissions, according to the following equations:

$$\text{Manufacturing emissions}_n = \text{Manufactured products}_n * EF_{Manu,n}$$

$$\text{Lifetime emissions}_n = \text{Bank}_n * EF_{Lifetime.n}$$

$$\text{Disposal emissions}_n = \text{F-Gases in disposed appliances at end of lifetime}(_n) * EF_{Disposal,n}$$

With EF = Emission Factor

    Bank = Total amount of gases in stock of appliances

For this approach, the bank of gases in the appliance stock is the main system and has to take into account all new and disposed appliances per year. In general it can be assumed:

$$\text{Bank}_n = \text{Bank}_{(n-1)} + \text{Amount of Gas adding to the bank}_n - \text{Amount of Gas leaving the bank}_n$$

$$\text{Amount of Gas adding to the bank}_n = \text{New appliances}_n * \text{average charge of appliance}$$

$$\text{Amount of Gas leaving the bank}_n = \text{Disposed appliances}_n * \text{average charge of appliance}$$

(In some cases it is also necessary to reflect Lifetime Emissions from year (n-1) leaving the bank, depending on assumptions with regard to equipment refill. In Schwarz et al. (2011) no refill is assumed for most appliances.)

If no information is available in relation to the quantity of appliances entering and leaving the annual stock, it is good practice to calculate the bank of F-Gases basing on assumptions about the amount of the annual total stock of appliances, multiplied with average charges of appliances. In this case it is good practice to estimate the disposal of appliances with the following equation:

$$\text{F-Gases in disposed appliances at end of lifetime}_n = \text{Bank}_{(n-\text{Lifetime})}/ \text{ Lifetime}$$

Projections of the bank have to be conducted for all individual chemical species already or potentially occurring in the type of appliance in question. To sum up emissions of all types of F-Gases their absolute amount in tons has to be multiplied by their Global Warming Potential (GWP) to calculate emissions in CO_2 equivalents.

Calculations have to start at the base year minus the average lifetime of appliances so as to include disposal emissions of appliances at end of their lifetime. Historical data in relation to the stock of appliances has to be gathered where possible however, in some cases it is necessary to fill gaps with expert estimates. Projections of the stock have to be done on the base of national projections e.g. from appliance industries or taking into account the most important trend for this appliance (GDP, population).

Policies and measures may

- o influence emission factors such as leakage rates, or
- o ban the use of F-Gases for specific types of appliances, or
- o induce the replacement of F-Gas by other gases with lower GWP.

To estimate the effects of policies and measures for each type of appliance a system of stock model for each affected F-Gas has to be implemented, including historical and projected data of the amount of appliances coming into the stock.

2.2.5   Policies and Measures

The following European directives and regulations have an impact on emissions from industrial processes. There are also national measures which have to be considered.

Table 25 Policies and Measures and related parameters affected by implementation of particular PAM in Industrial Processes sector.

Sector	Description	Legislation	Parameters/Variables
Cross-cutting	Geological storage of CO_2	Directive 2009/31/EC	*Emission factors, Final energy consumption by*

Sector	Description	Legislation	Parameters/Variables
			sector by fuel type, *Share of different forms of energy*
	EU Emissions Trading Scheme and Amending EU Emissions Trading Scheme to improve and extend the greenhouse gas emission allowance trading scheme of the Community	Directive 2003/87/EC *and* *Directive 2009/29/EC*	*Carbon price* *Carbon content of process input,* *Electricity consumption,* *Emission factors,* *Energy efficiency* *Final energy consumption by sector by fuel type,* *Share of different forms of energy*
	Integrated pollution prevention and control (IPPC) recast	Directive 2008/1/EC	*Emission factors*
	Kyoto Protocol project mechanisms	Directive 2004/101/EC	*Carbon content of process input* *Emission Factors*
	National Emission Ceilings for certain pollutants (NEC Directive)	Directive 2001/81/EC	*Emission ceilings for air pollutants*
	Decision:		
	Effort Sharing Decision	Decision 406/2009/EC	*Electricity consumption,* *Final energy consumption by sector by fuel type,* *Share of different forms of energy*
Industrial Process	F-gas regulation	Regulation 842/2006	*Ban of gases in specific appliances,* *Disposal of products,* *Emission factors,* *Lifetime of products,* *Share of gases*
Waste	Waste electrical and electronic equipment Directive	Directive 2002/95/EC	*Disposal of domestic refrigerators*
Transport	Mobile Air Conditioning Directive (HFC emissions from air conditioning in motor vehicles)	Directive 2006/40/EC	*Share of gases in personal cars*

All policies and measures resulting from cross-cutting directives mentioned above or other national policies and measures may generally have impacts on technical improvements resulting in reduced emission factors or on increased use of biomass for the replacement of fossil process inputs. It is good practice to analyse the effects of these directives and national PAMs on sub-sectoral level.

In the following subsectoral guidelines only those directives are explicitly mentioned, for which it is good practice to include them in national projections.

2.2.6   ETS and non-ETS split

Some of the emission sources in this sector are covered by the EU ETS Phase II and more will be covered in the EU ETS Phase III beginning 2013 because of the amendment of the EU ETS. With this increased coverage, which leads to more consistency with UNFCCC sector coverage, PFC from aluminum production (sector 2.C.3), and CO_2 and N_2O emissions of Nitric and Adipic acid production (sectors 2.B.2 and 2.B.3) are also included in EU ETS. More details about sectoral assumptions for the effect of ETS and the ETS- and non-ETS split can be found in each chapter of affected industrial process types. For general options on how to split emissions from EU ETS covered sources and non-covered sources, please see 1.A. Fuel Combustion section 1.2.4.2.

Under the Effort Sharing Decision (ESD), MS are committed to reducing emissions from non-EU ETS covered sources.

2.2.7   Source Specific QA/QC

It is important to ensure that resulting emission projections have verification and QA/QC similar to that applied to the historic inventory.

A "general" QA/QC (described in General Guidance – Part A Chapter A.8: Quality Assurance and Quality Control (QA/QC) for Projections) should be undertaken to ensure the quality (TCCCA) of the MS GHG projections from mineral industry (see also section 1.A. Fuel Combustion section 1.2.5).

The second step is to apply a sector specific QA/QC. It is a good practice to:

- o   check whether applied methods use input data (GDP, number of employees, etc) that is consistent with national economic, energy and activity projections used elsewhere in the projected emissions estimates.
- o   ensure consistency between the outcomes of the Member-State-energy model and Member-State-specific model when used for this sector. It should be ensured that activity data for industrial processes match those assumed for projections in Combustion in Manufacturing Industry and construction (1.A. Fuel Combustion section 1.4.2).
- o   if the projection of process emissions is calculated together with energy related industrial emissions, it is good practice to use the relation between industrial energy and process emissions for the base year resulting from GHG inventory

          data as starting point for the projected split and to explain developments along the projected timeline.

     o   reference all data sources within the spreadsheets / databases so that the input data is traceable.

2.3   Mineral industry (IPCC 2.A)

2.3.1   Introduction

Table 26 Detailed sector split for Mineral Industry.

IPCC 2006 source category		Description	Re-port
2A	Mineral Industry		☑
2A1	Cement Production	Process-related emissions from the production of various types of cement (ISIC: D2694).	☑
2A2	Lime Production	Process-related emissions from the production of various types of lime (ISIC: D2694).	☑
2A3	Glass Production	Process-related emissions from the production of various types of glass (ISIC: D2610).	☑
2A4	Other Process Uses of Carbonates	Includes limestone, dolomite and other carbonates etc. Emissions from the use of limestone, dolomite and other carbonates should be included in the industrial source category where they are emitted. Therefore, for example, where a carbonate is used as a flux for iron and steel production, resultant emissions should be reported under 2C1 "Iron and Steel Production" rather than this subcategory.	☑
2A5	Other (please specify)		☑

Source: IPCC (2006)

2.3.2   Cement production (IPCC 2.A.1)

2.3.2.1   Source description

In source category 2.A.1 (Cement Production) CO_2 emissions arise as a by-product in the production of clinker - an intermediate component in the cement manufacturing process.

2.3.2.2   Activity data projections

It is good practice to base projections on the production of clinker.

Grade 1

As described in 2. Industrial Processes section 2.2.1.2.

Grade 2

As described in 2. Industrial Processes section 2.2.1.3.

It is good practice to link activity data for cement with the trend of the economic development, preferably with the sectoral development of construction industries or with sectoral projections for the cement industry.

Grade 3

As described in 2. Industrial Processes section 2.2.1.4.

2.3.2.3   Emission Factor projections

In general, emission factors for cement production are relatively constant in inventory timeseries because of the chemical process from which process emissions result. This means that process emissions in this sector depend on

- o   the carbon content of the process input and
- o   the ratios of cement types produced.

Grade 1

As described in 2. Industrial Processes section 2.2.2.2.

Grade 2

As described in 2. Industrial Processes section 2.2.2.3.

If it can be foreseen that the carbon content of the kiln input or of cement types will change, it is good practice to adjust future emission factors to this projected development.
If the GHG emission inventories of the EU-27 are considered, the implied emissions factors range between 0.48 and 0.56 t CO_2 / t cement between 2005 and 2009. It is good practice to project emission factors within this range or to substantiate appropriately differing values (e.g. because of considerably higher use of biomass). WBCSD has published average disaggregated parameters for individual countries and different cement types based on a large amount of plant-specific data (http://wbcsdcement.org/GNR-2010/index.html the country specific trends, these can be helpful for the projection of emission factor development.

2.3.2.4   Policies and Measures

PAMs for industrial processes are listed in 2. Industrial Processes section 2.2.5.

Directive 2003/87/EC and 2009/29/EC on Emission Trading

Since cement production falls under the EU ETS (Main Activity Type Code 6) it is good practice to assume the effect of this measure and to assume, that all CO_2 process emissions from this source category are covered under the EU ETS.

2.3.2.5   Source Specific QA/QC

As described in 2. Industrial Processes section 2.2.7.

2.3.3   Lime production (IPCC 2.A.2)

2.3.3.1   Source description

For the production of lime, limestone or dolomite is heated at high temperatures to decompose the carbonates present - a process which releases CO_2.

2.3.3.2   Activity data projections

It is good practice to base projections on projected lime production or limestone consumption.

Grade 1

As described in 2. Industrial Processes section 2.2.1.2.

Grade 2

As described in 2. Industrial Processes section 2.2.1.3.

It is good practice to link activity data for lime with the trend of economic development, preferably with the sectoral development of mineral industries.

Grade 3

As described in 2. Industrial Processes section 2.2.1.4.

2.3.3.3   Emission Factor projections

The emission factor is generally directly linked to the carbon content of limestone or dolomite used and the quality of lime produced.

Grade 1

As described in 2. Industrial Processes section 2.2.2.2.

Grade 2

As described in section 2. Industrial Processes 2.2.2.3.

If it can be foreseen that the carbon content of the process input or output will change, it is good practice to adjust future emission factors to this projected development.

If the GHG emission inventories of the EU-27 are considered, emission factors vary between 0.64 and 0.89 t CO_2 / t lime production and are often constant. If emission projection is based on limestone consumption, an emission factor of 0.44 t CO_2 / t limestone consumption is used.

2.3.3.4　　　　　Policies and Measures

PAMs for commercial / institutional sector are listed in 2. Industrial Processes section 2.2.5.

Directive 2003/87/EC and 2009/29/EC on Emission Trading.

Since lime production falls under the EU ETS (Main Activity Type Code 6) it is good practice to assume the effect of this measure and to assume that all CO_2 process emissions from this source category are covered under the EU ETS.

2.3.3.5　　　　　Source Specific QA/QC

As described in 2. Industrial Processes section 2.2.7.

Special attention has to be paid on the fact, that lime is used for flue gas desulphurisation: the projection of lime production is therefore partly linked to the future use of coal for power generation (1.A.1).

2.3.4　　Other Mineral Products (IPCC 2.A.3 - 2.A.5)

2.3.4.1　　　　　Source description

There are several other mineral products which are mentioned in national GHG emission inventories, e.g.:

Table 27 Detailed sector split for Other Mineral Products.

IPCC 2006 source category		Description	Re-port
2A4	Other Process Uses of Carbonates	Includes limestone, dolomite and other carbonates etc. Emissions from the use of limestone, dolomite and other carbonates should be included in the industrial source category where they are emitted. Therefore, for example, where a carbonate is used as a flux for iron and steel production, resultant emissions should be reported under 2C1 "Iron and Steel Production" rather than this subcategory.	☑
2A4a	Ceramics	Process-related emissions from the production of bricks and roof tiles, vitrified clay pipes, refractory products, expanded clay products, wall and floor tiles, table and ornamental ware (household ceramics), sanitary ware, technical ceramics, and inorganic bonded abrasives (ISIC: D2691, D2692 and D2693).	
2A4b	Other Uses of Soda Ash	This should include emissions from soda ash use that are not included elsewhere. For example, soda ash used for glass should be reported in 2A3.	
2A4c	Non Metallurgical Magnesia Production	This source category should include emissions from magnesia production that are not included elsewhere. For example, where magnesia production is used for primary and secondary magnesium production, emissions	

		should be reported in relevant source category in Metals.	
2A4d	Other (please specify)	Process-related emissions reported under this sub-category should include all other miscellaneous uses of limestone, dolomite and other carbonates, except from uses already listed in the sub-categories above, and uses as fluxes or slagging agents in the Metals and Chemicals industries, or for the liming of soils and wetlands in Agriculture, Forestry and Other Land Uses (ISIC D269).	
2A5	Other (please specify)		☑

Source: IPCC (2006)

2.3.4.2 Activity data projections

It is good practice to base projections on specific production numbers as activity data.

Grade 1

As described in 2. Industrial Processes section 2.2.1.2.

Grade 2

As described in 2. Industrial Processes section 2.2.1.3.

It is good practice to link activity data with the trend of the economic development, preferably with the sectoral development of mineral industries.

Grade 3

As described in 2. Industrial Processes section 2.2.1.4.

2.3.4.3 Emission Factor projections

It is good practice to base projections of GHG emissions in this sector on national assumptions about carbon input and output.

Grade 1

As described in 2. Industrial Processes section 2.2.2.2.

Grade 2

As described in 2. Industrial Processes section 2.2.3.2.

If the GHG emission inventories of the EU-27 are considered, emission factors are often constant for all years.

2.3.4.4   Policies and Measures

PAMs for industrial processes are listed in 2. Industrial Processes section 2.2.5.

<u>Directive 2003/87/EC and 2009/29/EC on Emission Trading</u>

As glass and ceramic production and soda ash production and use are energy-intensive processes, it is good practice to assume the effects and to assume that all emissions are covered under the EU ETS (Main Activity Type Code 7 and 8).

2.3.4.5   Source Specific QA/QC

As described in 2. Industrial Processes section 2.2.7.

2.4   Chemical industry (IPCC 2.B)

Table 28 Detailed sector split for Chemical Industry.

IPCC 2006 source category		Description	Re-port
2B	Chemical Industry		☑
2B1	Ammonia Production	Ammonia (NH3) is a major industrial chemical and the most important nitrogenous material produced. Ammonia gas is used directly as a fertilizer, in heat treating, paper pulping, nitric acid and nitrates manufacture, nitric acid ester and nitro compound manufacture, explosives of various types, and as a refrigerant. Amines, amides, and miscellaneous other organic compounds, such as urea, are made from ammonia. The main greenhouse gas emitted from NH3 production is CO_2. CO_2 used in the production of urea, a downstream process, should be subtracted from the CO_2 generated and accounted for in the AFOLU Sector.	☑
2B2	Nitric Acid Production	Nitric acid is used as a raw material mainly in the manufacture of nitrogenous-based fertiliser. 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. The main greenhouse gas emitted from HNO_3 production is nitrous oxide.	☑
2B3	Adipic Acid Production	Adipic acid is used in the manufacture of a large number 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. The main greenhouse gas emitted from adipic acid production is nitrous oxide.	☑
2B4	Caprolactam, Glyoxal and Glyoxylic Acid Production	Most of the annual production of caprolactam ($NH(CH_2)5CO$) is consumed as the monomer for nylon-6 fibres and plastics, with a substantial proportion of the fibre used in carpet manufacturing. All commercial processes for the manufacture of caprolactam are based on either toluene or benzene. This subcategory also covers production of glyoxal (ethanedial) and glyoxylic acid production. The main greenhouse gas emitted from this subcategory is nitrous oxide.	
2B5	Carbide Production	The production of carbide can result in emissions of CO_2, CH_4, CO and SO2. Silicon carbide is a significant artificial abrasive. It is produced from silica sand or quartz and petroleum coke. Calcium carbide is used in the production of acetylene, in the manufacture of cyanamide (a	

IPCC 2006 source category		Description	Re-port
		minor historical use), and as a reductant in electric arc steel furnaces. It is made from calcium carbonate (limestone) and carbon-containing reductant (petroleum coke).	
2B6	Titanium Dioxide Production	Titanium dioxide (TiO_2) is the most important white pigment. The main use is in paint manufacture followed by paper, plastics, rubber, ceramics, fabrics, floor covering, printing ink, and other miscellaneous uses. The main production process is the chloride route, giving rise to CO_2 emissions that are likely to be significant. This category also includes synthetic rutile production using the Becher process, and titanium slag production, both of which are reduction processes using fossil fuels and resulting in CO_2 emissions. Synthetic rutile is the major input to TiO_2 production using the chloride route.	
2B7	Soda Ash Production	Soda ash (sodium carbonate, Na_2CO_3) is a white crystalline solid that is used as a raw material in a large number of industries including glass manufacture, soap and detergents, pulp and paper production and water treatment. Emissions of CO_2 from the production of soda ash vary dependent on the manufacturing process. Four different processes may be used to produce soda ash. Three of these processes, monohydrate, sodium sesquicarbonate (trona) and direct carbonation, are referred to as natural processes. The fourth, the Solvay process, is classified as a synthetic process.	
2B8	Petrochemical and Carbon Black Production		
2B9	Fluorochemical Production		
2B10	Other (Please specify)	For example, gases with global warming potential listed in IPCC assessment reports that do not fall within any categories above could be reported here, if they are estimated.	

Source: IPCC (2006)

2.4.1   Ammonia production (IPCC 2.B.1)

2.4.1.1   Source description

Ammonia (NH_3) production depends on a source of nitrogen and hydrogen. For the generation and separation of these elements the majority of plants use natural gas, but coal and oil may also be used. The carbon content of the hydrocarbons has to be eliminated for the production of NH_3 through conversion to CO_2 , which is the main GHG emission in this process.

2.4.1.2   Activity data projections

It is good practice to use

- o   ammonia production or
- o   natural gas consumption for ammonia production

as activity data for the calculation of CO_2 emissions from ammonia production.

Ammonia gas is used in many ways, e.g. directly for the production of nitorgenous fertiliser, in heat treating, paper pulping, nitric acid and nitrates manufacture, as a refrigerant or as a base material for organic compounds. The most important uses should be identified at MS level.

Grade 1

As described in 2. Industrial Processes section 2.2.1.2.

Grade 2

As described in 2. Industrial Processes section 2.2.1.3.

Because of the various uses of ammonia, it is good practice to analyse at a MS level which sector is the most relevant and to use the future trend of this sector for the projection of ammonia production. If no other information is available, it is good practice to link activity data for ammonia production with the trend of the sectoral economic development of chemical industries.

Grade 3

As described in 2. Industrial Processes section 2.2.1.4.

2.4.1.3   Emission Factor projections

Emission factors are dependent on the carbon content of the fuel used for the process and the process efficiency.

If natural gas consumption for ammonia production has been used for emission calculations in GHG inventories, it is good practice to use the general projection of emission factors for this fuel type (see 1.A Fuel Combustion section 1.2.3).

Grade 1

As described in 2. Industrial Processes section 2.2.2.2.

Grade 2

As described in 2. Industrial Processes section 2.2.2.3.

If the GHG emission inventories of the EU-27 are considered, emission factors have been relatively constant across the whole time series. If the production of ammonia has been used as activity, the related emissions factors range between 1 and 2.5 t CO_2 / t of ammonia production. It is good practice to project emission factors in this range or to substantiate differences.

2.4.1.4   Policies and Measures

PAMs for industrial processes are listed in 2. Industrial Processes section 2.2.5.

<u>2009/31/EC Geological storage of CO_2</u>

It is good practice to include assumptions about the future use of CCS in this subsector.

<u>Directive 2003/87/EC and 2009/29/EC on Emission Trading</u>

Since ammonia production falls under the EU ETS it is good practice to assume the effect of this measure <u>a</u>nd to assume that all CO_2 process emissions from this source category are covered under the EU ETS.

2.4.1.5   Source Specific QA/QC

As described in 2. Industrial Processes section 2.2.7.

2.4.2   Nitric acid production (IPCC 2.B.2)

2.4.2.1   Source description

During the production of nitric acid (HNO_3), nitrous oxide (N_2O) is generated as an unintended by-product of the high temperature catalytic oxidation of ammonia (NH_3). The amount of N_2O depends mainly on the design of the production process (combustion conditions, catalyst composition and burner design).

Nitric acid is used in many ways, e.g. in the manufacturing of nitrogenous-based fertiliser, in the production of adipic acid and explosives, for metal etching and in the processing of ferrous metals.

2.4.2.2   Activity data projections

It is good practice to use nitric acid production as activity data for the calculation of N_2O emissions.

Grade 1

As described in 2. Industrial Processes section 2.2.1.2.

Grade 2

As described in 2. Industrial Processes section 2.2.1.3.

Because of the various uses of nitric acid, it is good practice to analyse at a MS level which sector(s) is (are) the most relevant and to use the future trend of this sector for the projection of nitric acid production. If no other information is available, it is good practice to link activity data for nitric acid production with the trend of the sectoral economic development of chemical industries.

Grade 3

As described in 2. Industrial Processes section 2.2.1.4.

2.4.2.3   Emission Factor projections

Emission factors strongly depend on conditions and design of the process, but also on the use of abatement technologies.

Grade 1

As described in 2. Industrial Processes section 2.2.2.2.

Grade 2

As described in 2. Industrial Processes section 2.2.2.3.

Emission factors strongly depend on conditions and design of the process, but also on the use of abatement technologies. There is a general decrease of emission factors in GHG inventories of MS, reflecting technological advancements.
Considering GHG emission inventories of EU-27, the range of emissions factors range from 1.08 to 9.65 kg N_2O /t between 2005 and 2009.

2.4.2.4   Policies and Measures

PAMs for industrial processes are listed in 2. Industrial Processes section 2.2.5.

Directive 2003/87/EC and 2009/29/EC on Emission Trading

The inclusion into the EU-ETS will accelerate the decrease of emission factors because there is a high potential for emission reductions with regard to process design. With this it is good practice to assume effects of the EU-ETS in this source category and to assume that all process emissions are covered under the EU ETS. A comparison of nitric acid plants in Europe leads to the proposal of a benchmark of 1.21 kg N_2O /t HNO3[13].

2.4.2.5   Source Specific QA/QC

As described in 2. Industrial Processes section 2.2.7

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[13] Methodology for the free allocation of emission allowances in the EU ETS post 2012. Sector report for the chemical industry. Ecofys, Fraunhofer Initute for Systems and Innovation Research, Öko-Institut, by Order of the European Commission, November 2009

2.4.3   Adipic Acid Production (IPCC 2.B.3)

2.4.3.1   Source description

Adipic acid is used in the manufacture of several products such as synthetic fibres, coatings, plastics, urethane foams, elastomers and synthetic lubricants. Adipic acid is formed by an oxidation process from a cyclohexanone/cyclohexanol mixture; N_2O is generated as an unintended by-product. The amount of N_2O is dependent on the production process and any abatement methods used.

Some MS also report CO_2 emissions from adipic acid production, but the amounts are negligible and reporting is not obligatory.

2.4.3.2   Emission projections

If activity data and emission factors are available from most recent GHG inventories, it is good practice to project emissions for this source category separately for activity data and emissions factors as outlined in sections 2.2.1 and 2.2.2 . If data is deemed confidential, emission projections may be undertaken at the highest level of aggregation as outlined in section 2.2.3.

2.4.3.3   Policies and Measures

PAMs for industrial processes are listed in 2. Industrial Processes section 2.2.5.

Directive 2003/87/EC and 2009/29/EC on Emission Trading

It is good practice to assume the effects of the EU-ETS in this source category and to assume that all process emissions are covered under the EU ETS. Inclusion in the EU-ETS will accelerate the decrease in emission factors because there is a high potential for emission reductions with regard to process design. In an analysis conducted on adipic acid production reported in the EU ETS, it is proposed to use a benchmark emission factor of of 5.6 t CO_2 eq/t adipic acid, corresponding to an abatement efficiency of 94%[14].

2.4.3.4   Source Specific QA/QC

As described in 2. Industrial Processes section 2.2.7

2.4.4   Other Chemical Processes (IPCC 2.B.4 - 2.B.10)

2.4.4.1   Source description

There are several other chemical processes which are included in national GHG emission inventories, e.g. production of

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[14]   Methodology for the free allocation of emission allowances in the EU ETS post 2012. Sector report for the chemical industry. Ecofys, Fraunhofer Initute for Systems and Innovation Research, Öko-Institut, by Order of the European Commission, November 2009

- o   caprolactam, glyoxal and glyoxyliacid
- o   carbide
- o   titanium dioxide
- o   soda ash production
- o   petrochemical and carbon black
- o   catalytic Burning
- o   conversion loss
- o   fluorchemical, etc.

2.4.4.2   Emission projections

If activity data and emission factors are available from most recent GHG inventories, it is good practice to project emissions for this source category separately for activity data and emissions factors using the approach outlined in sections 2.2.1 and 2.2.2 . If data is deemed to be confidential, emission projections can be undertaken at the highest level of aggregation (see section 2.2.3).

2.4.4.3   Policies and Measures

PAMs for industrial processes are listed in 2. Industrial Processes section 2.2.5.

2.4.4.4   Source Specific QA/QC

As described in 2. Industrial Processes section 2.2.7.

Some chemical processes like catalytic burning and conversion loss may be reported in MS inventories under this source category. If this is the case, these projections have to be linked to fuel combustion activities in the sector of Energy Industries (1.A Fuel Combustion section 1.3.2) or Combustion in Manufacturing Industries (1.A Fuel Combustion section 1.4.2). It is good practice to check if these links have been taken into account in projection calculations.

2.5   Metal production (IPCC 2.C)

Table 29 Detailed sector split for Metal Industry.

IPCC 2006 source category		Description	Re-port
2C	Metal Industry		☑
2C1	Iron and Steel Production	Carbon dioxide is the predominant gas emitted from the production of iron and steel. The sources of the carbon dioxide emissions include that from carbon-containing reducing agents such as coke and pulverized coal, and, from minerals such as limestone and dolomite added.	☑
2C2	Ferroalloys Production	Ferroalloys production covers emissions from primary metallurgical reduction production of the most common ferroalloys, i.e. ferro-silicon, silicon metal, ferro-manganese, silicon manganese, and ferro-chromium, excluding those emissions relating to fuel use. From the production of these alloys, carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4) originating from ore- and reductant raw materials, is emitted.	☑
2C3	Aluminium Production	Aluminium Production covers primary production of aluminium, except the emissions related to the use of fuel. Carbon dioxide emissions result from the electrochemical reduction reaction of alumina with a carbon-	☑

IPCC 2006 source category		Description	Re-port
		based anode. Tetrafluoromethane (CF_4) and hexafluoroethane (C2F6) are also produced intermittently. No greenhouse gases are produced in recycling of aluminium other than from the fuels uses for metal remelting. Sulphur hexafluoride (SF6) emissions are not associated with primary aluminium production; however, casting of some high magnesium containing alloys does result in SF6 emissions and these emissions are accounted for in Section $2C_4$, Magnesium Production.	
2C4	Magnesium Production	Magnesium production covers GHG emissions related to both primary magnesium production as well as oxidation protection of magnesium metal during processing (recycling and casting), excluding those emissions relating to fuel use. In the primary production of magnesium, carbon dioxide (CO_2) is emitted during calcination of dolomite and magnesite raw materials. Primary production of magnesium from non-carbonate raw materials does not emit carbon dioxide. In the processing of liquid magnesium, cover gases containing carbon dioxide (CO_2), sulphur hexafluoride (SF6), the hydrofluorocarbon HFC 134a or the fluorinated ketone FK 5-1-12 (C3F7C(O)C2F5) may be used. Partial thermal decomposition and/or reaction between these compounds and liquid magnesium generates secondary compounds such as perfluorocarbons (PFCs), which are emitted in addition to unreacted cover gas constituents.	
2C5	Lead Production	Lead production covers production by the sintering/smelting process as well as direct smelting. Carbon dioxide emissions result as a product of the use of a variety of carbon-based reducing agents in both production processes.	
2C6	Zinc Production	Zinc production covers emissions from both primary production of zinc from ore as well as recovery of zinc from scrap metals, excluding emissions related to fuel use. Following calcination, zinc metal is produced through one of three methods; 1-electro-thermic distillation, 2-pyro-metallurgical smelting or 3-electrolysis. If method 1 or 2 is used, carbon dioxide (CO_2) is emitted. Method 3 does not result in carbon dioxide emissions. Recovery of zinc from metal scrap often uses the same methods as primary production and may thus produce carbon dioxide emissions, which is included in this section.	
2C7	Other (please specify)		☑

Source: IPCC (2006)

2.5.1   *Iron and steel production (IPCC 2.C.1)*

2.5.1.1   Source description

This sector includes iron and steel production as well as the production of sinter, pellet and direct reduced iron. These processes lead to CO_2 , CH_4 and N_2O emissions.
Pig iron production is the main source of emissions in this sector. For this process, iron oxide ores are reduced in blast furnaces, in which the carbon in coke or charcoal is used as both the reductant and the fuel. The process is also often aided by the use of carbonate fluxes (limestone), which leads to additional emissions that have to be reported under emissions from limestone use (2.A.3).

2.5.1.2   Activity data projections

Since carbon has a dual role as a reductant and a fuel in the production process, it is good practice to seperate emissions of these sources clearly and to use different activity data for each source e.g. the production of pig iron, crude steel, electric steel or sinter.

Grade 1

As described in 2. Industrial Processes section 2.2.1.2.

Grade 2

As described in 2. Industrial Processes section 2.2.1.3.

It is good practice to link activity data for iron and steel with the trend of the economic development, preferably the sectoral development of metal production industries.
It might also be relevant to include information on the development of population and of saturation rates with regard to iron and steel consumption. If these are relevant, it is good practice to include the trends of these parameters into projection calculations.

Grade 3

As described in 2. Industrial Processes section 2.2.1.4.

2.5.1.3   Emission Factor projections

The dual role of carbon as a reductant and a fuel in the production process of pig iron is the reason for differing methods for the allocation of process and combustion emissions between Member States. In addition there are many different ways to integrate process emissions of the different subsectors (e.g. process emissions for pig iron production are often included in the emissions of steel production).

For CH_4, emission factors are generally very small and it is good practice to hold them constant.

Grade 1

As described in 2. Industrial Processes section 2.2.2.2.

Grade 2

As described in 2. Industrial Processes section 2.2.2.3.

It is good practice to assume the effects of new technologies and their penetration rate to emission factors throughout the time series.

2.5.1.4   Policies and Measures

PAMs for industrial processes are listed in 2. Industrial Processes section 2.2.5.

Directive 2003/87/EC and 2009/29/EC on Emission Trading . Emissions from iron and steel industries fall under the EU ETS (Main Activity Type Code 5) it is good practice to assume the effect of this measure and to assume that all process emissions are covered under the EU ETS.

2.5.1.5   Source Specific QA/QC

As described in 2. Industrial Processes section 2.2.7.

2.5.2   Ferroalloys production (IPCC 2.C.2)

2.5.2.1   Source description

The production of ferroalloys involves a metallurgical reduction process that results in CO_2 emissions, which is the main source of GHG emissions in this subsector. In addition CH_4 emissions arise from the heating of carbon materials in the furnace and N_2O.

The process is often aided by the use of carbonate fluxes (limestone), which leads to additional emissions which have to be reported under emissions from limestone use (2.A.3).

2.5.2.2   Activity data projections

It is good practice to use the production of ferroalloys as activity data.

Grade 1

As described in 2. Industrial Processes section 2.2.1.2.

Grade 2

As described in 2. Industrial Processes section 2.2.1.3.

It is good practice to link activity data for ferroalloys with the trend of the economic development.

Grade 3

As described in 2. Industrial Processes section 2.2.1.4.

2.5.2.3   Emission factor projections

Emission factors strongly depend on conditions and design of the process, but also on the use of abatement technologies.

Grade 1

As described in 2. Industrial Processes section 2.2.2.2.

Grade 2

As described in 2. Industrial Processes section 2.2.2.3.

It is good practice to assume the effects of new technologies and their penetration rate to decrease emission factors along the timeline.

If the emission factors of the GHG inventory submission 2009 are considered, there is a broad range of emission factors for CO_2, ranging from 0,11 to 3,9 t CO_2 /t ferroalloy produced.
In GHG inventories CH_4 is only rarely reported; emission factors vary substantially.

2.5.2.4   Policies and Measures

PAMs for industrial processes are listed in 2. Industrial Processes section 2.2.5.

Directive 2003/87/EC and 2009/29/EC on Emission Trading

It is good practice to assume the effect of this measure and to assume that 75% of all process emissions are covered under the EU ETS.

2.5.2.5   Source Specific QA/QC

As described in 2. Industrial Processes section 2.2.7.

2.5.3   Aluminium Production (IPCC 2.C.3)

2.5.3.1   Source description

The most significant process emissions from the production of primary aluminium are CO_2, which arise from the consumption of carbon anodes in the reaction to converting aluminium oxide to aluminium metal, and Perfluorocarbon (PFC) emissions of CF_4 and C_2F_6 during anode effects.
From 2013 onwards, PFC emissions from aluminium production are included in the EU ETS. This is assumed to promote the introduction of abatement technologies in aluminium production facilities and emissions are expected to decrease significantly.

2.5.3.2   Activity data projections

It is good practice to base projections on the production of aluminium.

Grade 1

As described in 2. Industrial Processes section 2.2.1.2.

Grade 2

As described in 2. Industrial Processes section 2.2.1.3.

It is good practice to hold the production of primary aluminium constant as the time series 1990-2008 shows a quasi-constant metal output averaging 2.8 million t per year in the EU-27. Over the same time period world capacity has doubled, rapidly growing outside Europe, especially in China and Russia. It can be assumed that all global growth in capacity will take place outside the EU[15].

Grade 3

As described in 2. Industrial Processes section 2.2.1.4.

2.5.3.3   Emission factor projections

The quantity of CO_2 emitted depends on the process type as well as the stoichiometric relationship for the consumption of carbon at the anode. PFC emissions are only dependent on the technology used.

Grade 1

As described in section 2.2.2.2.

Grade 2

a) <u>CO_2 emissions</u>

If national information on the penetration of new technologies is available, it is good practice to use them for future development of emission factors. There is no general trend for emission factors regarding CO_2 emissions.

b) <u>PFC emissions</u>

With regard to PFC emissions, a decrease in emission factors for CF_4 and C_2F_6 can be observed from 1990-2009, as reported in GHG inventory reports. This has resulted from the introduction of point-fed prebake anode types, replacing Soederberg and side worked prebake anodes. It is good practice to assume a decrease of emission factor if a technology switch can be assumed.

2.5.3.4   Policies and Measures

PAMs for industrial processes are listed in 2. Industrial Processes section 2.2.5.

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[15]   Preparatory study for a review of Regulation (EC) No. 842/2006 on certain fluorinated greenhouse gases", prepared for the EU Commission in the context of Service Contract No 070307/2009/548866/SER/C4, September 2011

Directive 2003/87/EC and 2009/29/EC on Emission Trading

It is good practice to assume the effect of this measure <u>and</u> to assume that all CO_2 and PFC process emissions are covered under the EU ETS, which will accelerate a decrease in emission factors since there is a high potential for emission reductions through process design.

The switch to point feeding prebake anodes lowers the technical coefficient to 40 g CF_4. This value is considered to be the technical optimum in the long run (until 2050). This means that if the historical emission factor is not already lower, it is good practice to lower linearly the emission factor up to 2020 to a value of 0.04 kg CF_4/t of aluminium produced. The same approach applied to emission factors of C_2F_6, which should be reduced to 0.004 kg C_2F_6/t of aluminium produced up to 2020 (C_2F_6 emissions counting generally 1/10 of CF_4 emissions)[16].

2.5.3.5 Source Specific QA/QC

As described in 2. Industrial Processes section 2.2.7.

2.5.4 Other metal production (IPCC 2.C.4 – 2.C.7)

2.5.4.1 Source description

There are several other metal production processes which are included in national GHG emission inventories, e.g. production of:

- o copper
- o magnesium
- o non-ferrous-metals
- o silicium
- o zinc
- o battery recycling,

but also SF6 used in aluminium and magnesium foundries.

2.5.4.2 Emission projections

If activity data and emission factors are available from the most recent GHG inventories, it is good practice to project emissions for this source category separately for activity data and emissions factors following the approach outlined in sections 2.2.1 and 2.2.2 . If the data is deemed confidential, emission projection can be undertaken at the highest level of aggregation.

2.5.4.3 Policies and Measures

PAMs for industrial processes are listed in 2. Industrial Processes section 2.2.5.

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[16] Preparatory study for a review of Regulation (EC) No. 842/2006 on certain fluorinated greenhouse gases", prepared for the EU Commission in the context of Service Contract No 070307/2009/548866/SER/C4, September 2011

For SF6 used in aluminium and magnesium foundries:

F-gas Regulation

From 2008 onwards the F-gas Regulation prohibits the use of SF_6 for die casting plants with an annual SF_6 consumption of more than 850 kg. This measure almost halved the SF_6 consumption in the European magnesium industry and limits SF_6 use to smaller die casters, to sand casters and to recycling plants.

Directive 2003/87/EC and 2009/29/EC on Emission Trading

It is good practice to assume the effect of this measure <u>and</u> to assume that 50% of process emissions are covered under the EU ETS.

2.5.4.4   Source Specific QA/QC

As described in 2. Industrial Processes section 2.2.7.

2.6   Other production (IPCC 2.D)

2.6.1.1   Source description

There are several other production practices which are included in national GHG emission inventories. These are outlined in Table 30.

Table 30 Detailed sector split for Non-Energy products from Fuels and Solvent Use.

IPCC 2006 source category		Description	Re-port
2D	Non-Energy Products from Fuels and Solvent Use	The use of oil products and coal-derived oils primarily intended for purposes other than combustion.	☑
2D1	Lubricant Use	Lubricating oils, heat transfer oils, cutting oils and greases.	
2D2	Paraffin Wax Use	Oil-derived waxes such as petroleum jelly, paraffin waxes and other waxes.	
2D3	Solvent Use	NMVOC emissions from solvent use e.g. in paint application, degreasing and dry cleaning should be contained here. Emissions from the use of HFCs and PFCs as solvents should be reported under 2F5.	
2D4	Other (please specify)	For example, CH_4, CO and NMVOC emissions from asphalt production and use (including asphalt blowing), as well as NMVOC emissions from the use of other chemical products than solvents should be contained here, if relevant.	

Source: IPCC (2006)

2.6.1.2   Emission projections

If activity data and emission factors are available from the most recent GHG inventory, it is good practice to project emissions for this source category separately for activity data and emissions

factors following the approach outlined in sections 2.2.1 and 2.2.2 . If the data is deemed to be confidential, emission projections can be undertaken at the highest level of aggregation.

2.6.1.3   Policies and Measures

PAMs for industrial processes are listed in 2. Industrial Processes section 2.2.5.

2.6.1.4   Source Specific QA/QC

As described in 2. Industrial Processes section 2.2.7.

2.7   Electronics Industry (IPCC 2.E)

2.7.1   Source description

Table 31 Detailed sector split for Electronics Industry.

IPCC 2006 source category		Description	Re-port
2E	Electronics Industry		☑
2E1	Integrated Circuit or Semiconductor	Emissions of CF_4, C_2F_6, C_3F_8, c-C_4F_8, C_4F_6, C_4F_8O, C_5F_8, CHF_3, CH_2F_2, NF_3 and SF_6 from uses of these gases in Integrated Circuit (IC) manufacturing in rapidly evolving ways and in varying amounts, which depend on product (e.g., memory or logic devices) and equipment manufacturer.	
2E2	TFT Flat Panel Display	Uses and emissions of predominantly CF_4, CHF_3, NF_3 and SF_6 during the fabrication of thin-film transistors (TFTs) on glass substrates for flat panel display manufacture. In addition to these gases, C_2F_6, C_3F_8 and c-C_4F_8 may also be used and emitted during the manufacture of thin and smart displays.	
2E3	Photovoltaics	Photovoltaic cell manufacture may use and emit CF_4 and C_2F_6 among others.	
2E4	Heat Transfer Fluid	Heat transfer fluids, which include several fully fluorinated carbon compounds (either in pure form or in mixtures) with six or more carbon atoms, used and emitted during IC manufacture, testing and assembly. They are used in chillers, temperature shock testers and vapour phase reflow soldering.	
2E5	Other (please specify)		

Source: IPCC (2006)

2.7.2   Emission projections

If activity data and emission factors are available from most recent GHG inventories, it is good practice to project emissions for these source categories separately for activity data and emissions factors following the approach outlined in sections 2.2.1 and 2.2.2 . If the data is deemed to be confidential, emission projections can be undertaken at the highest level of aggregation.

Based on the results of the recent F-Gas report for the EU Commission[1] it is good practice to assume, that emissions of most F-gases in the sectors of semiconductors (2E1) and photovoltaics (2E2) remain constant apart from NF_3 which is increasingly used in new production facilities, if no new regulation is adopted, which aims to reduce these emissions. .

2.7.2.1   Grade 1

If the subsector is not a key source category it is good practice to use the most recent data and keep it constant.

2.7.2.2   Grade 2

If the subsector is a key category it is good practice to check if it seems probable that they will change due to:

- o   economic development (GVA or GDP) or sectoral economic trends (projected output per sector)
- o   technological development
- o   effects of policies and measures.

The size of the population generally influences these sectors, but in most source categories the effects of its growth and decrease are small in relation to the effects of parameters mentioned above.

If this is the case, it is good practice to project changing emissions along the time series, calculating variations in production index (t/a) or emissions between the years with the same rate, which can be identified for the trend of the most important parameter.

For projections of economic development and effects of PAMs it is good practice to use preferably national projections (e.g. from national ministries, economic research organizations and statistical offices), however if these are not available European projections should be used.

If no influences of the parameters mentioned are assumed to occur in the future, it is good practice to keep emissions constant.

2.7.2.3   Grade 3

If the subsector is a key category (actual emissions or trend), it is good practice to use national projections on the amount of production in future years or information about the shutdown or start-up of individual installations and their existing or expected production.

2.7.3   Policies and Measures

PAMs for industrial processes are listed in 2. Industrial Processes section 2.2.5.

2.7.4   Source Specific QA/QC

As described in 2. Industrial Processes section 2.2.7.

2.8   Product Uses as Substitutes for Ozone Depleting Substances (IPCC 2.F)

2.8.1   Source description

Table 32 Detailed sector split for Product Uses as Substitutes for Ozone Depleting Substances.

IPCC 2006 source category		Description	Re-port
2F	Product Uses as Substitutes for Ozone Depleting Substances		☑
2F1	Refrigeration and Air Conditioning	Refrigeration and air-conditioning systems are usually classified in six application domains or categories. These categories utilise different technologies such as heat exchangers, expansion devices, pipings and compressors. The six application domains are domestic refrigeration, commercial refrigeration, industrial processes, transport refrigeration, stationary air conditioning, mobile air-conditioning systems. For all these applications, various HFCs are selectively replacing CFCs and HCFCs. For example, in developed countries, HFC-134a has replaced CFC-12 in domestic refrigeration and mobile air conditioning systems, and blends of HFCs such as R-407C (HFC-32/HFC-125/HFC-134a) and R-410A (HFC-32/HFC-125) are replacing HCFC-22 mainly in stationary air conditioning. Other, non HFC substances are used to replace CFCs and HCFCs such as iso-butane in domestic refrigeration or ammonia in industrial refrigeration. HFC-152a is also being considered for mobile air conditioning in several regions.	
2F2	Foam Blowing Agents	HFCs are being used as replacements for CFCs and HCFCs in foams, particularly in closed-cell insulation applications. Compounds that are being used include HFC-245fa, HFC-365mfc, HFC-227ea, HFC-134a, and HFC-152a. The processes and applications for which these various HFCs are being used include insulation boards and panels, pipe sections, sprayed systems and one-component gap filling foams. For open-cell foams, such as integral skin products for automotive steering wheels and facias, emissions of HFCs used as blowing agents are likely to occur during the manufacturing process. In closed-cell foam, emissions not only occur during the manufacturing phase, but usually extend into the in-use phase and often the majority of emission occurs at the end-of-life (de-commissioning losses). Accordingly, emissions can occur over a period of up to 50 years or even longer.	
2F3	Fire Protection	There are two general types of fire protection (fire suppression) equipment that use greenhouse gases as partial replacements for halons: portable (streaming) equipment, and fixed (flooding) equipment. The non-ozone depleting, industrial gases HFCs, PFCs and more recently a fluoroketone are mainly used as substitutes for halons, typically halon 1301, in flooding equipment. PFCs played an	

		early role in halon 1301 replacement but current use is limited to replenishment of previously installed systems. HFCs in portable equipment, typically replacing halon 1211, are available but have achieved very limited market acceptance due primarily to their high cost. PFC use in new portable extinguishers is currently limited to a small amount (few percent) in an HCFC blend.	
2F4	Aerosols	Most aerosol packages now contain hydrocarbon (HC) as propellants but, in a small fraction of the total, HFCs and PFCs may be used as propellants or solvents. Emissions from aerosols usually occur shortly after production, on average six months after sale. During the use of aerosols, 100% of the chemical is emitted. The 5 main sources are metered dose inhalers (MDIs), 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 contact, lubricants, pipe-freezers) and other general products (e.g. silly string, tire inflators, claxons), although in some regions the use of such general products is restricted. The HFCs currently used as propellants are HFC 134a, HFC 227ea, and HFC 152a. The substance HFC 43 10mee and a PFC, perfluorohexane, are used as solvents in industrial aerosol products.	
2F5	Solvents	HFCs and, to a much lesser extent PFCs, are being used as substitutes for ozone depleting substances (most notably CFC-113). Typical HFCs used are HFC-365mfc and HFC-43-10mee. Use of these fluorinated replacements is much less widespread than the ozone depleting substances they replace. Re-capture and re-use is also much more widely practiced The primary areas of use are precision cleaning, electronics cleaning, metal cleaning and deposition applications. Emissions from aerosols containing solvents should be reported undercategory 2F4 "Aerosols" rather than under this category.	
2F6	Other Applications (please specify)	The properties of ozone depleting substances have made them attractive for a variety of niche applications not covered in other sub-source categories. These include electronics testing, heat transfer, dielectric fluid and medical applications. The properties of HFCs and PFCs are equally attractive in some of these sectors and they have been adopted as substitutes. There are also some historical uses of PFCs, as well as emerging use of HFCs, in these applications. These applications have leakage rates ranging from 100% emissive in year of application to around 1% per annum.	

Source: IPCC (2006)

2.8.2 Refrigeration and Air Conditioning Equipment (IPCC 2.F.1)

2.8.2.1 Source description

In the sector of refrigeration and air conditioning several different appliance types have to be considered:

o Domestic Refrigeration
o Transport Refrigeration

    o   Commercial Refrigeration
    o   Industrial Refrigeration
    o   Stationary Air-Conditioning
    o   Mobile Air-Conditioning

2.8.2.2   Emission projection

For the general projection methodology please refer to section 2.2.4.

In this source category a large range of types of appliances are included, which are affected by different policies and measures. If the effects of policies and measures are to be considered it is good practice to calculate projections at a level of disaggregation which takes into account the types of appliances and the gases contained therein. The most important emission sources are lifetime and disposal emissions. In general it is good practice to neglect manufacturing emissions and to pay attention to the amount of imported appliances from European and Non-European countries, which may be effected to a different degree by policies and measures than nationally produced appliances.

Grade 1

For the general Grade 1 projection methodology please refer to section 2.2.4.2.

If this sector is not a source category, it is good practice to use the projections factors provided in table 33 for a projection of aggregated F-Gases in this source category, preferably for each type of appliance.

Table 33 Refrigeration and AC - Grade 1 Projection factors.

	Projection factors - for all gases in relation to 2010 data				
	2010	2015	2020	2025	2030
Without measures	100%	137%	157%	171%	182%
Domestic Refrigeration	100%	70%	46%	1%	1%
Commercial Refrigeration	100%	116%	128%	133%	137%
Industrial Refrigeration	100%	149%	156%	162%	160%
Transport refrigeration	100%	129%	136%	141%	146%
Stationary Air conditioning	100%	237%	336%	400%	448%
Mobile air conditioning	100%	120%	130%	139%	148%
With measures	100%	106%	109%	100%	93%
Domestic Refrigeration	100%	53%	35%	1%	1%
Commercial Refrigeration	100%	70%	76%	80%	82%
Industrial Refrigeration	100%	96%	101%	105%	103%
Transport refrigeration	100%	129%	136%	141%	146%
Stationary Air conditioning	100%	184%	251%	297%	329%
Mobile air conditioning	100%	110%	90%	54%	25%

Source: Aggregation of results from Schwarz et al. (2011)[17]

Grade 2

For the general Grade 2 projection methodology please refer to section 0.

If this sector is a source category, it is good practice to calculate projections on the level of gases for all types of appliances included in this source category.

Table 34 Refrigeration and AC - Grade 2 Projection factors.

	Projection factors - in relation to 2010 data				
	2010	2015	2020	2025	2030
Without measures	100%	137%	157%	171%	182%
Domestic Refrigeration					
HFC 134a	100%	70%	46%	1%	1%
Commercial Refrigeration					
HFC 134a	100%	107%	114%	119%	122%
HFC 125	100%	120%	132%	137%	141%
HFC 143a	100%	115%	126%	131%	135%
Industrial Refrigeration					
HFC 134a	100%	283%	208%	139%	86%
HFC 125	100%	152%	159%	163%	161%
HFC 143a	100%	141%	154%	166%	167%
HFC 32	100%	119%	73%	31%	0%
Transport refrigeration					
HFC 143a	100%	139%	146%	151%	155%
HFC 125	100%	120%	126%	130%	134%
HFC 134a	100%	110%	120%	130%	140%
Stationary Air conditioning					
HFC 32	100%	247%	364%	435%	490%
HFC 125	100%	246%	361%	432%	487%
HFC 134a	100%	167%	127%	136%	143%
HFC 143a	100%	285%	466%	914%	1114%
Mobile air conditioning					
HFC 134a	100%	120%	130%	139%	148%
With measures	100%	106%	109%	100%	93%
Domestic Refrigeration					
HFC 134a	100%	53%	35%	1%	1%
Commercial Refrigeration					
HFC 134a	100%	63%	68%	71%	73%
HFC 125	100%	72%	79%	82%	85%
HFC 143a	100%	69%	76%	79%	81%
Industrial Refrigeration					
HFC 134a	100%	189%	145%	103%	55%

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[17]   Schwarz et al (2011): Preparatory study for a review of Regulation (EC) No. 842/2006 on certain fluorinated greenhouse gases", prepared for the EU Commission in the context of Service Contract No 070307/2009/548866/SER/C4, September 2011

	Projection factors - in relation to 2010 data				
	2010	2015	2020	2025	2030
HFC 125	100%	98%	103%	106%	103%
HFC 143a	100%	90%	99%	106%	107%
HFC 32	100%	81%	53%	28%	0%
Transport refrigeration					
HFC 143a	100%	139%	146%	151%	155%
HFC 125	100%	120%	126%	130%	134%
HFC 134a	100%	110%	120%	130%	140%
Stationary Air conditioning					
HFC 32	100%	195%	272%	323%	359%
HFC 125	100%	194%	271%	321%	357%
HFC 134a	100%	99%	83%	88%	94%
HFC 143a	100%	253%	408%	688%	845%
Mobile air conditioning					
HFC 134a	100%	110%	90%	54%	25%

Source: Aggregation of results from Schwarz et al. (2011)[18]

Grade 3

If this category is a key source category and additional European or national policies and measures are to be included, a detailed projection for each appliance type, gas and emission source concerned has to be performed. The general methodology is outlined in section 2.2.4. Detailed guidance is given in the following paragraphs for each type of appliance.

a) Domestic refrigeration

HFCs/CFCs for domestic refrigeration have generally been replaced by R-600a by the European manufacturers. As a result, there is no HFC used for manufacturing after 2010 in the European Union. The importation of refrigerators from outside of the EU filled with HFCs is very small and is assumed to be constant. Household refrigerators are already covered by the WEEE Directive (Directive 2002/95/EC) which requires appropriate end-of-life treatment including recovery (collection schemes). The application of Art 4(1) of the F-gas Regulation requires that end-of-life recovery must be carried out by certified personnel.
As a result, it is good practice to project decreasing HFC emissions from domestic refrigeration up to the level of lifetime emissions of HFCs from the banks of imported refrigerators and their disposal emissions after end of lifetime.

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[18]   Schwarz et al (2011): Preparatory study for a review of Regulation (EC) No. 842/2006 on certain fluorinated greenhouse gases", prepared for the EU Commission in the context of Service Contract No 070307/2009/548866/SER/C4, September 2011

b) Road Transport and Ship Refrigeration

GHG emissions for road transport and ship refrigeration are in general relatively low compared to other subsectors. If these sectors are of national relevance in GHG emission inventories it is good practice to calculate projections as described in section 0, basing on the stock of vehicles.

c) Commercial Refrigeration (IPCC 2.F.1.a)

Commercial refrigeration is a very important source category for F-Gas emissions in this sector. It depends on a large range of appliances of very different sizes, filled with different gases. Appliances with charges of more than 50 kg in this subsector are affected by Article 3 and 4 of the F-gas Regulation. Equipment with charges of more than 3 kg (which is by far the majority of appliances in this subsector) are affected by containment and recovery measures according to the F-Gas Regulation. Some sectors like the catering industry or convenience shops run equipment below 3 kg or hermetically sealed systems, which are not subject to the key containment measures (e.g. leak checks, records, leakage detection systems) according to the F-gas Regulation.

It is good practice to calculate projections as outlined in section 0, basing on the quantity of commercial refrigeration appliances.

If this data is not available, it is good practice to calculate emission projections from commercial refrigeration using food sales area as the basis, following the equation below:

Refrigerant in cooling units (n) = Sales area (n) * specific amount of refrigerants per shop or area

Data about food sales area may be available from national statistical office. Projections have to be performed or gathered for each type of sales area. If national data is not available, food sales area data per person from other, similar countries may be used, because it is generally quite comparable amongst European countries. In general it is good practice to assume high growth rates for larger supermarkets, whereas smaller ones show decreasing rates.

Specific amount of refrigerants per shop or area should be assumed and it is good practice to hold these values constant throughout the projected time series.

Bank(Gas,n) = Refrigerant in cooling units(n) * Share of gas

The share of gases which are in use as refrigerants for commercial refrigeration are assumed for each year for the calculation of refrigerant banks. Different types of commercial refrigeration have to be considered, depending on the type of sales area and year, it is good practice to differentiate between central systems, condensing units and hermetically sealed units.

It is good practice to calculate disposal emissions with the following equation, assuming lifetime for centralized systems of 12 years and for condensing units and hermetically sealed units incl. vending machines 15 years lifetime:

Disposal,n=Bank (n-LT) / LT

For the calculation of lifetime and disposal emissions, adequate <u>emissions factors</u> have to be used, default values are shown in the table below for a without measures scenario and with existing measures scenario.

Table 35 Commercial refrigeration – Default emission factors.

	Average lifetime emission factors (%)		Average disposal emission factors (%)	
	1995-2010	2015-2030	1995-2010	2015-2030
Without measures				
Central systems	15%		30%	
Condensing units	10%		50%	
Hermetic units	1%		70%	
With existing measures				
Central systems	15%	9%	30%	20%
Condensing units	10%	6%	50%	25%
Hermetic units	1%	1%	70%	35%

Source: Schwarz et al. (2011)

If the effects of additional measures shall be calculated, it is good practice to assume decreasing shares of fluorinated gases in cooling units over time.

d) Industrial Refrigeration (IPCC 2.F.1.b)

Emissions from industrial refrigeration mainly occur from leakages during lifetime and from disposal after end of lifetime. It is good practice to calculate projections as described in section 0, based on the quantity of industrial refrigeration appliances.

If this data is not available, it is good practice to calculate emission projections from industrial refrigeration on assumptions of the quantity of goods which need cooling in various industrial sectors or directly using the installed refrigeration capacity for that sector. From the estimated installed capacity refrigerant banks can be derived, using sector specific indices of charge.

Refrigeration Capacity = goods which need cooling* specific annual cooling needs

Bank (gas,n) = Refrigeration Capacity * charge * percentage of refrigerant

Refrigeration Capacity can directly be derived from national statistics, however if this is not possible, it is good practice to use amounts of produced goods which need cooling from national statistics and to multiply this quantity with specific annual cooling needs. The table below shows default values for specific annual cooling needs and average charges for some sectors for which it is good practice to include in detailed projection calculations:

Table 36 Industrial refrigeration- parameters for Grade 3.

Sector of Industrial refrigeration	Specific annual cooling needs		Average charges
			kg / kW
Food industry			
Beer production	0.045	kW / t	3.65
Wine production	0.0344	kW / t	2
Meat production	0.045	kW / t	5.612
Dairy industry	0.013	kW / t	2.88
Chocolat production	0.0095	kW / t	4.7
Frozen food	0.0525	kW / t	7.6
Fruit juice / Gaseous drinks	0.003	kW / t	5
Milk farms	0.0167	kW / t	1.5
Other Industry			
Cold storage	0.032	kW / m^3	6
Ice rinks	250	kW / unit	500
Other industry (50% chemical)	no specifc value		5

Source: Schwarz et al. (2011)

The projection of refrigerant banks has to be made for each sector of industrial refrigeration. It is good practice to assume an increase in pace with GDP development (e.g. frozen food), in pace with population (fruit juice and cold storage) or constant values (other sectors).

Percentages of refrigerants included in industrial cooling have to be assumed for each year, taking into account slow changes because of the long lifetimes of cooling equipment: As default values for lifetime of cooling equipment, 20 years is proposed for farm milk cooling, ice rinks and other industry and 30 years is proposed for other sectors.

For the calculation of lifetime and disposal emissions, proposed emission factors are presented in Table 37.

Table 37 Industrial refrigeration- Emission factors.

Sector of Industrial refrigeration	Average lifetime emission factors (%)		Average disposal emission factors (%)	
	1995-2010	2015-2030	1995-2010	2015-2030
Food industry				
Beer production	9%	5%		
Wine production	8%	5%		
Meat production	9%	5%		
Dairy industry	9%	5%	30%	20%
Chocolat production	8%	5%		
Frozen food	9%	5%		
Fruit juice / Gaseous drinks	8%	5%		
Milk farms	8%	8%		
Other Industry				
Cold storage	9%	5%		
Ice rinks	9%	5%	30%	20%
Other industry (50% chemical)	12%	7%		

Source: Schwarz et al. (2011)

In general, equipment in industrial refrigeration have a larger charge than 3 kg, indeed in most sectors charges over 100 kg are typical. As a consequence industrial refrigeration is addressed by all measures of the F-Gas Regulation. With this in mind, leakage rates will be reduced into the future, which induces decreasing lifetime emission factors. Only for milk cooling on farms are charges below 3 kg, with thus these cooling units are not affected by F-Gas Regulations. Recovery efficiency at the end-of-lifetime is assumed to rise, and as a result, it is good practice to reduce the emission factors for disposal from 30% in 2010 to 20% in the year 2015 onwards.

If the effects of additional measures are to be calculated, it is good practice to assume decreasing shares of fluorinated gases in cooling units over time.

e) Stationary Air Conditioning (IPCC 2.F.1.c)

There is a vast range of stationary air-conditioning (AC) equipment, in which F-Gases are included. Emissions mainly occur from leakages during lifetime and from disposal after end of lifetime. It is good practice to calculate emission projections as described in section 0, basing on the stock of appliances for each type of air conditioning unit, e.g.:

- o Split and factory-sealed moveable air conditioning devices (Room AC)
- o Multisplit (Variable Refrigerant Flow types) and packaged systems (units with combined compressor, condenser and evaporator, mounted outdoor, mostly on rooftops)
- o Displacement and centrifugal chillers
- o Heatpumps

For the projection of stocks it is good practice to assume high growth rates until 2030 for Room AC and a saturation of the stock of multisplit, packaged systems and chillers around the year 2015. For heat pumps it is good practice to assume an increase of stock until saturation is reached at a level of 4% of population (EHPA 2010[19]).

Default values for the average charges of appliances are given in Table 38.

For most of the devices several types of F-Gases have to be taken into account for emission calculations, with the share of each gas changing over time. For this purpose a system has to be implemented which indicates the share of F-Gases used for each AC device along with the further development of these shares. For these systems assumptions in relation to the lifetime of air conditioning equipment should be included, considering a slow change in the shares of F-Gases in refrigerant banks depending on lifetimes. Default values for the lifetime of AC equipment and emission factors for lifetime and disposal emissions are presented in Table 38.

Table 38 Stationary Air Conditioning – default values and emission factors.

	Average Charges (kg/unit)	Lifetime (years)	Average lifetime emission factors (%)		Average disposal emission factors (%)	
			1995-2010	2015-2030 with existing measures	1995-2010	2015-2030 with existing measures
Room AC	0.75 - 1.5	10	5%	5%	70%	35%
VRF & Packages	13.5 / 10.5	13. / 10	5%	3%	30%	20%
Chillers	2 (mini), 10 (<100 kW), 95 (>100 kW)	12 (mini), 25 (<100 kW), 15 (>100 kW)	4%	2%	30%	20%
Heatpumps	2.7	15	3.5%	3.5%	70%	35%

Source: Schwarz et al. (2011)

The size of equipment determines, if equipment types are affected by the F-Gas regulation (Art. 3). Article 4(1) on recovery applies to all stationary F-gas containing equipment. As a result leakage rates will be reduced, which induces decreasing lifetime emission factors. It is good practice to reduce lifetime emission factors to 60% of the levels in the year 2010 from 2015 onwards. Only the emissions factors for split devices and heatpumps are expected not to decrease because typical charges are below 3 kg. In addition it is good practice to assume rising recovery efficiency at the end-of-lifetime, with emission factors for disposal reducing from 30% in 2010 to 20% in the year 2015 onwards.

If the effects of additional measures shall be calculated, it is good practice to assume decreasing shares of fluorinated gases in cooling units over time.

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19   EHPA (European Heat Pump Association), Outlook 2010. European Heat Pump Statistics, Summary, Brussels 2010

f) Mobile Air Conditioning (IPCC 2.F.1.d)

F-Gases are used in mobile air-conditioning (MAC) units in all kind of vehicles. It is good practice to calculate emission projections as described in section 0 for each type of vehicle: cars, trucks, busses, trains and ships separately. Emissions occur from leakages during equipment lifetime and from disposal at the end of equipment lifetime.

It is good practice to base emission projections on the stock of vehicles and national statistics of mobile air conditioning (MAC) per vehicle types. F-Gas banks are calculated by multiplying the stock of vehicles with mobile air conditioning with typical charges per vehicle. Default values are presented in Table 39.

Table 39 Mobile Air Conditioning – default values and emission factors.

	Average Charges (kg/unit)	Lifetime (years)	MAC quota for new vehicles	Average lifetime emission factors (%)	Average disposal emission factors (%)
Personal Car	0.625	12	96%	10%	70%
Bus	10.4	10	57-96%	15%	30%
Truck					
< 1.5 t	1.0		45%	10%	
1.5 t-7 t	1.0	10	43%	15%	70%
>7 t	1.2		90%	15%	
Ship					
Cruise	6400				
Passenger	520	40		40%	30%
Cargo/Container	160				
Rail					
Rail	8				
Tram	30	25	100%	7%	30%
Metro	10				

Source: Schwarz et al. (2011)

For the projection of the stock of cars it good practice to assume a trend which follows the GDP projection until a vehicle density of 750 cars /100 persons is reached, which can be assumed to be the saturation rate of passenger cars in each EU country. Once saturation is reached, the fleet size follows the population trend in a country.

For the projection of the stock of trucks it is good practice to assume a trend which follows the national GDP projection. If different types of trucks are considered, it is good practice to assume a constant amount of medium and heavy trucks (>1.5 t). For the projection of buses it is good practice to assume no growth from the base year on, the same goes for rail vehicles and ships with MAC, other than container ships. For the latter it is good practice to assume a growth based on historical national growth rates of this type of ship.

Regarding the quotas of mobile air conditioning, default values for new registered vehicles are presented per type of vehicle in Table 39.

It is good practice to assume that actually (2010) only HFC 134a is used as F-Gas in mobile air conditioning. Amounts of HFO are low but increasing, especially for personal cars which are affected by the MAC-directive. If several gases have to be considered in projections for MAC, the changing shares of F-Gases in new vehicles throughout the time series have to be projected. These changes affect the shares of F-Gases in the banks, depending on lifetimes of vehicles. It is good practice to implement a system of F-Gas-shares to reflect these changes in an appropriate way. Default values for lifetime of vehicles are presented in Table 39.

For the calculation of lifetime and disposal emissions, adequate emissions factors have to be used, default values are given in Table 39.

2.8.2.3 Policies and Measures

PAMs for industrial processes are listed in section 2.2.5

Regulation No 842/2006 – F-Gas Regulation

Many appliances under this source category are affected by this regulation, detailed information is given in section 2.8.2.2 for each type of appliance.

2.8.2.4 Source Specific QA/QC

As described in section 2.2.7.

For the calculation of projections with Grade 3 methodologies it is good practice to consider the amount of imported appliances which may not be affected by existing or additional national or European regulations.

2.8.3 Foam Blowing (IPCC 2.F.2)

2.8.3.1 Source description

Several types of F-Gases and types of foams have to be considered for detailed projections of emissions. For these it is good practice to differentiate between One Component Foams (OCF), (including so-called two-component PU foam), Extruded Polystyrene Foam (XPS) and PU rigid and PU integral Foam (PU foam), of which only one-component foams are affected by existing policies and measures.

Grade 1

For the general Grade 1 projection methodology please refer to section 2.2.4.2.

If this sector is not a source category, it is good practice to use the projections factors given in Table 40 for a projection of aggregated F-Gases in this source category, preferably for each type of foam.

Table 40 Foams – Projection factors Grade 1.

	Projection factors - for all gases in relation to 2010 data				
	2010	2015	2020	2025	2030
Total	100%	110%	121%	132%	143%
OCF	100%	110%	122%	135%	149%
XPS	100%	105%	110%	115%	120%
PU foam	100%	117%	135%	153%	170%

Source: Aggregation of results from Schwarz et al. (2011)[20]

For the inclusion of the F-Gas regulation for F-Gases in OCF, follow the approach outlined in section 2.2.3.2.

Grade 2

For the general Grade 2 projection methodology please refer to section 0. If this sector is a source category, it is good practice to calculate projections for all types of foams included in this source category.

Table 41 Foams – Projection factors Grade 2.

	Projection factors- in relation to 2010 data				
	2010	2015	2020	2025	2030
Total	100%	110%	121%	132%	143%
OCF					
HFC 134a	100%	110%	122%	135%	149%
XPS					
HFC 134a	100%	107%	113%	120%	126%
HFC 152a	100%	100%	100%	100%	100%
PU foam					
HFC 134a	100%	56%	40%	39%	37%
HFC 365mfc	100%	123%	144%	164%	183%
HFC 245fa	100%	123%	144%	163%	182%

Source: Aggregation of results from Schwarz et al. (2011)

For the inclusion of the F-Gas regulation for F-Gases in OCF, follow the approach outlined in section 2.8.3.2.

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[20]   Schwarz et al (2011): Preparatory study for a review of Regulation (EC) No. 842/2006 on certain fluorinated greenhouse gases", prepared for the EU Commission in the context of Service Contract No 070307/2009/548866/SER/C4, September 2011

Grade 3

If this category is a key source category and additional European or national policies and measures are to be included, a detailed projection for each type of foam, gas and emission source concerned has to be performed. The general methodology is as described in section 2.2.4. Detailed guidance is given in the following paragraphs for each type of foam.

OCF: It is good practice to calculate only lifetime emissions, assuming that all one component foam cans are used in the year of manufacture, emitting all gas included. With this in mind, it is good practice to base projection calculations on the amount of cans sold including HFC 134a, multiplied by an average charge per can. As a default value it is good practice to assume 0.11 kg as the average charge, and a growth rate of sales of 2%. The effects of existing measures as outlined in section 2.8.3.2 should be included.

XPS: It is good practice to calculate manufacturing and lifetime emissions for HFC 134a, but only manufacturing emissions from HFC 152 a. Disposal emissions will not occur until 2050 as the lifetime can be assumed to be 50 years. It is good practice to estimate the HFC 134a bank based on the amount of installed XPS with HFC 134a, subtracting lifetime emissions from the bank for each year. It is good practice to project constant values for each year of the projection.

PU foam: It is good practice to calculate manufacturing and lifetime emissions for HFC 365mfc and HFC 245fa and to estimate the HFC 134a bank based on the amount of manufactured PU foam and subtracting lifetime emissions from the bank for each year. Disposal emissions do not occur until 2050 as the lifetime can be assumed to be 50 years. It is good practice to project constant values for each year of the projection. For the inclusion of additional measures it is good practice to assume the replacement of F-Gases for non-spray foams.

Default emission factors are shown in Table 42.

Table 42 Foams – Default emission factors.

Average emission factors (%)	Manufacturing emissions	Lifetime emissions
OCF		
HFC 134a		100%
XPS		
HFC 134a	30%	0.75%
HFC 152a	100%	10%
PU foam		
HFC 134a		
HFC 365mfc	10% (rigid)	1%
HFC 245fa	100% (integral skin)	

Source: Schwarz et al. (2011)

2.8.3.2   Policies and Measures

PAMs for industrial processes are listed in section 2.2.5.

Regulation No 842/2006 – F-Gas Regulation

The F-Gas regulation (Article 9) applies only to OCF, whereby sales of OCF containing HFCs to the market are prohibited, except when required to meet national safety standards. It is therefore good practice to assume a strong decrease in the use of OCF down to the amount of cans which are necessary to meet national safety standards.

2.8.3.3   Source Specific QA/QC

Please follow the approach outlined in section 2.2.7.

For the calculation of projections with Grade 3 methodologies it is good practice to consider the amount of imported foam.

2.8.4   Fire Extinguishers (IPCC 2.F.3)

2.8.4.1   Source description

Fire extinguishers are filled with several types of Hydrofluorocarbons (HFC gases): HFC 227ea, HFC 23, HFC 125, HFC 236fa, HFC 134a. Emissions occur from both the bank of each gas but also during equipment lifetime (from fire extinguishers in operation status) and from equipment disposal.

2.8.4.2   Emission Projections

For general methodology please refer to section 2.2.4.

Grade 1

If fire extinguishers are not a key source category then no additional measures shall be quantified in projections. It is good practice to follow the approach developed by Schwarz et al (2011) for a without measures scenario and a with existing measures scenario (including national and European measures in place before the end of 2010).

For this purpose it is good practice to multiply the most recent GHG emission data in CO_2 equivalent (including all gases) with general projection factors of the specific year for each projected year, as outlined in Table 43.

Table 43 Fire extinguishers - Projection factors for Grade 1.

	Projection factor for fire extinguishers - for all emission sources and all gases (% of CO$_2$ eq 2010)				
	2010	2015	2020	2025	2030
Without measures EU-27	0%	22%	37%	45%	36%
With existing measures EU-27	0%	10%	23%	31%	23%

Source: Aggregation of results from Schwarz et al. (2011)[21]

Grade 2

If fire extinguishers are a key source category and no additional measures are to be quantified in emission projections, it is good practice to focus on each gas, and adjust national projections to be in line with those presented by Schwarz et al. (2011).

For this purpose it is good practice to multiply the most recent GHG emission data in ton of each gas affected with general projection factors of the specific year for each projected year, as presented in Table 44.

Table 44 Fire extinguishers - Grade 2 Projection factors.

	Projection factor for fire extinguishers - for all emission sources (% of ton per gas in 2010)				
	2010	2015	2020	2025	2030
Without measures					
HFC 227ea	100%	108%	129%	135%	141%
HFC 23	100%	133%	143%	145%	145%
HFC 125	100%	105%	121%	140%	148%
HFC 236fa	100%	105%	119%	141%	153%
With existing measures					
HFC 227ea	100%	97%	117%	125%	127%
HFC 23	100%	120%	129%	130%	130%
HFC 125	100%	95%	109%	130%	134%
HFC 236fa	100%	95%	107%	127%	138%

Source: Aggregation of results from Schwarz et al. (2011)

For information about underlying assumptions with regard to the inclusion of existing measures refer to section 2.8.4.3.

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[21] Schwarz et al (2011): Preparatory study for a review of Regulation (EC) No. 842/2006 on certain fluorinated greenhouse gases", prepared for the EU Commission in the context of Service Contract No 070307/2009/548866/SER/C4, September 2011

Grade 3

If fire extinguishers are a key source category and additional measures are to be quantified in emission projections, it is good practice to perform a detailed calculation.

For the calculation of lifetime emissions the modelling of the <u>bank of each F-Gas</u> is necessary for each gas, starting in the year 1995. Estimates of the quantity of the bank for each gas can be derived from most recent GHG inventories. The disposal and refill of extinguishers must be considered and included in the calculation of the banks. It is good practice to assume a lifetime of 20 years.

Lifetime and disposal emissions have to be calculated based on the bank and disposal of gases, as described in section 0. For the calculation of the bank it is good practice to assume a growth rate of 1% per year up to 2025. As a starting point for the calculation of the bank the amount of fluid in operating systems from GHG inventory can be used.

Default values for lifetime and disposal emission factors are shown in Table 45.

Table 45 Fire- extinguishers - Emission factors.

	Average lifetime emission factors (%)		Average disposal emission factors (%)	
	1995-2010	2015-2030	1995-2010	2015-2030
Without measures				
HFC 227ea	2,3%	2,3%	10,0%	9,0%
HFC 23	2,1%	2,1%	10,0%	9,0%
HFC 125	2,3%	2,3%	10,0%	9,0%
HFC 236fa	5,0%	5,0%	10,0%	9,0%
With existing measures				
HFC 227ea	2,3%	2,1%	10,0%	9,0%
HFC 23	2,1%	1,9%	10,0%	9,0%
HFC 125	2,3%	2,1%	10,0%	9,0%
HFC 236fa	5,0%	4,5%	10,0%	9,0%

Source: Schwarz et al. (2011)

Follow the approach presented in section 2.8.4.3 with regard to the inclusion of existing measures.

2.8.4.3   Policies and Measures

PAMs for industrial processes are listed in section 2.2.5.

<u>Regulation No 842/2006 – F-Gas Regulation</u>

Fixed fire protection systems are subject to the measures prescribed in Article 3 and 4 of the F-gas Regulation. Additional future policies and measures are possible which may increase the replacement of F-Gases in fire extinguishers or further decrease emission factors.

In Schwarz et al (2011), the containment and recovery measures by certified personnel according to Article 3 and 4 of the F-Gas Regulation are not assumed to show substantial additional reduction

effects to the existing use phase emissions, because regular control measures have always been common practice. As a consequence it is good practice to assume only a slight decrease of use-phase emission factors from 2011 onwards up to 2015 and a small reduction effect with regard to end-of - life emissions with a decrease in the disposal emission factor from 10% to 9%.

2.8.4.4   Source Specific QA/QC

Please follow the approach outlined in section 2.2.7.

2.8.5   Aerosols/Metered Dose Inhalers (IPCC 2.F.4)

2.8.5.1   Source description

Emission projections in this subsector cover two different sources of emissions (aerosols and metered dose inhalers) which are affected differently by different measures.
The Following guidelines are based on methodologies presented by Schwarz et al. (2011)[22].

2.8.5.2   Emission projections

For general methodology please refer to section 2.2.4.

If it can be foreseen that policies or measures will affect the use of aerosol, detailed emission projections for metered dose inhalers (MDI) and aerosols have to be conducted separately because emissions from metered dose inhalers are not effected from existing regulations on F-Gases. Manufacturing emissions for aerosols are very small and do not have to be considered. It is good practice to assume, that all aerosols are emitted in the same year of production and that no disposal emissions occur.

Grade 1

If this source category is not a key source, it is good practice to scale the most recent data from the GHG inventory with the projection factors outlined in Table 46.

Table 46 Aerosols/MDI Projection factors.

	Projection factors - for all gases in relation to 2010 data				
	2010	2015	2020	2025	2030
MDI and Aerosols	100%	102%	104%	106%	108%

Source: Aggregation of results from Schwarz et al. (2011)[23]

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[22]   Schwarz et al (2011): Preparatory study for a review of Regulation (EC) No. 842/2006 on certain fluorinated greenhouse gases", prepared for the EU Commission in the context of Service Contract No 070307/2009/548866/SER/C4, September 2011

[23]   Schwarz et al (2011): Preparatory study for a review of Regulation (EC) No. 842/2006 on certain fluorinated greenhouse gases", prepared for the EU Commission in the context of Service Contract No 070307/2009/548866/SER/C4, September 2011

Grade 2

If the source is a key source category, it is good practice to calculate emission projections at the level of gas used, using the results of Schwarz et al (2011) for the "with existing measures" scenario.

First, MDI emissions have to be separated from the total amount of emissions in this sector, as they are not affected by existing policies and measures. Their projection should be based on assumptions in relation to <u>population development</u>, <u>asthma prevalence</u> and <u>percentages of asthma sufferers that use spray inhalators</u>. The results of Schwarz et al (2011) for emissions from MDI are shown in Table 47 and can be used as default values:

Table 47 Aerosols/MDI - Default MDI emissions.

	MDI emissions in kt CO_2 eq (from HFC 134a and HFC 227ea)				
	2010	2015	2020	2025	2030
Austria	29	30	32	33	34
Belgium	46	48	51	53	55
Bulgaria	11	11	11	11	11
Cyprus	2	2	2	2	3
Czech Republic	74	77	79	81	82
Denmark	5	5	5	6	6
Estonia	4	4	4	4	4
Finland	18	18	19	20	20
France	328	345	362	378	394
Germany	303	309	315	321	326
Greece	18	19	19	20	20
Hungary	29	29	30	30	30
Ireland	64	72	79	85	90
Italy	240	250	259	266	274
Latvia	9	9	9	9	9
Lithuania	13	13	13	14	14
Luxembourg	2	2	2	3	3
Malta	3	3	3	4	4
Netherlands	39	41	42	44	45
Poland	139	142	146	148	149
Portugal	46	48	50	52	53
Romania	30	31	31	31	32
Slovakia	41	42	43	44	45
Slovenia	11	12	12	12	12
Spain	253	274	291	304	315
Sweden	11	11	12	13	13
United Kingdom	882	931	983	1.036	1.089

Source: Aggregation of results from Schwarz et al. (2011)

The default share of gases is 88% HFC 134a to 12% HFC 227ea.

It is good practice to assume that aerosol emissions are stable from 2008 on, considering existing F-Gas regulation (see section 2.8.5.3). With these assumptions and based on recent GHG inventory data emissions projections can be calculated for each Gas affected.

Grade 3

If aerosols are a key source and additional policies and measures are forecast to induce the replacement of general aerosols, it is good practice to apply the following methodology.

If not the default results from Grade 2 shall be applied for the calculation of *MDI emissions*, it is good practice to project lifetime emissions using the following equations:

HFC_Consumption_MDI (n) = Persons with Asthma using spray inhalators * 80 g HFC

Persons with Asthma using spray inhalators = population * prevalence * percentage of spray inhalators.

Assumptions in relation to the prevalence and the share of spray inhalators are dependent on national circumstances. Schwarz et al (2011) assume that the prevalence of asthma will rise by 0.5% per year whereas the share of the use of spray inhalators remains constant. National default values for prevalence and the share of spray inhalators are presented in Table 48.

Table 48 Aerosols/MDI - default values for the prevalence of asthma and share of spray inhalators.

	Prevalences (year 2010)	Share of spray inhalators
	%	%
Austria	5.8	50
Belgium	6	60
Bulgaria	1.5	80
Cyprus	2.4	80
Czech Republic	8	75
Denmark	3	25
Estonia	5.4	50
Finland	8	35
France	6.8	65
Germany	6.9	45
Greece	1.9	70
Hungary	3	80
Ireland	14.6	80
Italy	4.5	75

	Prevalences (year 2010)	Share of spray inhalators
	%	%
Latvia	4.2	80
Lithuania	4.2	80
Luxembourg	6	60
Malta	8	80
Netherlands	8	25
Poland	4.1	75
Portugal	4.8	75
Romania	1.5	80
Slovakia	8	80
Slovenia	5.8	80
Spain	5.7	80
Sweden	6.5	15
United Kingdom	16	75

Source: Schwarz et al. (2011)

The default share of gases is 88% HFC 134a to 12% HFC 227ea.

For the first year of projections, the use of **General and Novelty Aerosols** is calculated as the difference of emissions reported in this sector from the most recent GHG emission inventory and MDI emissions.

The effect of additional measures has to be implied on aerosol emissions of future years.
E.g. a measure could be adopted, which leads to a replacement of HFC 134a in General aerosols by HFC 1234ze with a penetration rate of 95% up to 2020. This replacement may be directly applied to an equivalent reduction in lifetime emissions of HFC 134a, because aerosol emissions are assumed to be emitted directly to the atmosphere.

For assumptions in relation to existing measures see section 2.8.5.3.

2.8.5.3   Policies and Measures

PAMs for industrial processes are presented in section 2.2.5.

Regulation No 842/2006 – F-Gas Regulation

The HFC share in propellant gas preparations will decrease in future years on foot of Article 2(5) of the F Gas regulation which will result in a reduction in emissions from the use of novelty aerosols.

2.8.5.4   Source Specific QA/QC

Please follow the approach outlined in section 2.2.7.

2.8.6   Other (2.F.5 and 2.F.6)

2.8.6.1   Source description

There are several other sources of fluorinated gases which are included in national GHG emission inventories, e.g. Solvents, Semiconductor Manufacture, Electrical Equipment and various other appliances.

2.8.6.2   Emission projections

It is good practice to report historical data for 2000, 2005, and 2010 and to use the most recent GHG data for the subsector provided by MS in their inventory submissions as starting point for the calculation of projections.

Grade 1

It is good practice to hold emissions constant to most recent data from GHG inventories.

Grade 2

If this source is a key source category it is good practice to apply the trend of the most important parameters which may influence emissions to the most recent data from GHG inventories.

Grade 3

For the calculation of detailed projections refer to section 0.

2.8.6.3   Policies and Measures

PAMs are presented section 2.2.5.

2.8.6.4   Source Specific QA/QC

Please follow the approach outlined in section 2.2.7.

2.9   Product Use (IPCC 2.G and 2.H)

2.9.1   Source description

Product Use covers greenhouse gas emissions occurring from the use of greenhouse gases in products, and from non-energy uses of fossil fuel carbon.

Table 49 Detailed sector split for Product Use.

IPCC 2006 source category		Description	Re-port
2G	Other Product Manufacture and Use		

IPCC 2006 source category		Description	Re-port
2G1	Electrical Equipment	Electrical equipment is used in the transmission and distribution of electricity above 1 kV. SF6 is used in gas-insulated switchgear (GIS), gas circuit breakers (GCB), gas-insulated transformers (GIT), gas-insulated lines (GIL), outdoor gas-insulated instrument transformers, reclosers, switches, ring main units and other equipment.	
2G2	SF6 and PFCs from Other Product Uses		
2G3	N$_2$O from Product Uses		
2G4	Other (Please specify)		
2H	Other		
2H1	Pulp and Paper Industry		
2H2	Food and Beverages Industry		
2H3	Other (please specify)		☑

Source: IPCC (2006)

2.9.1.1   Emission projections

It is good practice to report historical data for 2000, 2005, and 2010 and to use the most recent GHG data for the subsector provided by MS in their inventory submissions as starting point for the calculation of projections.

Grade 1

It is good practice to hold emissions constant to most recent data from GHG inventories.

Grade 2

If this source is a key source category it is good practice to apply the trend of the most important parameters which may influence emissions (preferably the population growth or GDP growth) to the most recent data from GHG inventories.

Grade 3

For the calculation of detailed projections refer to section 0.

2.9.1.2   Policies and Measures

PAMs are presented section 2.2.5.

2.9.1.3   Source Specific QA/QC

Please follow the approach outlined in section 2.2.7.

B.3 Agriculture (IPCC sector 4)

3.1   Introduction

3.1.1   Source description

Emissions from agricultural sources can be difficult to determine with a high degree of accuracy because a large number of parameters impact on the rate of emission. Added uncertainty is then introduced when estimating emission projections, as this requires the trends and changes in farming practices to be taken into account, and these are often strongly driven by national and international policies.

The extent to which detailed data are available for the agriculture sector varies greatly across different countries. As a result, the use of the graded approach is particularly important in supporting the calculation of emission projections for agriculture.

The sources included in the Agriculture sector are described in the table below. The largest sources are typically CH_4 from enteric fermentation, and N_2O emissions from both manure management and the application of fertiliser to land, both allocated to 3A in the following table.

Table 50 Sector split for Agriculture.

IPCC 2006 source category			Re-port
3	Agriculture, Forestry, and Other Land Use[24]	Emissions and removals from forest land, cropland, grassland, wetlands, settlements, and other land. Also includes emissions from livestock and manure management, emissions from managed soils, and emissions from liming and urea application. Methods to estimate annual harvested wood product (HWP) variables are also covered in this category.	☑
3A	Livestock	Methane emissions from enteric fermentation, and methane and nitrous oxide emissions from manure management.	☑
3C	Aggregate Sources and Non-CO_2 Emissions Sources on Land	Includes emissions from activities that are likely to be reported at an aggregated level or even country level.	☑

Source: IPCC (2006)

3.1.2   Policies and Measures

A number of specific international policies and measures will have an effect on agriculture emissions in the future. Table 51 presents EU legislation associated with the agriculture sector. MS evaluation of the impact of these policies and measures may mean that information on parameters and variables associated with determining emission projections at higher grade levels are available.

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[24] In the IPCC 2006 Guidelines the 1996 sectors 4 Agriculture and 5 LULUCF aggregated to this Sector 3.

Table 51 Policies and Measures and related parameters affected by implementation of particular PAM in Agriculture sector.

Sector	Description	Legislation	Parameters/Variables
Cross-cutting	Biofuels directive	Directive 2009/28/EC	
	Integrated pollution prevention and control (IPPC) recast	Directive 2008/1/EC	*Emission ceilings for air pollutants,* *Emission factors,* *N excretion rates,* *Manure management system usage(for housed swine and poultry)* *SWDS waste composition*
	EU Emissions trading scheme	Directive 2003/87/EC	*Emission factors*
	Biofuel Directive	Directive 2003/30/EC	
	Kyoto Protocol project mechanisms	Directive 2004/101/EC	*Emission factors*
	National Emission Ceilings for certain pollutants (NEC Directive)	Directive 2001/81/EC	*Emission ceilings for air pollutants*
	Water Framework Directive	Directive 2000/60/EC	*N input to managed soils from organic fertiliser*
	Decision:		
	Effort Sharing Decision	Decision 406/2009/EC	
Agriculture	*Directives:*		
	Common Agricultural Policy (CAP) Reform	Directive 2006/144/EC	
	Nitrates Directive	Directive91/676/EEC	*N input to managed soils from organic fertiliser,* *N input to managed soils from different types of synthetic fertiliser*
	Sewage Sludge Directive	Directive 86/278/EEC	*N input to managed soils from organic fertiliser*
	Regulations:		
	CAP "Health Check" 2008 and the "Set aside" regulation	Regulation 73/2009	
	EC Fertiliser	Regulation 2003/2003	*N input to managed soils from organic fertiliser,* *N input to managed soils from different types of synthetic fertiliser*
	Common rules for direct support schemes under CAP	Regulation 1782/2003	
	Support for rural development	Regulation 1783/2003 amending a number of other	

Sector	Description	Legislation	Parameters/Variables
		Regulations	
	Transition to rural development support	Regulation 2603/1999	
	Pre-accession measures for agriculture and rural development	Regulation 1268/1999	*N excretion rates, manure management system usage, N inputs to managed soils*
	Agricultural production methods compatible with environment	Regulation 2078/92	*N input to managed soils from different types of synthetic fertiliser*
	Aid scheme for forestry measures in agriculture	Regulation 2080/92	

Historically, national and international policies have typically aimed to control agricultural production rather than livestock numbers. Given that, at lower Grades, agricultural livestock numbers are used as activity data for many sources, it is important to understand the link between livestock numbers and agricultural production to ensure suitably reliable emission projection estimates. Production is directly linked to livestock numbers by yield, and this typically varies with time. Consequently determining trends in yield will allow improved emission projection estimates to be made.

More recently, there has been a significant shift in focus of legislation, with more emphasis on environmental stewardship, modernisation of agricultural infrastructure and the promotion of best practice, rather than controlling levels of agricultural production. The relationship between some PAMs and emissions are therefore more complex to determine, bringing increased levels of uncertainty to emission projection estimates.

GHG projections from enteric fermentation are primarily determined by future livestock numbers i.e. activity data. Trends in yield are therefore particularly important to assess the extent to which PAMs controlling agricultural production will have an influence on livestock numbers.

Activity data is important for estimating emission projections from manure management, whether this is livestock numbers or a more detailed evaluation of nitrogen excretion. However manure management practice is also an important parameter in determining emissions, and this can be more strongly influenced by national environmental policies. Several EU PAMs have a direct impact on N_2O emissions from manure management. As indicated in the table above, IPPC has an impact on large swine and poultry units. The legislation aims to control emissions by ensuring good practice is used in determining N feed inputs and housing/manure management practices. There are also best practice measures associated with manure management under Regulation (EC) No 1268/1999 - Pre-accession measures for agriculture and rural development.

Emissions from soils are directly influenced by the Nitrates Directive, which controls the amount of N that can be applied to land under certain circumstances. This can have a significant impact on the activity data (national levels of synthetic N that are applied) for emissions from soils. This is also true

for the Water Framework and Sewage Sludge Directives. A number of other PAMs will impact on emissions from soils, although the impact may be less direct and more complex to evaluate. For example:

- o Regulation (EEC) No 2078/92 – "Agricultural production methods compatible with environment" includes measures to support organic farming
- o Regulation (EC) No 1268/1999 – "Pre-accession measures for agriculture and rural development" includes measures to introduce best practice in farming
- o Regulation (EC) No 2003/2003 – "EC Fertilisers" Allows the EC to control the products that can be advertised and sold as fertilisers.

All of these PAMs will have an impact on the levels of N that are applied to land, however the size of the impact is not straightforward to quantify and in some circumstances may not be significantly large.

There are a number of other PAMS which can impact on future emissions from agriculture, but which are difficult to quantify. For example, Table 51 above includes several PAMs for which nothing has been identified in the Parameters/Variables column. This is because, whilst the PAMs may bring about changes to farming, it is not possible to determine specific parameters and variables used in estimating emissions which may be influenced.

When calculating the future impact of PAMs, it should also be acknowledged that there can be a far from comprehensive change in farming practices following the implementation of particular PAMs. This very much depends on the way PAMs are introduced or the level to which they are enforced at the national level. Furthermore, significant change can take a number of years to materialise, and it is good practice to consider this when considering when changes are likely to occur in the projected time series.

In addition to PAMs there are other external factors which have the potential to influence emissions. For example:

- o Changes in the demand of different food types, caused by the buying patterns of consumers
- o The introduction of new crop strains or increased use of particular animal breeds
- o Climatic changes, which can result in change to farming practices as well as changes to the crops that are farmed.
- o Changes to food prices, or significant changes to the importation of food from outside the EU area.

Clearly trying to capture the impact of PAMs and other factors is a complex process. Typically, using a Grade 1 approach is unlikely to fully capture the impacts from introducing PAMs, and consequently a Grade 2 approach is preferable for many of the sources in the agriculture sector, and obviously those which are key sources.

3.1.3   Parameters for Agriculture sector

Table 52 presents an overview of parameters needed for each grade to estimate GHG projections from Agriculture subsectors. Each approach is described further in this chapter

Table 52 Overview of parameters per Grade needed for Agriculture sector

Grade	Parameters
3A Livestock	
Enteric Fermentation (IPCC 3A1)	
Grade 3	Projected demand for meat and dairy products + Projected yield data (litres milk/head, kg meat/head etc.) + Projected Methane Conversion Factor (M_{CF}) => ***Grade 3***
Grade 2	Projected livestock numbers + Projected yield data (litres milk/head, kg meat/head etc.) => ***Grade 2***
Grade 1	Projected livestock numbers => ***Grade 1***
Manure Management (IPCC 3A2)	
a) Methane	
Grade 3	Projected livestock numbers + Projected volatile solids excreted + Projected maximum methane producing capacity + Projected Methane Conversion Factor (MCF) + Projected use of different manure handling systems => ***Grade 3***
Grade 2	Projected livestock numbers + Projected feed characteristics + Projected use of different manure handling system=> ***Grade 2***
Grade 1	Projected livestock numbers => ***Grade 1***
b) Nitrous Oxide	
Grade 3	Projected livestock numbers + Full N flow assessment => ***Grade 3***
Grade 2	Projected livestock numbers + Projected N excretion (country specific) + Projected use of different manure handling system => ***Grade 2***
Grade 1	Projected livestock numbers + Projected N excretion => ***Grade 1***
Rice Cultivation (IPCC 4C)	
Grade 3	Projected harvested area + Projected use of different rice field management practices + Projected meteorological parameters => ***Grade 3***
Grade 2	Projected harvested area + Projected use of different rice field management practices => ***Grade 2***
Grade 1	Projected harvested area => ***Grade 1***
N_2O Emissions from Managed Soils (IPCC 4D)	
Grade 3	Projected livestock numbers + Projected yield data (litres milk/head, kg meat/head etc.) + Projected areas of arable/cereal products + Projected yield data (tonnes/ha) + Projected field conditions during application (soil type, meteorological conditions etc.) + Projected use of different application techniques (broadcast, trailing hose, trailing shoe, injection etc.) => ***Grade 3***
Grade 2	Projected livestock numbers + Projected yield data (litres milk/head, kg meat/head etc.) + Projected synthetic fertilizer use + Projected use of different application techniques (broadcast, trailing hose, trailing shoe, injection etc.) + Projected areas of arable/cereal products => ***Grade 2***
Grade 1	Projected livestock numbers + Projected synthetic fertilizer use + Projected areas of arable/cereal products => ***Grade 1***

Field Burning of Agricultural Residues (IPCC 4F)	
Grade 3	Projected area of field burning by crop type + Projected crop yields => *Grade 3*
Grade 2	Projected area of field burning => *Grade 2*
Grade 1	Current area of field burning => *Grade 1*

3.2   Livestock (IPCC 4.A and 4.B)

Table 53 presents the sources included under Livestock. Methodologies for estimating emissions from these sources are given in detail in the following sections.

Table 53 Detailed sector split for Agriculture, Forestry, and Other Land Use.

IPCC 2006 source category		Description	Re-port
3	Agriculture, Forestry, and Other Land Use	Emissions and removals from forest land, cropland, grassland, wetlands, settlements, and other land. Also includes emissions from livestock and manure management, emissions from managed soils, and emissions from liming and urea application. Methods to estimate annual harvested wood product (HWP) variables are also covered in this category.	☑
3A	Livestock	Methane emissions from enteric fermentation, and methane and nitrous oxide emissions from manure management.	☑
3A1	Enteric Fermentation	Methane emissions from herbivores as a by-product of enteric fermentation (a digestive process by which carbohydrates are broken down by micro-organisms into simple molecules for absorption into the bloodstream). Ruminant animals (e.g., cattle, sheep) are major sources with moderate amounts produced from non-ruminant animals (e.g., pigs, horses).	☑
3A2	Manure Management	Methane and nitrous oxide emissions from the decomposition of manure under low oxygen or anaerobic conditions. These conditions often occur when large numbers of animals are managed in a confined area (e.g. dairy farms, beef feedlots, and swine and poultry farms), where manure is typically stored in large piles or disposed of in lagoons and other types of manure management systems.	☑

Source: IPCC (2006)

3.3   Methane Emissions from Enteric Fermentation (IPCC 4.A)

3.3.1   Source description

In the source category 4.A Enteric Fermentation, CH_4 emissions occur due to the nature of the digestive systems of livestock. The amount of enteric methane emitted is driven primarily by the number of animals, the type of digestive system, and the type and amount of feed consumed. Cattle, buffalo and sheep are the largest sources of enteric CH_4 emissions. Some emission control measures

can be used, but these do not influence the emissions to the same extent as the livestock numbers and the amount of agricultural produce that is generated per head of livestock[25].

Grades and Decision Tree

Figure B.3-1 presents generalized decision tree for selecting grades to estimate GHG emission projections from agriculture.
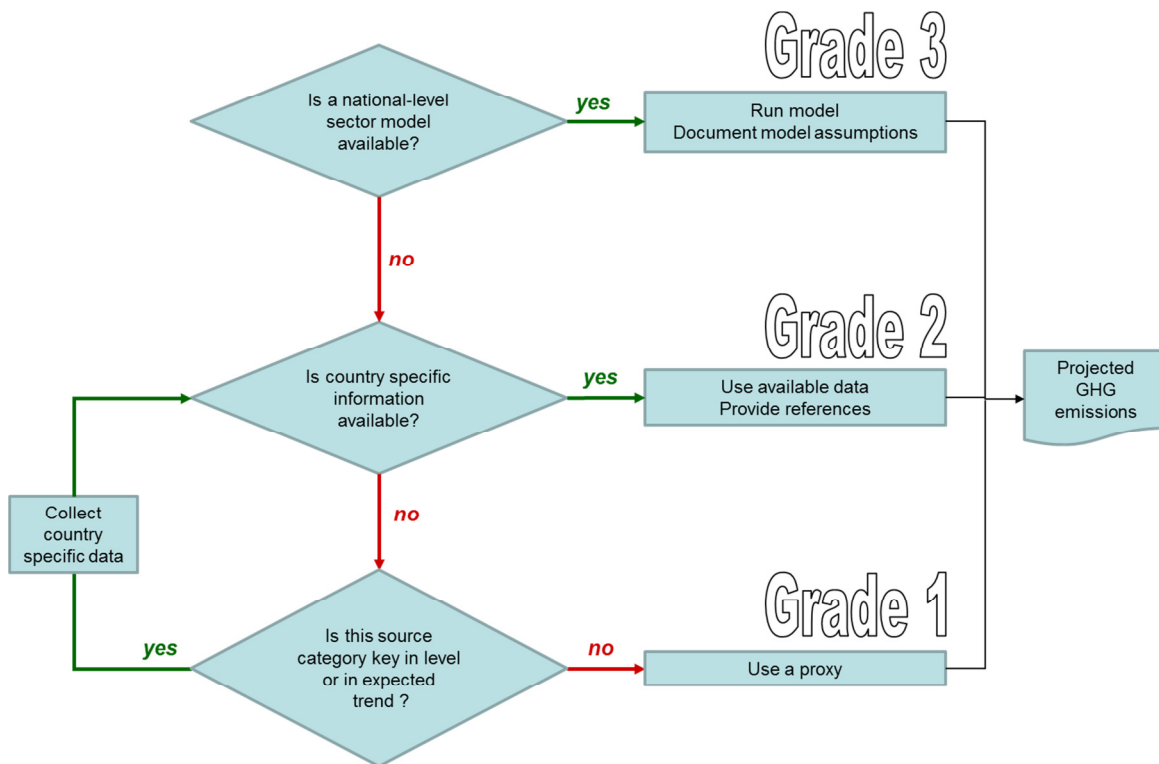
Figure B.3-1 Generalised decision tree for GHG emission projections from agriculture activities.

If a national projection model is available that will provide projected livestock numbers, milk yield and impacts of future policies, then Grade 3 should be used and relevant QA/QC procedures should be applied. If a national projection model is not available, but there is projected activity data disaggregated by livestock sub-categories with yield data for each sub-category then Grade 2 should be used. If country specific data is not available and it is not a key category then simple livestock projects (probably derived from extrapolation of current trends should be used (Grade 1).

Data Sources

Future emissions from enteric fermentation are dependent on a variety of factors. For example:

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[25] This is known as the "yield".

      o   Technological advances that result in increased milk production efficiency can lead to livestock population reductions;
      o   Policies that alter the importing/exporting regulations and subsidises available to farmers (e.g. PAMS associated with CAP reforms);
      o   Changes in regional climatic conditions that alter the livestock species weighting;
      o   Changes in the demand for agricultural products.

This can make predicting emissions complex. However, the starting point for making emission estimates (unless detailed agricultural models is available) is to consider the livestock numbers, and the associated emission factors.

a) Livestock Numbers

Livestock numbers are one of the most important parameters in accurately determining emissions and projections from enteric fermentation. The data is also used for other sources in the agriculture sector (see 4.B Manure Management), so it is recommended that resources are used to compile projected livestock categories and sub-categories that are as detailed as the available data allow.

Official datasets of projected national livestock numbers are typically available in most countries, and these should be used (although it is important to understand the details of the scenario which has been used to generate the projected livestock dataset). If projected livestock numbers need to be generated, then approaches with different levels of sophistication can be used – both in terms of the factors that are taken into account, and the detail to which different livestock classes and sub-classes are quantified.

At the simplest level, historic data can be used for projected years (Grade 1). Substantial improvements can be made to this by considering the trends in the historic animal numbers, and extrapolating accordingly to obtain a without measures scenario (Grade 2). However, farming practices in the agriculture sector are influenced by extensive policies and measures, and taking into account the impact of these on activity data statistics such as livestock numbers can be complex.

Livestock numbers can be predicted by using available agriculture models (which also take into account economic parameters), such as CAPRI – the Common Agricultural Policy Regionalised Impact modelling system (http://www.capri-model.org/). CAPRI is an agricultural-economic model, and includes supply and market modules, allowing it to indicate the impacts of PAMs on agricultural emissions. The model supports work by the EU on agricultural PAMs. Therefore the use of this model to determine projected emissions is helpful, as it ensures a degree of consistency with the policy analysis undertaken by the EU.

Trends in farming, and the implementation of PAMs can substantially impact livestock numbers. For example, policies and measures that control milk production impact on livestock numbers of dairy cattle directly, through the milk yield per animal, making future milk yields an important parameter to be able to determine. Milk yield per animal has increased with time. However, future increases are expected to be smaller as milk yields in most European countries are already considered to be high.

Future milk yields will be influenced by trends towards more sustainable and closed loop oriented production. Feeding of high amounts of concentrated feed to dairy cows is being investigated in some countries. In addition, dairy cattle in some countries are mainly based on a grassland diet, and therefore there will be limited increase in the milk yield. As a result, milk yield increases are expected to vary across European countries, but probably not continue to increase at the rate seen in recent years.

If the MS have available national models to project these activity data, then it should be used and QA/QC procedures should be carried out to identify any differences and the causes thereof with international models.

b) Emission Factors

The CH_4 emissions in this sector depend on gross energy (amount of energy an animal needs for performance), and the fraction of gross energy in feed that is converted into CH_4. These two parameters are dependent on a range of variables describing the performance of the livestock sub-categories and feed characteristics.

Accurately projecting these factors requires information on several things:

- o Policies and measures: As explained above Section 3.1.2, most policies and measures are introduced on an economic basis, which then indirectly influences the livestock numbers or yields.

Changes to diet: This can be related to policies and measures above, but diet change that is not driven by policies and measures may also occur. For example, changes may make it economically more or less favourable to provide animals with feed, rather than grazing on pasture.

Species change: There may be significant changes in the dominant species within a sub-category. This can then give rise to changes in emission factors for the relevant sub-category.

- o Technology: The introduction of some technologies have the potential to impact on emission factors. For example, the use of feed additives to inhibit enteric fermentation in dairy cattle has been explored (although their future use is not currently expected to be extensive).

Since emission projections are likely to be derived from the latest historic inventory, it is probable that the same emission estimation grade will be used for the projections as the historic emissions estimates. However, in the agriculture sector, assessing some of the future policies and measures requires a rather detailed approach. It is therefore possible that projected emissions are calculated using a more sophisticated method than historic emission estimates (although typically this would then be used with the historic input datasets).

If projected emission factors are not available, then it should be possible to derive them in the same way as those for historic years (see Chapter 10 of the 2006 IPCC Guidelines). This requires estimates of projected energy intake and methane conversion factors – and hence information on project trends associated with animal feed.

Where no information is available on projected trends in farming practices, then it will be necessary to assume that emission factors for future years are unchanged from historic years.

Grade 1

Projected livestock population should be available from national sources. Where these are not readily available, projected data should be estimated by using the historic livestock data, and extrapolating trends. It will also be possible to compare these data with projected livestock numbers from other sources, such as the results generated by the CAPRI model for EU policy support.

Livestock sub-categories can be fairly simple. For example, cattle may only be split into dairy and non-dairy cattle, and it may be necessary to assume that the proportions of the total remain constant with time if data are only available on the total number of cattle.

It is good practice to use emission factors from the historic emissions inventory, and assumed not to change with time, unless additional information is available to indicate otherwise.

Grade 2

Grade 2 is, in general, the same as Grade 1, but with more detailed input data that allows for a more accurate calculation of projected emission estimates.

Livestock sub-categories are expected to be detailed, with well characterised livestock numbers. The methodology for determining the projected livestock data should be transparent, so that dependence on existing data and the levels of uncertainty can be understood.

Emission factors may be based on the historic emissions inventory, but information on gross energy intake is used to calculate projected emission factors rather than assume that the emission factors are constant with time (see see Chapter 10.3.2 of the 2006 IPCC Guidelines). It may be that yield data are available for projected years, rather than gross energy intake, but the latter can be derived from the yield.

Grade 3

A Grade 3 methodology typically uses detailed modelling. It is good practice for this modelling to take into account national circumstances to project livestock numbers, gross energy intake data, and methane conversion factors.

Use of such a nationally specific approach can mean that differences arise when compared to other models such as CAPRI. Good QA/QC practices will be needed, and in particular thorough documentation will be needed to ensure transparency. This then allows any arising differences to be understood, and to identify any issues with consistency. Consideration will also need to be given to potential impacts on other source sectors. For example the growth or reduction of the livestock sector in agriculture can give rise to changes in the levels of farming crops. So cross-checks between these two sectors will be needed to ensure consistency across the different source sectors.

The use of a Grade 3 approach provides the capability to perform detailed agriculture-economic modelling, and hence determine the importance of each of the sub-categories (i.e. livestock number) and how livestock numbers for each of the sub-categories may be affected by a range of different PAMs.

3.3.2 Policies and Measures

The influence of PAMs has been considered in Section 3.1.2. The relationships between different PAMs and emissions from enteric fermentation can be complex. But of particular importance are the PAMs that influence livestock numbers and/or feed characteristics, either directly or through the control of agricultural produce levels.

3.3.3 Source Specific QA/QC

Several common input datasets are used for estimating emissions from different agricultural sources. For example, livestock numbers are key drivers for estimating emission from both enteric fermentation and manure management. It is important that these input data are consistent across the different sources of the emissions projection. Specific QA/QC routines should be put in places to ensure that consistency is maintained.

It is important that the methodology used in collating the projected livestock population is reviewed. Livestock numbers estimated for different times of the year can vary considerably due to production practices. Furthermore, referring to the methodology provides a better understanding of the associated uncertainty levels as well as any specific shortcomings.

Where country specific emission factors are estimated, it is good practice to compare these with data from the IPCC Guidelines (see Chapter 10.3.2 of the 2006 IPCC Guidelines), as well as any data available from neighbouring countries. This ensures a degree of consistency.

As with all sources, time series of emissions, activity data and emission factors should be investigated for step changes, dips and jumps. Any unusual features in the time series will need to be understood and explained. Whilst sudden changes in farming practice are possible (for example through the introduction of specific legislation) it is generally not common.

3.4 Methane and N_2O Emissions from Manure Management (IPCC 4.B)

3.4.1 Source description

The agriculture category 4B Manure Management includes emissions of N_2O and CH_4 from livestock manure, which is principally composed of organic material.

Methane is produced from the decomposition of manure under anaerobic conditions. The extent to which anaerobic conditions occur is dependent on the type of manure management system that is used. For example, the use of lagoons or storing manure in large piles will give rise to anaerobic conditions.

Emissions of N_2O from manure management arise through direct and indirect pathways. The detailed processes involved in the agricultural N-cycle that give rise to emission of N_2O are detailed in the IPCC Guidance (see Chapter 10.5 of the 2006 IPCC Guidelines), but in summary:

- o Direct emissions of N_2O arise when ammoniacal nitrogen in the manure is oxidised to nitrate nitrogen (nitrification) in aerobic conditions. Nitrate and nitrite is then transformed into N_2O in anaerobic conditions (denitrification).
- o Indirect emissions of N_2O result from the direct emission of NH_3 and NOx. A portion of these emissions is redeposited back to the soil surface, and can be re-emitted as N_2O.

The approach to estimating emissions of N_2O from manure management has been significantly revised between the 1996 and 2006 IPCC Guidelines. The methodology in the 1996 Guidelines is based on calculating the amount of N being managed by different manure management systems, each of which has a corresponding N_2O EF. The 2006 methodology uses an approach that evaluates the complete flow of N, and is considered to be an improvement on the approach outlined in the 1996 Guidelines.

The amounts of N lost at each stage of the manure management process (housing, storage, application to crops) depend on the N content of the manure. So it is important to be able to quantify the N being excreted by the livestock, and all of the subsequent N losses through the management process. The final step is to determine the N content of the manure applied to crops as fertiliser. This is needed to estimate the emissions reported under 4D N_2O Emissions from Managed Soils (See Chapter B.4 Agriculture section 3.5.2).

In evaluating the N-flow, emissions of NH_3 and NO_X also need to be quantified as losses. So it is good practices to ensure that the methodologies used for GHGs and air quality pollutants are consistent.

Grades and Decision Tree

a) Methane

Figure B.3-2 presents generalized decision tree for selecting grades to estimate CH_4 emission projections from manure management activities.
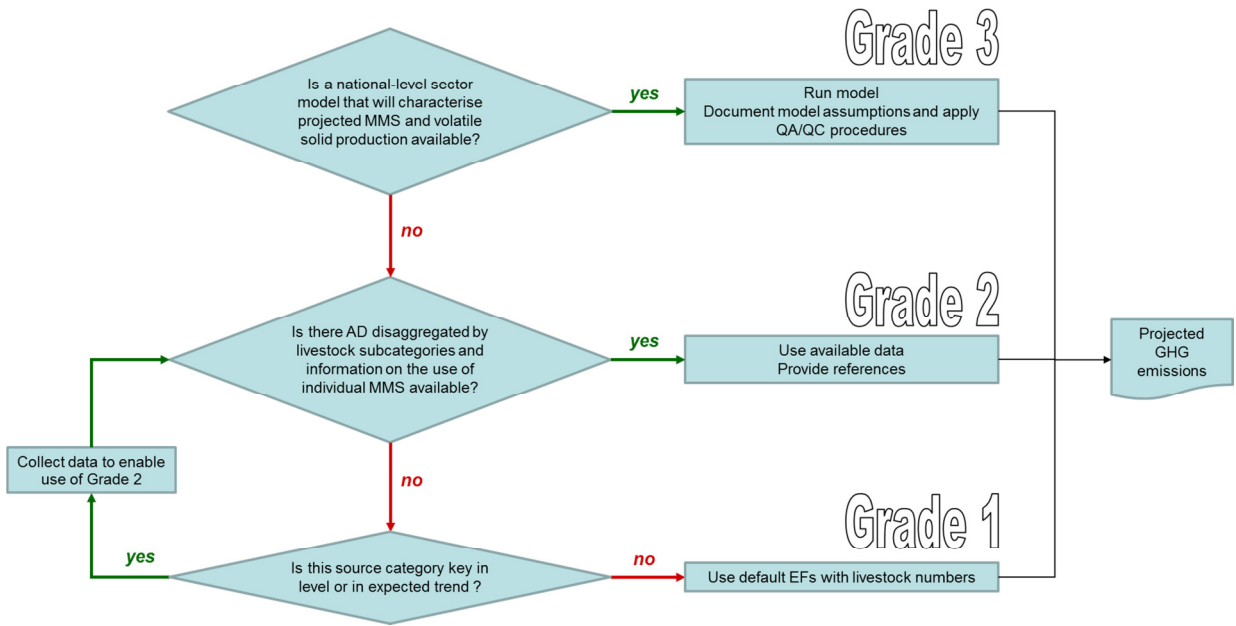
Figure B.3-2 Generalised decision tree for CH₄ emission projections from manure management. MMS-Manure Management Systems, AD- Activity Data.

b) Nitrous oxide

Figure B.3-3 presents generalized decision tree for selecting grades to estimate N₂O emission projections from manure management activities.
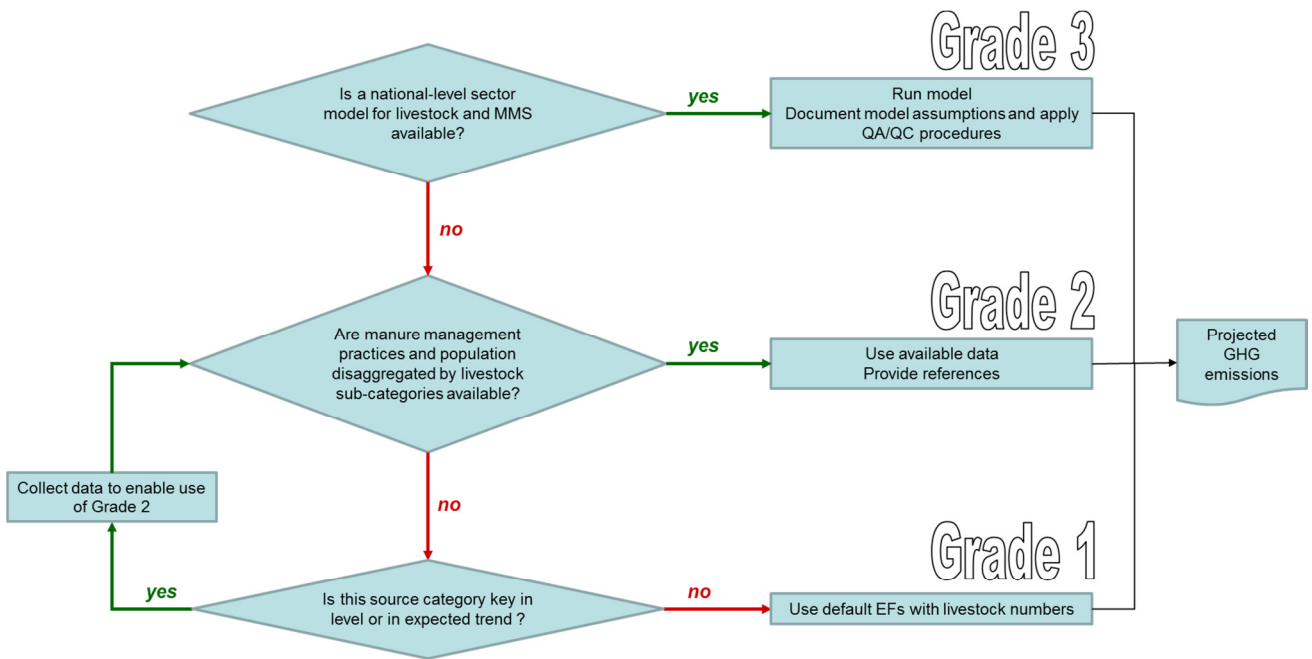
Figure B.3-3 Generalised decision tree for N₂O emission projections from manure management. MMS-Manure Management Systems, AD- Activity Data.

Data Sources

a) CH$_4$ from Manure management (IPCC 4.B)

For Grade 1 calculations, projected livestock data are required, and methods for obtaining these data are explained in section 3.3. It is assumed that emission factors for each of the livestock sub-classes do not change with time (unless information is available to the contrary), and hence this information can be obtained from the historic emissions inventory, or default values may be used from Chapter 10.4 of the IPCC 2006 Guidelines.

For higher Grade calculations, projected emission factors will need to be calculated. Chapter 10.4 of the IPCC 2006 Guidelines provides the calculation methodology for generating country specific emission factors, and it can be seen that research will need to be undertaken to evaluate the following:

- o   Daily volatile solid excreted for each livestock category
- o   The maximum methane producing capacity for manure by livestock category
- o   Methane conversion factors for each manure management system (by climate region)
- o   The fraction of different livestock categories in each manure handling system (in each climate region)

These parameters are derived from a detailed quantification of the projected animal feed characteristics, and the use of different manure management systems.

The first step in estimating these projected parameters is to understand the current situation. Country specific surveys allow a detailed characterisation of both manure and the different manure management practices. This, in turn, will provide detailed historic emission estimates or emission projection. However, obtaining a full understanding of the manure management practices being used, and predicting how these will change with time, requires a large farm survey across several years. Such information is available in some countries, but is a large undertaking and requires a substantial amount of investment and infrastructure.

b) N$_2$O Manure management (IPCC 4.B)

For Grade 1 calculations, N excretion is determined, and then default emission factors are applied for the use of different manure management systems. This information is readily available from the historic emissions inventory, and default values are provided in the IPCC 2006 Guidelines (Chapter 10.5).

For higher Grade methodologies, the N-pathways for the entire process (from manure excretion, housing, storage and subsequent application to land) are characterized. Ideally this means using country specific information on projected N excretion rates, and the extent which different manure management systems are expected to be used in the future. The most challenging aspects of this

approach are to determine some of the detailed aspects of the manure management systems. For example, the method of manure storage and the length of time that manure is stored before application to land. It is recommended that expert advice is sought on how these parameters will differ in future years compared to the situation in the historic emissions inventory.

Grade 1

a) Methane

For Grade 1 calculations projected livestock data should be used that is consistent with the methods outlined in section 3.3.

Emission factors from the most recent year of the historic national GHG inventory (or an average of the emission factor from recent years) should be used for the projected emission estimates.

This approach assumes there are no changes in the emission factors with time, and changes to emissions are simply driven by changes to the animal numbers.

b) Nitrous oxide

The approach to be used is similar to that outlined for CH_4, in that projected livestock data should be consistent with that used for estimating emissions from Enteric Fermentation, and emission factors should be taken from the historic emissions inventory, or default factors taken from the IPCC 2006 Guidelines.

Grade 2

a) Methane

For Grade 2 calculations, the same approach is used as that in Grade 1, except that changes to emission factors are taken into account. This requires the future feed characteristics (such as the energy density of feed) and the gross energy to be evaluated, as well as changes to the manure management handling systems. A more detailed livestock stratification is typically required compared to the Grade 1 approach. The outcome of investigating and evaluating projected feed characteristics allows the parameters used in calculating the projected emission factors to be determined, namely:

- o Daily volatile solid excreted for each livestock category;
- o The maximum methane producing capacity for manure by livestock category;
- o Methane conversion factors for each manure management system (by climate region);
- o The fraction of different livestock categories in each manure handling system (in each climate region).

Incorporating year specific emission factors into the emissions calculation represents a substantial improvement over the Grade 1 approach.

b) Nitrous oxide

A Grade 2 approach uses the same basic methodology as Grade 1, except that country specific data and projections are used for N excretion and the use of different manure management systems.

Where the historic emissions inventory uses a Tier 2 methodology, it should be possible to use these country specific data to estimate future country specific N excretion rates for different livestock types (if this is not already available). Calculating the future N excretion requires data on the properties and amount of animal feed, animal weights etc. as already outlined for CH_4 in section a) above.

The reason that it is particularly advantageous to use country specific data is because this not only gives information on the amount of nitrogen entering the management systems and the N_2O emissions, but it also allows a more accurate evaluation of indirect emissions. This is important as it affect the amount of N in the manure that is passed to the next stage of the housing-storage-spreading process.

If it is not possible to obtain country specific data for the Grade 2 approach, then it may be possible to use data on manure management systems from neighbouring countries. Whilst this is not genuinely country specific, it is likely to be a better approach than using default values from the IPCC 2006 Guidelines.

Grade 3

a) Methane

It may be possible to use detailed country specific modelling that provides similar data to that outlined for Grade 2, but with a more detailed stratification of livestock, and by including other parameters such as projected changes in ambient temperature, and any changes to the species distribution that may arise within each livestock sub-category. Detailed modelling may draw on data at the regional scale, or be able to reflect differences in farming practices driven by farm size. For example large pig and poultry farming units will need to comply with IPPC legislation, and will therefore differ from smaller units.

b) Nitrous oxide

The Grade3 approach for N_2O entails quantifying the N pathways throughout the manure management process, as outlined in the 2006 IPCC Guidelines. As a result it is sensible to regard the total amount of N in the manure as the activity data rather than the livestock numbers (although the manure N will be derived from the livestock numbers).

Application of this methodology to projections requires future N excretion rates to be estimated. Typically this is done by drawing on information from historic trends and using expert advice for estimating projected data for different livestock types. A similar approach is used to determine the projected use of different manure management systems is required.

A Grade 3 approach typically represents very detailed country specific data being used as input. For example information may be available on regional variations in farming practices to allow more detailed calculations, or data may be available that allows stratification of farms of different size.. With this level of detail, this approach is well suited to evaluating different future scenarios.

When considering the input data, it is important to ensure that other controlling factors are taken into account. For example, future livestock numbers and production are expected to be significantly influenced by international policies, as explained in Section 3.1.2- so simple extrapolation of some existing trends may be inappropriate. Future changes in the demand for different agricultural products can also affect the size of the different agricultural sectors. This may be significant not just within e.g. livestock farming, but land use may also move between cropland and that used for animals. Consequently, modelling at this level of detail usually includes the consideration of economic impacts.

The extent to which results from a nationally specific model agree with similar modelling work undertaken at the international scale should be assessed. Differences in assumptions and the underlying input data will need to be understood, and ideally addressed.

3.4.2 Policies and Measures

The influence of PAMs has been considered in Section 3.1.2. The relationships between different PAMs and emissions from manure management can be complex. But of particular importance are the PAMs that influence livestock numbers (and hence N excretion), the use of different manure management systems, and manure handling practices in general (duration and conditions of storage, application to land etc.).

3.4.3 Source Specific QA/QC

Source specific QA/QC for enteric fermentation is included in Section 3.3.3, and all of these aspects are also relevant for manure management. In addition to this there are a number of aspects of QA/QC that relate specifically to the emissions of both CH_4 and N_2O from manure management.

There are some datasets which are common to Enteric Fermentation and Manure Management – for example projected livestock data. It is important to ensure that these datasets are consistent across the different emission sources. This is also true for underlying assumptions that may be made in estimating projected datasets for both sources (e.g. changes to manure management practices).

It is good practice to compare any country specific emission factors and variables that have been calculated with the default values presented in the 2006 IPCC Guidelines. The reasons for differences should be explored, understood and explained in a transparent manner. Comparisons can also be

made with information from international studies, such as output from GAINS, or the CAPRI model. These are used to underpin EU policy formation, and therefore is it important that any differences in assumptions and underlying data used in emission calculations can be identified and explained.

If N_2O emissions have been evaluated by using an N-flow approach, the N input and output terms should balance for each manure management system. It is therefore possible to check that for each manure management system the total N excretion (and any terms relating to the addition of straw for bedding) equals the N output as emissions to air during housing, emissions to air during storage, leaching, run-off, and N in the resulting manure that is applied to cropland[26]

3.5   Aggregate Sources and Non-CO$_2$ Emissions Sources on Land (IPCC 4.C and 4.D)

3.5.1   Rice Cultivation (IPCC 4.C)

3.5.1.1   Source description

The production of rice in flooded fields is a source of CH_4, because organic matter decomposes under anaerobic conditions, and is released primarily though the plants. Emissions depend on a number of different variables, including: number and duration of crops grown, water regimes before and during the cultivation period, and organic and inorganic soil amendments and temperature.

Emissions of N_2O also arise from rice cultivation because rice cultivation is a part of the agricultural nitrogen cycle in much the same way as any other crop type. The approach used to estimate N_2O emissions from rice cultivation should therefore be taken from Chapter B.3 section 3.5.

FAOSTAT[27] indicates that several European countries have areas of rice paddies in 2010— Italy and Spain being the countries with the largest harvested areas (238,500 and 119,300 ha respectively). Rice cultivation contributed ~4% to the total CH_4 emissions for Italy.

Grades and Decision Tree

Figure B.3-4 presents generalized decision tree for selecting grades to estimate GHG emission projections from rice cultivation.

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[26]   And where appropriate, manure that is used for other purposes, such as burning for fuel or use as a building material.

[27]   http://faostat.fao.org/on statistics for 2009, updated 11/05/2011.
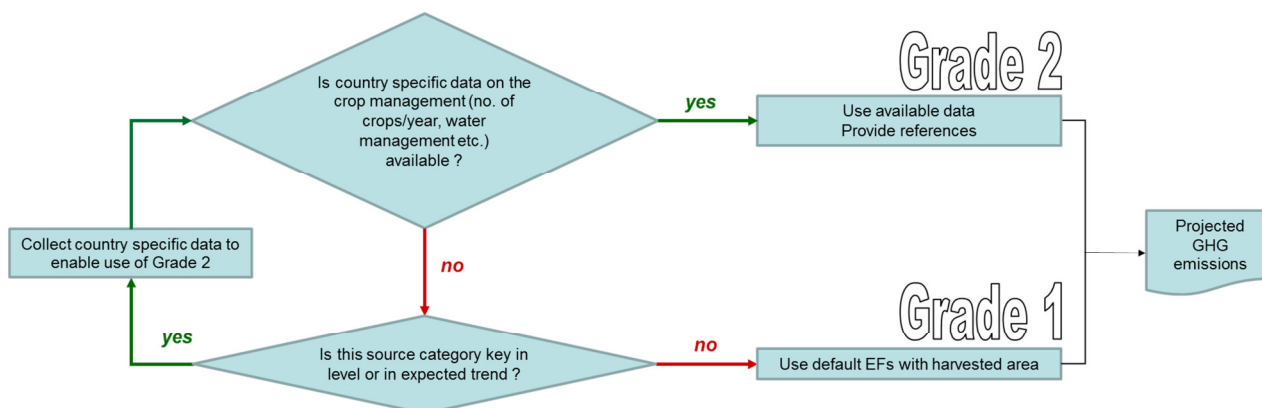
Figure B.3-4 Generalised decision tree for GHG emission projections from rice cultivation.

Data Sources

The projected harvested area is required for estimating emission projections. For most inventories, rice cultivation is not a key source, and the harvested area does not substantially vary with time. It is therefore possible to use a simple approach to estimate projected harvest areas, such as considering the harvested area from the most recent historic year, the current trends with time, and projecting these into future years. Where the source is a key source, more detailed agricultural economic modelling can be undertaken to establish the harvested area for future years.

The harvested area represents the cultivated area multiplied by the number of crops in a year. So in estimating future harvested areas, it is important to consider any changes to the cultivation practices that might arise.

Emission factors for future years are unlikely to substantially different to those for current years, unless changes to farming practices are expected.

Grade 1

A simple method can be used, whereby the total harvested area for each of the projected years can be combined with a generic CH_4 emission factor from the literature (see Chapter 5.5 of the 2006 IPCC Guidelines). The emission factor is therefore assumed to be unchanged in future years.

Information on the total harvested area can often be obtained from agricultural projections, or from projected tonnes of annual rice production (a constant yield, in tonnes/ha, can be assumed and used to convert tonnes of product to harvested area). Where the harvested area for future years is not available, it may be estimated by extending current and historic trends to future years.

Grade 2

A Grade 2 approach can be used where country specific data are available on the different ways in which the rice fields are managed (irrigated, rainfed, deep water, other), and/or country specific emissions factors. Harvested areas for the different types of rice fields for future years are required.

Where these are not available, it will be necessary to make estimates from the historic data by using extrapolation. Section A includes an overview of best practice in techniques that can be used.

There is a body of literature investigating emissions, and emission factors from rice cultivation in Europe, and Italy in particular. Information can be found in the 2010 NIR submission for Italy (available from http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/5270.php).

There are several parameters that could affect the CH_4 emission factor for future years. The impact of the following examples should be taken into account: changing the harvesting practices (e.g. increasing the number of crops/year) and changing the balance of field management (between irrigated, rain fed, deepwater). Other parameters can only be taken into account if a more detailed approach is taken or more detailed data are available; for example, increased temperatures and the use of different rice cultivars.

Grade 3

Detailed agriculture economic modelling can be undertaken if the facilities exist, for example using the DNDC model (detailed at http://www.dndc.sr.unh.edu/). This provides the activity data needed to make the emissions calculation either as tonnes of rice produced, or harvested area.

Further information is not included here as a Grade 2 methodology is generally considered to be detailed enough for the purposes of countries in Europe. But in the longer-term, changes to climate and the resulting changes to rain patterns might be given consideration.

3.5.1.2 Policies and Measures

The influence of PAMs on agriculture in general has been considered in Section 3.1.2. Whilst some may be relevant for rice production, it may be that national level PAMs are equally as important in determining the levels of rice production.

3.5.1.3 Source Specific QA/QC

Emissions inventory best practice QA/QC techniques should be used. In addition checks can be made on the following parameters to investigate consistency across the historic and projected time series:

a) Yield and area

The relationship between cultivated area and harvested area is determined by the number of crops per year. It is therefore not expected to change significantly from year to year, unless there has been a substantial change in the farming practices. Similarly, yield is given by the amount of rice produced per unit of harvested area. In a Grade 1 approach this is expected to be constant with time. A Grade 2 approach may use more detailed information and give rise to an increasing yield with time.

b) Rice field management

If information is available on the different ways in which the rice fields are managed, then a useful check can be performed to ensure that trends with time are relatively smooth.

3.5.2　　N$_2$O Emissions from Managed Soils (IPCC 4.D)

3.5.2.1　　Source description

N$_2$O is produced naturally in soils through nitrification and denitrification, and it passes from microbial cells into the soil, and then into the atmosphere. The availability of inorganic N in the soil is one of the main controlling factors in this reaction.

The approach that is used for estimating emissions of N$_2$O from managed soils is to quantify the amount of N that is added to soils, and then combine this with emission factors. Sources of N include: application of synthetic fertiliser, application of organic fertiliser[28], manure deposited from livestock during grazing, and crop residues that are ploughed back into the soil. N can also be mineralised in soil organic matter following drainage/management of organic soils, or cultivation/land-use change on mineral soils. So these also need to be taken into account.

As well as direct emissions of N$_2$O from soil, there are two indirect emission pathways:

- o Emissions of NH$_3$ and NOx (from managed soils or fossil fuel combustion) can be deposited on the soil surface, and be re-emitted as N$_2$O .
- o Following leaching and run-off, N can be emitted as N$_2$O .

It is possible to make some general comments about the existing trends in agriculture, and how these may impact on future years.
There are increasingly stringent controls on the amount of synthetic fertiliser (and other sources of N) that are being applied to crop land. The Nitrates Directive, Water Framework Directive are accompanied by a wide range of national level guidelines and legislation aimed at ensuring that excessive N is not applied to cropland.

When estimating projected amounts of N being applied to cropland, it would be reasonable to expect that the impact of introducing the policies mentioned above is to reduce the amount of excess N being applied to soils. This would reduce both direct and indirect emissions.

There is also a general trend with time to more intensive farming practices. In some countries it may therefore be that in future years the time that livestock spend in housing is increased, and the time on pasture is decreased. This would give rise to a number of changes, but the most important for emissions from soils is that the N deposited directly to the soil from grazing livestock would decrease, and is replaced by an increase in the amount of N being handled by different manure management systems. It may also be that the total N excretion per head increases.

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[28] The application of sewage sludge should be included if relevant.

In recent years, the application of sewage sludge to land has been seen in a less favourable light by the general public and supermarkets. Despite the introduction of the safe sewage sludge matrix and EU legislation aimed at ensuring that application to land is safe(Sewage Sludge Directive, 86/278/EEC), several European countries have chosen to ban the practice, and in others the amount being applied to cropland has substantially decreased.

Grades and Decision Tree

It is good practice to use same decision trees as in 2006 IPCC guidance (Volume 4 Figure 11.2 and 11.3). Figure B.3-5 presents generalized decision tree for selecting grades to estimate N_2O emission projections from managed soils.
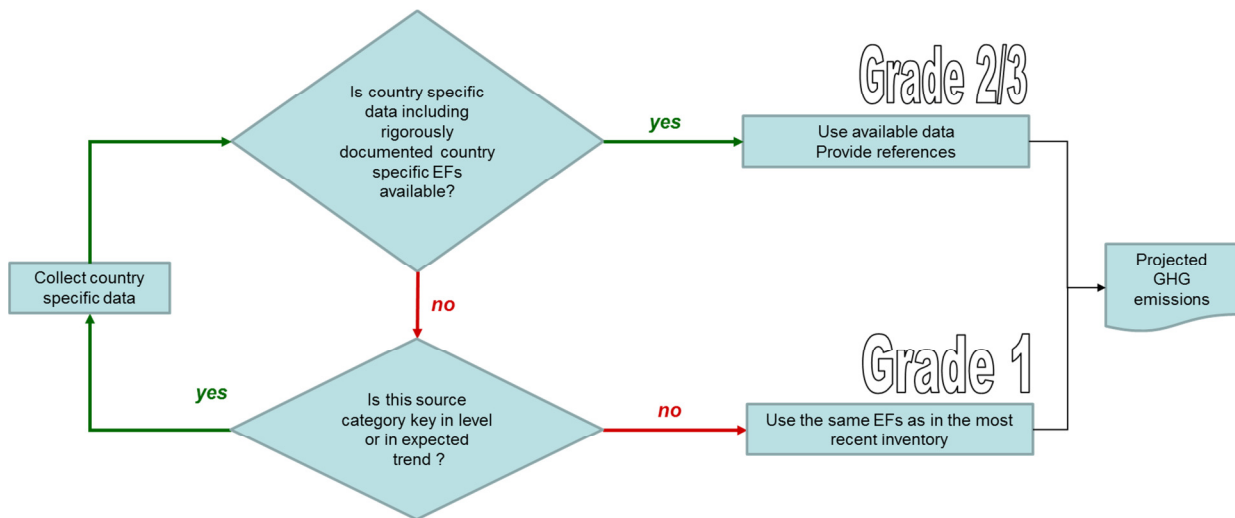
Figure B.3-5 Generalised decision tree for N_2O emission projections from managed soils.

Data Sources

A number of different activity data terms need to be evaluated to determine the total N input into the soil:

- o Synthetic N fertilisers: Projected national annual consumption data are sometimes available. Where they are not, projected estimates can be made from existing historical data (sourced from national Governments or FAOSTAT);
- o Organic N applied as fertiliser (animal manure, compost, sewage sludge, rendering waste): These data should be calculated as part of the methodology for estimating emissions from manure management (see Section 3.4 above);
- o Urine and dung N deposited on pasture, range and paddock by grazing animals: These data should be calculated as part of the methodology for estimating emissions from manure management (see Section 3.4 above);
- o N in crop residues: This requires detailed characterisation of projected arable crop areas. It may not be possible to obtain official national estimates, in which case estimates may need to be generated by extrapolation of existing historic data;

- o   N mineralisation associated with loss of soil organic matter resulting from change of land use or
- o   management of mineral soils : This is included under LULUCF, and therefore detailed in Section B.5;
- o   Drainage/management of organic soils: This is included under LULUCF, and therefore detailed in Section B.5;
- o   Projected activity data may be available from agricultural government departments. This may either represent relatively simple extrapolation of historic data, or may be the output of detailed economic-agricultural modelling. These kinds of modelling studies characterise future agricultural practices by determining the production levels in the future. These are then related to livestock numbers and crop areas by yield statistics. The modelling studies can also take into account changes in farming practices. Modelling can therefore provide input data sets needed for the projected emission calculations.

Where modelled output is not available, extrapolation and expert advice usually needs to be applied to the existing historical data.

Grade 1

a) Direct Emissions

The Grade 1 approach presented in the 2006 IPCC Guidelines quantifies the amount of N input into the soil from the various pathways. These activity datasets are then combined with default emission factors to produce an estimate of direct N_2O emissions from soil.

To estimate emission projections from this source a similar approach is used. Projected activity data is sourced as explained in the sections above. The emission factors that are used for the emission projections are assumed not to change with time, and are therefore the same as those used for the historic emission estimates. It is appreciated that this represents a significant simplification. However, deriving emission factors that vary across the time series requires a substantial amount of detailed input data.

b) Indirect Emissions

The activity data required for estimating indirect emission projections is similar to that for direct emissions. Emission factors for each of the indirect terms are assumed to be the same as for historic emission estimates.

Grade 2 and 3

The Grade 2 approach represents a significant increase in detail level compared to the Grade 1. Grade 3 is typically associated with very detailed modelling studies, but which are broadly similar in approach to Grade 2. Consequently it is sensible to consider Grades 2 and 3 together.

a) Direct Emissions

A Grade 2 approach considers the conditions under which each of the N input terms is applied to the soil. This allows an extra layer of stratification, and different emission factors can be used to reflect the different conditions. A substantial amount of country specific data is required to achieve this, and it is generally the case that where this is undertaken for historic years, the level of detail allows a similar approach to be used for projections.

b) Indirect Emissions

The more comprehensive data that is required for the Level 2 approach allows a more detailed evaluation of the processes that lead to some of the indirect emissions. For example, understanding the levels of N that are being input into different soils types in different conditions not only allow the direct emissions of N_2O to be better estimated, but also allow more reliable estimates of leaching and run-off.

3.5.2.2   Policies and Measures

The influence of PAMs on agriculture in general are considered in Section 3.1.2, and some comments are also included in Section 3.5.2.1. Several recent environmentally based EU PAMs (e.g. the Nitrates Directive and the Water Framework Directive) have brought about controls on the quantities of N that can be applied to soils with specific aims of reducing N run-off into water courses, reducing N deposition to areas of natural vegetation and hence lowering levels of acidification and eutrophication. National PAMs have also been introduced in several countries in Europe, not just to help deliver on international commitments, but also meet targets at the national level.

The result of introducing these PAMs is that there are some substantial decreases to the levels of synthetic fertiliser that may be used. It is also the case that in some circumstances emission factors are reduced, but this is more difficult to take into account in emission calculations because it depends on very localised conditions.

3.5.2.3   Source Specific QA/QC

General guidance on good practice in QA/QC for emission inventories can be found in Section A of this guidance. Particularly relevant aspects for N_2O emissions from managed soils relate to comparing any country specific emission factors with the default values from the 2006 IPCC Guidelines or countries using similar farming practices. Similarly, any nationally sourced livestock and crop data should be checked with international sources (such as FAOSTAT) for consistency.

The approach that is used in determining N emissions from soils is to first consider the different input sources of N. It is important that all underlying data used in these calculations are consistent with other parts of the emission inventory compilation (in particular 4A Enteric Fermentation and 4B Manure Management). For example, calculations under 4B Manure Management generate the estimates of the total N in manure that is applied to managed soils, and forms one of the most important input terms in this section.

3.6   Other agricultural sources (IPCC 4.E to 4.G)

3.6.1   Prescribed Burning of Savannas (IPCC 4.E)

This source is not relevant for European countries and therefore no further information is provided.

3.6.2   Field Burning of Agricultural Residues (IPCC 4.F)

3.6.2.1   Source description

This sector covers the emissions of non-CO_2 greenhouse gases from the burning (in the field) of crop residue and other agricultural waste on site. This practice is banned in some European countries through legislation or as a requirement of various environmental schemes, and continues in others. This source can give rise to significant emissions of indirect greenhouse gases, but is in general a small source of CH_4 and N_2O .

3.6.2.2   Data Sources

Other than the annual area of different crops, parameters influencing the emissions of CH_4, N_2O and indirect greenhouse gases are not expected to vary significantly with time. Consequently, emission factors are not expected to change for future years, making projection calculations relatively straightforward for this sector.

Projected areas of different crop types are required to estimate the projected emissions from the burning of agricultural residues. These can either be obtained directly from agricultural-economic modelling, or by converting projected tonnes of crop produced to the corresponding area by using yield data (noting that the yield may change with time). The crop areas data for future years should at least identify each of the different major cereal types (wheat, barley, maize and oats).

Several variables affect the emission factors for different crop types. These include

- o   Ratio of residue to crop product;
- o   Fraction of residue burned;
- o   Dry matter content of residue;
- o   Fraction oxidised in burning; and
- o   Carbon or Nitrogen content of the residue.

Methodological details are given in the IPCC 1996 Reference Manual (Chapter 4.4.3). The fraction of residue that is burned may reduce in future years depending on changes to farming practices or the introduction of legislation. However, where no information is available on this, it is reasonable to assume that the parameters listed above do not vary for future years. Consequently, the resulting emission factors will not change, and the emission factors used for the historic emissions inventory can also be used for projected years.

3.6.2.3   Grade 1

The extent to which on-field burning of crop residues occurs in future years is assumed to be the same as in historic years. Both emission factors and activity data (crop areas) for future years are taken from the historic emission estimates, and as a result, the projections are constant with time.

Future legislation relating to introducing a ban on on-field burning should also be taken into account if information is available.

3.6.2.4   Grade 2

Emission factors for future years are assumed to be similar to those used in historic years. However projected crop areas are used in the calculation of emissions. Where projected crop areas are not available, then may be calculated from projected mass of cereals produced, and converted into corresponding crop areas by using the yield (tonnes of cereal/hectare), and assume that current yields may be applied to future years.

Future legislation relating to introducing a ban on on-field burning should also be taken into account if information is available.

3.6.2.5   Grade 3

Grade 3 uses the same approach as Grade 2, but also takes into account changes to future yields.

3.6.2.6   Policies and Measures

The influence of PAMs on agriculture in general has been considered in Section 3.1.2. Whilst some may influence the levels of future cereal production and hence emissions from this source, the most important policy relates to whether the practice of on-field burning of crop residues is banned at some point in the future.

3.6.2.7   Source Specific QA/QC

The activity data used for this source (crop areas for future years) should be checked for consistency with sources reported in Section 4.D Emissions from Agricultural Soils.

Under most circumstances, the emission factors applied to future years will be the same as those used for historic years. A consistency check across the entire time series is therefore advised.

3.7   Other (IPCC 4.G)

It is not possible to specify a methodology for sources which have not been identified at the time of writing. However, for sources reported in this category, it is good practice to follow the generic principles that have been used all chapters of this guidance. Section A.5 Methodological Choice of this Guidance outlines the use of the generic a graded approach and the principles of defining the three different levels of methodology.

B.4 LULUCF (IPCC sector 5)

4.1 Introduction

The Land-Use-Land-Use-Change-and-Forestry sector covers the GHG emissions and removals due to land use and land management except those that are included in the Agricultural Sector (see chapter Agriculture). It consists of the six major subcategories forest land, cropland, grassland, wetlands, settlements and other land and land use change categories between these land use types. In addition, further subcategories exist that deal with specific emissions/removals or activities at these lands, like emissions due to N fertilization of forest lands, drainage of soils and wetlands, N_2O emissions from disturbance due to land-use conversion to cropland, emissions from agricultural lime application and biomass burning. Changes in the harvested wood products pool became for the second commitment period a further obligatory part of the LULUCF reporting.

The historic GHG emissions due to carbon [idem when C or N are used elsewhere to represent carbon or nitrogen] stock changes in biomass (aboveground, belowground), dead wood, litter and soil in the six subcategories need to be estimated and reported by the parties in the national inventory submissions under the UN-FCCC, provided it is managed land. Only the historic emissions/removals of the subcategories wetlands remaining wetlands, settlements remaining settlements and other land remaining other land are not obligatory to be reported.

The LULUCF sector is a very comprehensive one. The IPCC GPG and guidelines for the LULUCF sector[29,30] set a general frame for the broad range of existing approaches and methods.

A complete and consistent land-use and land-use-change statistic is the prerequisite and backbone of all LULUCF estimates, its derivation challenging. Data gaps and deviations between different statistics frequently exist, and there is a need to compile information from different statistics into a consistent and complete area statistic of the country.

Another uniqueness of the LULUCF sector is that the emissions/removals are typically the results of gains and losses (e.g. biomass increment minus harvest). The LULUCF emissions and removals are seldom estimated on the basis of direct methods, but have to build on assessments, surveys and data for rather different purposes. So, further input data and tools are needed to indirectly derive the final emission/removal factors. Frequently, there are information gaps and time series gaps that need to be overcome. The emission/removal estimates are typically accompanied by high uncertainties. But the LULUCF subcategories are often key categories which requests higher tier methods for the emission/removal estimates, country specific data and approaches.

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[29]   IPCC 2003: Good practice guidance for land use, land-use change and forestry. IPCC National Greenhouse Gas Inventories Programme, Technical Support Unit, c/o Institute for Global Environmental Strategies, Kamiyamaguchi, Hayama, Kanagawa, Japan.

[30]   IPCC 2006: 2006 IPCC Guidelines for National Greenhouse Gas Inventories – Vol. 4: Agriculture, forestry and other land use. IPCC National Greenhouse Gas Inventories Programme, Technical Support Unit, c/o Institute for Global Environmental Strategies, Kamiyamaguchi, Hayama, Kanagawa, Japan.

Projections in LULUCF are even more demanding. Due to the complexities there is little work on LULUCF projections. The available LULUCF projections frequently cover only single subcategories or pools and the methods of the approaches differ in an even wider range than for the historic emissions. Often there is also a lack in transparency[31].

A significant impetus to LULUCF projections has resulted from the recent "reference level discussions" within the negotiations for a post-Kyoto-Protocol GHG emission reduction commitment ("Cancun decisions"[32]). As a consequence parties were required to provide estimates of emissions/removals from forest management (including all pools and also harvested wood products) to 2020 as a basis for a reference level for accounting the future emissions/removals from this activity. The Annex-I-parties had to submit information according to a set of questions with their reference levels. These submissions were undertaken a review [33]. Under the lead of JRC a group of modelling experts (EFI, IIASA) carried out estimates for the reference levels of EU countries on basis of the same modelling tools (EFISCEN, G4M) and assumptions and with country specific forest and harvested wood pool data[34]. Several EU countries used the results of these projections by JRC, while other EU members and non-EU-Annex-I-countries submitted their own estimates.

The following guidelines for LULUCF projections build on the 2003 IPCC GPG on LULUCF[35] and 2006 IPCC Guidelines on AFOLU[36]. Higher grade projections require information of the future change of key parameters and variables according to impacts. The proposed general grade 1 projection methods for LULUCF will enable each country with complete historic LULUCF emission/removal reporting (which is meanwhile obligatory) to come up at least with grade 1 projections for all LULUCF subcategories and pools, regardless of what Tier approach they use in the inventory for all LULUCF sectors.

4.2   Policies and Measures

There are a few international PAMs that may have, directly or indirectly, an impact on the future emission/removal rates in the LULUCF sector (Table 54). Even for those, the impact in the nations may vary from country to country and it is difficult to quantify or foresee their role in the future

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[31]   See for instance the most recent "National Communications" (NC5) of the Annex-I-countries at the UN-FCCC website: http://unfccc.int/national_reports/annex_i_natcom/submitted_natcom/items/4903.php

[32]   UN-FCCC 2010: The Cancun Agreements: Land use, land-use change and forestry. UN, FCCC/KP/CMP/2010/12/Add. 1, http://unfccc.int/resource/docs/2010/cmp6/eng/12a01.pdf" \l "page=5

[33]   The forest management reference level submissions of the parties and their technical assessment reports have been compiled at the UN-FCCC website: http://unfccc.int/bodies/awg-kp/items/5896.php

[34]   Böttcher, H., H Verkerk, M Gusti, P Havlik, U Schneider (2011): Analysis of potential and costs of LULUCF use by EU Member States, Final Report of contract nr 07.0303/2009/541003 (European Commission, DG Climate Action), IIASA, Laxenburg, http://www.iiasa.ac.at/Research/FOR/LULUCF/LULUCF_Final_Report_Sep21_2011_UNFCCC_review_update.pdf

[35]   IPCC 2003: Good practice guidance for land use, land-use change and forestry. IPCC National Greenhouse Gas Inventories Programme, Technical Support Unit, c/o Institute for Global Environmental Strategies, Kamiyamaguchi, Hayama, Kanagawa, Japan.

[36]   IPCC 2006: 2006 IPCC Guidelines for National Greenhouse Gas Inventories – Vol. 4: Agriculture, forestry and other land use. IPCC National Greenhouse Gas Inventories Programme, Technical Support Unit, c/o Institute for Global Environmental Strategies, Kamiyamaguchi, Hayama, Kanagawa, Japan.

emission/removal rates of LULUCF. It is up to the national implementation of these international PAMs and, particularly, up to national/regional circumstances and PAMs what will be the future emissions/removals in the LULUCF subcategories. A wide range of possible national PAMs with impact on the future LULUCF emissions/removals exist and, in addition, the outcomes may vary from country to country depending also on the competition with various other targets of land management. Therefore, it is crucial for any LULUCF projections to take the specific national framework conditions with respect to PAMs into account. This requests for forecasts at least a close collaboration with the national expertise, even better – the LULUCF projections should be carried out by national institutions that have this specific knowledge.

Table 54 International policies and measures with a possible direct/indirect impact on future LULUCF emissions/removals (legislation in italics under negotiation)

Policy area	Description	Legislation	Parameters/Variables
Crosscutting	Kyoto-Protocol and related decisions	Kyoto-Protocol and related decisions at UN and EU level	*AD and EF of Art.3.3 activities (af-/reforestation, deforestation); influenced ADs: areas of af-/reforestation and their stratification* *AD and EF of those Art.3.4 activities and in those countries that have chosen any of the following Art.3.4.activities as to be accounted under the Kyoto Protocol: forest management, cropland management, grazing land management, revegetation; potentially influenced ADs and EFs: areas of forest land, cropland, grassland, their management and their land-use-changes; growth and harvest rates, C stock changes in soil and dead organic matter pools* *Elected Art.3.4-activities for the first commitment period have to be also accounted in the following commitment periods*
	Post-Kyoto-Protocol-Decisions for the second commitment period	Decision2/CMP7 (Durban Decision on LULUCF) *and related EU decisions*	*AD and EF of Art.3.3 activities (af-/reforestation, deforestation) in the second commitment period; influenced ADs: same as for Art.3.3 activities in line above* *AD and EF of forest management (including harvested wood products) in the second commitment period; influenced ADs and EFs: areas of forest land and its land-use-changes; growth and harvest rates, C stock changes in soil, dead organic matter pools and harvested wood products* *AD and EF of those activities and in those countries that have chosen any of the following activities as to be accounted in the second commitment-period: cropland management, grazing land management, revegetation, wetland drainage and rewetting; potentially influenced ADs and EFs: areas of cropland, grassland and peat land, their management and their land-use-changes; growth and harvest rates, C stock*

			changes in soil and dead organic matter pools; peat extraction activities
			The implementation of this decision at EU level (a related EC proposal for an EU decision on LULUCF) is currently under negotiation. The outcome is not yet clear and may cause some deviations or further obligations with respect to LULUCF.
	20/20/20 target of the EU climate and energy package	EU climate and energy package	AD and EF in various LULUCF subcategories; potentially influenced ADs and EFs: areas of forest land, cropland, grassland, their management and their land-use-changes; growth and harvest rates, C stock changes in soil and dead organic matter pools
	EU Directive on the promotion of the use of energy from renewable sources	Directive 2009/28/EC	AD and EF in various LULUCF subcategories; potentially influenced ADs and EFs: areas of forest land, cropland, grassland, their management and their land-use-changes; growth and harvest rates, C stock changes in soil and dead organic matter pools
Forestland, cropland, grassland	Council Regulation on support for rural development by the European Agricultural Fund for Rural Development	Council Regulation (EC) 1698/2005	AD and EF in forest land, cropland and grassland; potentially influenced ADs and EFs: areas of forest land, cropland, grassland, their management and their land-use-changes; growth and harvest rates, C stock changes in soil and dead organic matter pools But, implementation is in the nations and related PAMs in the member states may vary in wide range from country to country.
Cropland, grassland	Council Regulation on organic production and labelling of organic products	Council Regulation (EC) 834/2007	AD and EF in cropland and grassland under organic production; potentially influenced ADs and EFs: areas of cropland and grassland, their management and their land-use-changes; C stock changes in biomass and soil
Cropland, grassland	Council Regulation establishing common rules for direct support schemes for farmers under the common agricultural policy and establishing certain support schemes for farmers	Council Regulation (EC) 73/2009	AD and EF in cropland and grassland; potentially influenced ADs and EFs: areas of cropland and grassland, their management and their land-use-changes; C stock changes in biomass and soil
Cropland, grassland	EU agricultural policy for 2014 to 2020	Several related regulations and directives under negotiation	AD and EF in cropland and grassland; potentially influenced ADs and EFs: areas of cropland and grassland, their management and their land-use-changes; C stock changes in biomass and soil

The Kyoto-Protocol itself, the related decisions (both at UN- and EU-level) and the implementation by parties (e.g. enhanced af-/reforestation activities, election of voluntary Art.3.4 activities) represent incentives for related national PAMs to influence the land management in the obligatory or chosen activities. The implementation varies from country to country, according to the elected activities, but also with respect of the type of measures that were implemented (from no measures, direct subsidy payments to land owners to broad national programs). For instance, several countries started af-/reforestation programs to facilitate the meeting of the Kyoto-Protocol emission reduction targets. It is clear that the measures will have an impact beyond the Kyoto-Protocol period and will also have an influence on the future emissions/removals in the related LULUCF subcategories. With the LULUCF Durban decisions (UN-FCCC 2011, Decision2/CMP7) the rules for LULUCF were changed which will likely cause also a change of the impact on the future emissions/removals of LULUCF activities or subcategories.

Forest management (together with the harvested wood products pool) has become obligatory to be accounted in the second commitment period. The achieved emissions/removals for this activity are no more accounted on a gross/net basis, but in comparison to a reference level (less removals or higher emissions than the reference level are accounted as emission, more removals or less emissions than the reference level as removals) and with an additional cap. The reference level itself represents a national projection of the future emission/removals of forest management and the harvested wood products pool for the period 2013-20 under business as usual (PAMs) until December 2009.

A further voluntary activity (wetland drainage and rewetting) can be elected to meet the reduction targets of the second commitment period (beside, cropland management, grazing land management, revegation).

Both decisions, those for the first and second commitment period, and their national implementations shall be taken into account for projections of the future LULUCF emissions/removals. The impact may differ from country to country. For instance, with respect to forest management the accounting framework tends to focus on the emissions and removals in forest land and in the harvested wood products pools. But, several countries (e.g. Finland, Germany, Switzerland) meanwhile made a more comprehensive assessment of the effects of the whole wood chain from the forest site to the avoided emissions (in other sectors) due to the use of forest/wood products on the national GHG balance in order to have a better basis for the derivation of measures to improve the national GHG balance. Depending on the national circumstances the range of measures in the member states may go even in opposite directions with respect to the impact on the trend of emissions/removals of forest management.

So, it is crucial to take the national circumstances into account when assessing the impact of these international decisions on the LULUCF GHG balance of the individual member states.

The election of any further activities makes a difference as well, how countries will initiate measures in those sectors to improve their greenhouse gas balance.

Further cross cutting decisions are the 20/20/20 target of the EU climate and energy package and the EU Directive on the promotion of the use of energy from renewable sources (Directive 2009/28/EC). Both PAMs may have rather different outcomes in the individual countries with respect to the emissions/removals in several subcategories. Again, the national implementation of these legislative instruments needs to be taken into consideration for an accurate assessment of their impact on the future national LULUCF emission. A few examples of conflicting measures may highlight the broad range of possible outcomes. It is evident that there is a certain degree of contradiction between enhancing or keeping past removals in the forest land and the goal to increase the share of wood in energy supply[37]. Or, an incentive towards the construction of hydroelectric power plants due to the 20/20/20 target represents also an incentive for related LUCs and emissions at such lands. Or, the demand for biofuels may be connected to management changes in forest land, cropland and grassland or have an impact on related LUCs (e.g. short rotation plantation vs. sustainable forest management, intensification of forest, cropland and grassland management with related changes in the LULUCF emissions/removals at the sites). For instance, intensification of cropland management and a higher use of organic residues for the purpose of energy supply could lead to carbon loss in soil. Or, the use of wood for energy supply competes with the use of wood for other purposes (or with the cascade use of wood) under reasons of immediate demand and timely provision. So, it is rather difficult to assess the impact of these decisions on the future emissions/removals in LULUCF. A thorough survey through national PAMs of implementation of these EU decisions is needed for a correct assessment of the impact in the single member states.

The same is true for the listed EU regulations with respect to agriculture in Table 54. They represent a framework for PAMs in the member states on the cropland and grassland management, but their implementation and the related economic conditions and setting of priorities is very much up to the national or regional level. Nevertheless, they give some general incentives that may have a common impact in all countries. For instance, EC 73/2009 (with relation to the former EC 1728/2003) promotes the maintenance of permanent pasture. Regulation EC 834/2007 provides a common frame for organic agriculture. Council Regulation 1698/2005 gives the basic principles for subsidy payments of rural development measures (e. g. agri environment measures) in the EU member states. Currently the legal proposals for a reform of the European common agricultural policy 2014-20 are under negotiation (e.g. "greening the first pillar"). Several decisions may have a direct or indirect impact on the future emissions/removals in the LULUCF sector.

International nature or landscape protection decisions were not listed in Table 54 but may have also a direct or indirect influence on the future LULUCF emissions/removals and need therefore to be taken into account when dealing with projections on LULUCF emissions. A realisation of certain desired projects or changes in land use or land management practices may be in conflict with such international conventions and therefore unlikely to be realised. Examples for such international protection categories are areas under the Ramsar Convention, Natura 2000 areas, UNESCO world heritage regions and national parks.

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[37]   Böttcher, H., P J Verkerk, M Gusti, P Havlik, G Grassi (2012) Projection of the future EU forest CO2 sink as affected by recent bioenergy policies using two advanced forest management models. Global Change Biology – Bioenergy doi: 10.1111/j.1757-1707.2011.01152.x

The assessment of the impact of PAMs, international and national, on future LULUCF emissions fails to lead to correct conclusions if the fundamentals and most important determinants for land management and their national shapings are not taken into account. These are income, provisions of related goods and/or basic non-economic services (e.g. protection from natural dangers like avalanches and mudflows - see for instance the elements of sustainable forest management), space (e.g. for building measures).

4.3   Grades and Decision Tree

The following two decision trees should be run individually for each LULUCF subcategory and pool, according to the further stratification of the subcategories that is used for the historic emission/removal estimates and with respect to the biomass pools for both, biomass gains and losses (increment and drain).

Decision tree for LULUCF activity data (AD) projections:

Figure B.4-1 presents a generalized decision tree for selecting grades for future activity data for LULUCF sector.
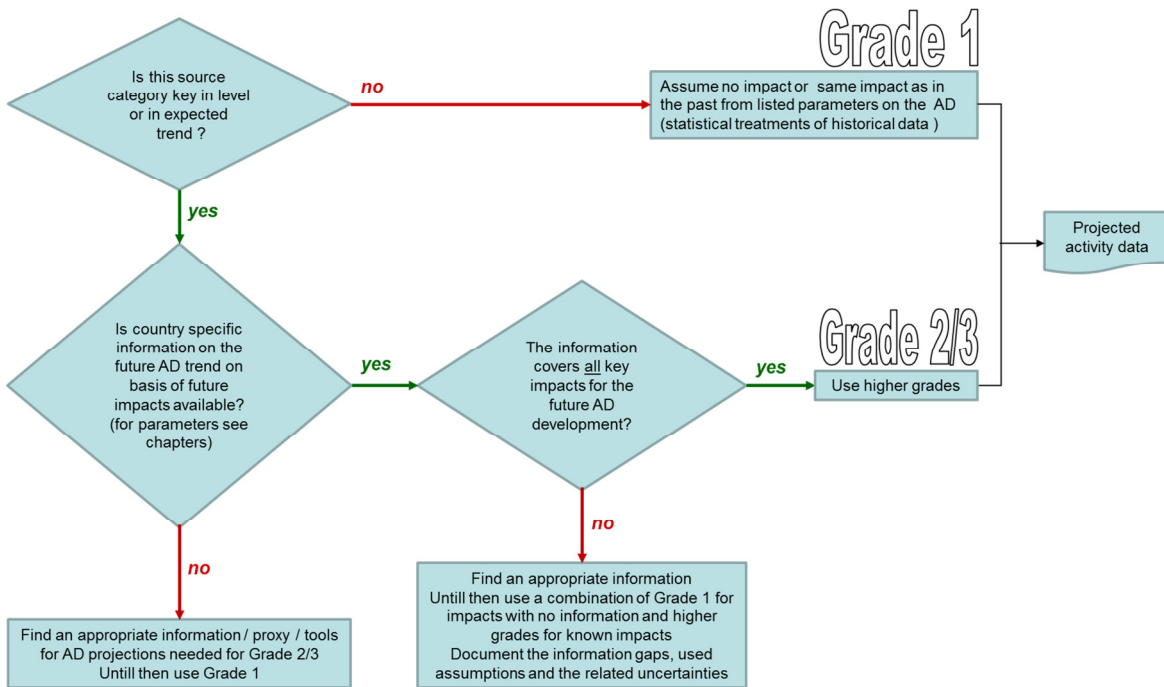
Figure B.4-1 Generalised decision tree for future activity data for LULUCF.

Decision tree for LULUCF emission factor (EF) projections:

Figure B.4-2 presents a generalized decision tree for selecting grades for future emission factors for LULUCF sector.

Grade 1

Is this source category and C pool key in level or in expected trend ?

no

Assume no impact or same impact as in the past from listed parameters on the Efs (statistical treatments of historical data)

yes

Projected emission factors

Were historic emissions/remo vals estimated with higher tiers?

yes

Is country specific information on the future EF trend on basis of future impacts available? (for parameters see chapters)

yes

The information covers all key impacts for the future EFs development?

yes

Grade 2/3

Use higher grades

no

Collect country specific information to estimate historic emissions with higher tiers
Untill then use Grade 1 projections

no

Find an appropriate information / proxy / tools for EFs projections needed for Grade 2/3
Untill then use Grade 1

no

Find an appropriate information Untill then use a combination of Grade 1 for impacts with no information and higher grades for known impacts Document the information gaps, used assumptions and the related uncertainties

Figure B.4-2 Generalised decision tree for future emission factors for LULUCF.

The logic/meaning of the decision trees can be understood in the following manner: A prerequisite for a possible use of higher grade methods for projections is both, the use of higher tier methods for the historic LULUCF emissions/removals estimates and the availability of information/tools to carry out higher grade LULUCF emission/removal projections. Without a more appropriate method for estimating the country specific historic LULUCF emissions/removals, the basic country specific knowledge for the projections of these emissions in a higher grade quality will be also lacking. On the other hand, if a country used higher tier methods for the historic emissions but has no idea on the future development of the AD and EF due to a lack of information or projection tools, it may not be able to provide more accurate projections than a country that used for historic and projected emissions tier 1/grade 1 methods. Emissions and removals in the LULUCF sector may change considerable within a short period of time. So, an equal treatment of such two countries with respect to the grade categorization is fair.

4.4   A general grade 1 approach for LULUCF emission/removal projections

In the following a grade 1 method for AD and EF projections is proposed. The grade 1 methods represent statistical treatments of historical data that allow each country to provide a complete set of projections for each LULUCF subcategory and pool. The only prerequisite is complete reporting of historic LULUCF emissions/removals under the UN-FCCC and Kyoto-Protocol.

4.4.1   Grade 1 activity data projections

The 2003 IPCC GPG on LULUCF and the 2006 IPCC guidelines on AFOLU distinguish between three different methodological approaches to derive areas for land-use, land-use change and forestry. This

may be adequate for the compilation of historic AD, however the quality of information available for projections may be different. AD projections may range from mere extrapolations of historic AD to sophisticated predictions of future land use under the expected or planned change of various impact parameters. Therefore, a graded approach for AD projections is proposed here.

It is important to start the grade 1 AD projections with the same AD approach according to the 2003 IPCC GPG on LULUCF as used for the derivation of historic land-use data. For instance, if a country estimated its historic AD figures with approach 1 (total areas of land-use categories across time are used), it should start the grade 1 projections with approach 1 (step 1). Alternatively, step 1 of a country should be the projections of the land-use-change areas if approach 2 was used for its historic reporting of ADs (information on the historic LUC between land use categories was used). The future areas of the complementary subcategory (total area of the subcategory or area of the LUC-subcategory, respectively) should be estimated in step 2 by starting from the last reported historic area of this complementary subcategory and consistent with the already projected areas of step 1. These estimates and adjustments should result in a consistent LULUCF matrix where the annual changes of subcategory totals across time are covered by related land-use changes. In the end, the sum of all subcategory areas should result exactly in the total area of the country.

Frequently, countries use a mix of the three IPCC approaches to get a consistent and complete historic land-use-land-use-change statistic for their territory. In this case, the AD subcategory projection should use the approaches that have been used historically. The projection should always start at those land-use or land-use-change subcategories with more accurate historic data (based on more accurate surveys and statistics). The projections should continue then stepwise through the next subcategories corresponding to the decreasing quality of the historic AD estimates. These area projections should be done in a manner that leads to a consistent and complete land-use-land-use-change statistic for all individual years of the projection period.

There are two alternatives of grade 1 AD projections proposed:

Alternative 1:

Use the average historic annual rate of AD of the subcategory for the last ten years as future AD for the projections. This alternative can be used if significant past trends in AD data do not exist or are not expected to continue in the future. Particularly areas of land-use-change can change considerable within a time series. The use of the average of the past ten years is therefore recommended as a more robust figure for the projections (instead of the AD figure of the last historical reporting year).

Alternative 2:

Use the trend value or trend function for AD projections. This alternative can be used if 1) there is a statistically significant trend for the known historic annual rate of AD data in the period before the projection (amount of years for trend detection can be variable) and 2) it is expected from expert judgement (without using methods of higher grades) that the trend will continue. These two points should be transparently explained when using this alternative.

A party may in fact require the use of both alternatives to derive a complete LULUCF AD statistic.

For consistency a party should maintain the same level of stratification as that used in the national inventory.

Therefore, grade 1 AD projections should also cover those historically reported LULUCF subcategories the AD of which were not taken directly out of statistics or assessments, but indirectly on basis of AD for other subcategories and on basis of assumptions from logic. The same approaches/assumptions as for the historic AD should be used for such LULUCF subcategories, but adjustments are eventually needed according to the "availability" of area for other subcategories after the AD projection of historically well-known subcategories. This qualitative difference between the projected areas of subcategories should be described transparently.

The 2003 IPCC GPG on LULUCF allows the use of the subcategory "Other Land" to meet exactly the total area of the country. The same approach could be used for the projections when necessary as a last resource. However, care should be taken that the land brought in that way under this category does not conspicuously and unrealistically deviate from reported historic area data on "Other land".

The LUC matrix tables as demonstrated in the 2003 IPCC GPG on LULUCF facilitate AD projections in a consistent manner. Similar tables where the individual areas of the LULUCF subcategories are listed across time together with control estimate lines (or columns) may be helpful. In these control estimate lines (or columns) the resulting total changes from all inserted or estimated LUC areas can be checked against the related change of the total area of a subcategory between two years.

4.4.2 *Grade 1 emission factors projections*

The emission projections could be in principle carried out on basis of the historic emissions/removals, without any additional AD projection. However, historic AD data may have a different trend than the historic EFs. Therefore, a separate projection of AD and EF may result in more appropriate projections of the future emissions/removals.

The emission/removal is the result of AD times EF. AD in LULUCF are mainly areas of subcategories and the grade 1 method for projections is described in chapter 4.1. The future EF needed for the projections are on a per area unit basis (e.g. EF per ha). Area specific EFs are estimated automatically in the CRFs for historic LULUCF reporting as "implied emission factors" (IEF). These IEFs for the single reporting years can be taken out from the historic CRFs for each subcategory and C pool and used for the grade 1 projections of EFs according to the following two alternative approaches.

Corresponding to the grade 1 AD projections, two alternatives of grade 1 EF projections are proposed:

Alternative 1:

Use the average historic IEF of the subcategory and pool for the last ten years as future EF for the projections. This alternative can be used if significant past trends in EF data do not exist or are not

expected to continue in the future. Particularly, the IEF can vary considerable within a time series. Reasons may be the yearly variations in weather and growth conditions or disturbances like storm felling's. The use of the average IEF of the last ten years for the projections (instead of the use of the IEF of the last historic reporting year) is therefore more robust .

Alternative 2:

Use the trend value or trend function of historic IEFs as EF projection. This alternative can be used if 1) there is a statistically significant trend for the known historic IEF in the years before the projection period (number of years for trend detection can be variable) and 2) according to expert judgement (without using methods of higher grades) the trend will continue. These two points should be transparently explained when using this alternative.

A party may in fact require the use of both alternatives to derive future EFs.

For land-use change categories the IEF of living biomass and dead organic matter (DOM) could be meaningless when for the land-use change category losses or gains of stocks are not constant for the whole conversion period. In such cases, an improved method could be to first stratify the land according to "age of conversion" and then building the projection age-class by age-class.

Each individual EF should be projected with such grade 1 methods (for instance both, the EFs for biomass gains and for biomass losses). This may lead to more appropriate projections than the use of an average EF across several pools or subcategories.

Even a further stratified projection may be useful for certain subcategories or pools. LULUCF EFs are frequently the result of several variables that are combined (e.g. volumes, densities, expansion factors, root/shoot ratios, C contents). An examination of these individual variables may give evidence some were changing historically according to a trend while others remained stable or changed in a different manner. A more stratified projection of the single variables for the derivation of the EF may lead to more accurate EF projections.

For consistency a party should maintain the same level of stratification as that used in the national inventory.

As indicated above, grade 1 emission projections of the LULUCF category or LULUCF subcategories may be the result of different combinations of these grade 1 AD and EF projection alternatives depending on the historic (and expected future) trend of ADs and EFs.

4.5   Higher grade projections

The following chapters show that almost all of the higher grade projection methods need as prerequisite that the historic AD, EF and/or emissions/removals of the LULUCF sector were estimated also with higher tier methods. So, if such approaches were not or could not be used for the estimates of historic AD, EF and/or emissions, grade 1 projection methods should be used. Exemptions of that general principle may be based on the availability of new data, new information

for projections or new projection tools that allow higher grade projections independent from historic data. However, time series consistency with historic figures should be secured also in such cases.

The Guidelines for Annex I National Communications[38] provide very general, but limited guidance for making projections, and should be followed also for the LULUCF sector projections. It should be also noted that the methodologies for estimates (e.g. approaches, equations, EFs) as laid down in the 2003 IPCC GPG on LULUCF and 2006 IPCC guidelines on AFOLU are equally valid for the LULUCF projections. Consistency reasons request that. Therefore, they are not repeated in the following chapters, but the information in these chapters must be interpreted in connection with the methodologies as described in these two IPCC documents.

Nevertheless, methodologies for projections may cause a drop out of certain approaches in the IPCC guidelines because - as a matter of fact – projections cannot build on measurements but only on tools that allow forecasts. On the other hand, further information on possible impacts on the variables for the estimates is required for accurate projections. Such information goes beyond the needs for estimates of historic emissions. Higher grade projections are often using empirical or process-based models. These elements, specific approaches, tools and information for higher grade projections, are described in the following chapters.

4.5.1   *Forest land remaining forest land (5.A.1)*

4.5.1.1   Activity Data

Grade 2 and Grade 3

Higher grade methods in activity data projections of subcategory 5.A.1 are all approaches that go beyond the extrapolation of trends or averages as described in chapter 4.4.10. A prerequisite for such higher grade methods for the derivation of the future area of "forest land remaining forest land" is the availability of sound historic data on forest land and on the LUC areas to forest land (subcategory 5.A.2) and a resolution of the historic activity data in line with higher tier methods according to the 2003 IPCC GPG on LULUCF. After the IPCC GPG default transition period of 20 years 5.A.2 areas move to the sub category "forest land remaining forest land". So, the future change in the area of 5.A.1 is particularly dependent on the amount of such LUC areas to forests in the past. Besides, also information that allows a projection of future activities of such LUCs is needed if the projection period goes beyond 20 years. Such specific information for long time projections on LUC to forest land may be regional or national long time plans for af-/reforestation or specific information on future activity changes in other land management categories that lead to forests (for instance, stop in agricultural management due to economic reasons, abandonment of lands, etc.).

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[38]   UN-FCCC 2000: Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part II: UNFCCC reporting guidelines on national communications. http://unfccc.int/resource/docs/cop5/07.pdf

The second reason for future changes in the area of 5.A.1 is LUC from forests to other land uses. Such LUCs lead immediately in the year of LUC to a loss of area of 5.A.1. Higher grade projection methods for the area changes of 5.A.1 should therefore take into account any information on the future demand of forest land for other land uses. Driving forces for such LUCs may be the demand for settlement or wetland area. But frequently, also conversions to grasslands or croplands represent significant reasons for forest land losses. Any information that allows more specific estimates for such future LUCs from forest lands to other land uses beyond extrapolation of historic trends or beyond the use of historic averages should be taken into consideration when using higher grade projection methods for the area changes of 5.A.1. Such information may be based on related political programs or decisions, documents of spatial planning, major infrastructural or construction plans, legal provisions such as forest acts and natural protection acts, etc.

So, the dependence of changes in one land management category on the future development of other land use categories ideally requires also a broad survey of potential future reasons for changes in the areas of linked land use categories. Higher grade projection methods shall take that into account.

Time series area consistency is needed with respect to the change in area of 5.A.1 and the LUC areas to and from forests. In addition, the same disaggregation as for historic reporting is needed. A division into managed and unmanaged forestland consistent with the historic reporting is needed because emission/removal estimates and projections are only requested for the first type

4.5.1.2   Biomass

Equally to the estimates of historic emission two basic concepts may be used for projections of the biomass changes in 5.A.1, the default method (increment minus drain) or the stock change method. The methods are described in detail in the 2003 IPCC GPG on LULUCF and 2006 IPPC guidelines on AFOLU.

Particularly for the projections of biomass changes in 5.A.1 higher tier estimates of historic emissions of this pool are needed as prerequisite. In many countries higher tier methods for the estimates of this pool are already realized and frequently there is also such an obligation due to the significant contribution of this pool (subcategory) to the total GHG balance of the country (key category).

The future change in 5.A.1 area projected with higher grades is taken into account for any of the higher grade projections.

The same stratification and time series consistency with the estimates on historic 5.A.1 biomass changes is needed for the projections.

The country specifics for biomass growth and harvest as described below suggest that for each country the most appropriate tools are used for the projections. A uniform model that simulates well for each country does not exist. Nevertheless, there are elements that could be harmonised for all countries before the projections are carried out (beside the common inspection of the same impact parameters, as listed below). The future trend of the global wood prices could be projected for all countries and then taken by the member states for their own projections. Nevertheless, also this

general trend would need then to be converted into future country specific wood prices and trends, due to the impact of the available species and assortment compositions and domestic impacts on the wood prices (like specific offer and demand structures). The local situation may be also rather independent from the global one, particular for countries with no or a low export of wood or without a significant wood based industry. It should be also noted that situations exist where the wood price is not at all a determinant for forest management operations – examples are given below.

Forest management operations (e.g. biomass harvest) are correlated to the change in the pool of harvested wood products and are also linked to the projected future use of domestic wood as biofuel. As a consequence, consistency of the projections of wood harvests and their assortment with the assumed future change of the harvested wood products pool (chapter 4.5.19.1) but also with the expected use of domestic wood as bioenergy is needed (indirectly influencing the emissions in the energy sector).

Grade 2

Grade 2 methods use specific information to adjust historic biomass growth/harvest rates or stock changes derived with higher tier methods to projections of such changes or estimate them directly. Such information may be, for instance, a change in the growth rates according to expected changes in the species and/or age composition of the growing stocks (for instance due to a change in forest management or due to the historic age distribution). With respect to biomass losses there are several potential impact parameters that may have an influence on the future harvest rates, like the wood prices, the harvest costs, the age or DBH and species composition of the forests with respect to the availability of timber economically attractive for extraction (e.g. timber assortments), demand for wood, the access to the forests for harvest operations, limitations due to nature or other protection targets. Several international and national PAMs exist that have an influence on the future harvest rates. Higher grade methods should take them into account for the projections. Frequently, these are national, regional or forest enterprise specific programs. It is therefore needed to take the specific national expertise for the projections into account. Also the ownership structure and the related motivation for harvest of wood differ from country to country (e.g.: from small forest ownership to big enterprises; from owners living by the income of the forests to owners who are economically independent from selling of forest products).

Grade 2 methods take any such available information into account to derive more specific projections of the biomass changes. Since the available information is frequently based on or related to stem wood, the same tools/methods as for the estimates of historic biomass changes must be taken into account for the projections (see 2003 IPCC GPG on LULUCF and 2006 IPPC guidelines on AFOLU). Grade 2 methods assess the impacts on the future growth and harvest rates or stock changes of stem wood also with respect to their influences on changes in the conversion/expansion ratios to t C of total above and belowground biomass. Changes in the species and age composition of increment and harvest or stocks in the projected years are relevant here.

Grade 3

Grade 3 methods use sophisticated tools that allow accurate projections on basis of detailed information on impact parameters on the future growth and harvest rates or stock changes. Growth and yield models are typical tools for such Grade 3 projections, often connected with an economic tool to predict the wood prices, rarely ecological or process based models are used for such purpose. Plenty of such models exist, for several species (tree level), forest types (stand level) and growth regions in the world. Frequently they were derived on basis of empiric results from forest inventories or long time monitoring plots and according to a number of assessed management regimes. The prerequisites as described in chapter 4.7 must be fulfilled before the models can be used for the regional conditions under consideration. Models developed on the own local or regional data/conditions should be given preference.

The models request several data and input variables. These are species, age or DBH composition of the forests in a detailed resolution according to climate or growth regions, information that is only available on basis of forest inventories. Silvicultural treatments as well as economic input variables like wood prices and harvest costs, eventually also climate and ecological site characteristics, are further input variables that are key to use the models. Most accurate results can be expected when the models are run at site resolution (e.g. for each site of a forest inventory grid) and the results are aggregated and extrapolated then afterwards.

It is important to note that even sophisticated models may not account for all parameters that are crucial for the future increment and harvest rates. For instance, a lack of access to forests which will reach DBHs attractive for harvest operations may cause that model predicted harvest rates will not happen. Nature or other protection measures/targets may cause a deviation to future harvest rates according to the model results. Or, incentives due to PAMs may change the circumstances for forest management and cause deviations from the pure model results of future harvest rates. The ownership structure and their specifics may cause deviations from any purely economically motivated forest management as frequently inherent in growth and yield models on basis of forest composition, silvicultural treatments, wood prices and extraction costs (e.g. forest owners who are not living by the forests may have rather different motivations for forest management, like own fuel wood supply, hunting or understanding the forest as a saving for times of higher financial needs). Grade 3 projection methods take such influences into account. Particularly this kind of knowledge is frequently only available in national expert institutes. Therefore, it is recommended that higher grade projections for forest biomass changes are carried out by national expert institutes or at least in a very close cooperation with those to clarify and quantify all such possible impacts.

Grade 3 projections are specific for the individual calculation steps to the t C of total above- and belowground biomass growth, drain and/or stock change. This means specific projections for the future conversion/expansion ratios from stem wood to total above- and belowground biomass consistent with the expected changes of future growth and drain rates or stock changes and their composition (e.g. in species and age).

4.5.1.3   Dead organic matter

Grade 2 and Grade 3

Litter (in sense of the 2003 IPCC GPG on LULUCF) is treated together with the soil pool (chapter 4.5.1.4) because the higher grade tools for projections are the same. Frequently these tools don't provide separate results for the humus layer and the mineral soil. So, in this chapter only the dead wood pool is treated.

Higher grade methods integrate specific information on the future trend of the dead wood pool on basis of higher tier estimates of the historic stocks and stock changes. For instance, specific PAMs may exist to promote a certain amount of dead wood in the forests due to biodiversity reasons. Alternatively, a country may have already the recommended amount of dead wood for such target in its forests so that lower or no more increases in the dead wood pool may be expected for the future. Also opposite PAMs may exist that let expect a future decrease of dead wood due to the rising demand for wood or due to economic reasons. Expected future changes in the forest management regimes and in the disturbances may be further reasons for changes in the dead wood pool that differ to those in the past. Steady increases or decreases in the stand density due to the forest management in place can be reasons for future changes in the dead wood pool.

Grade 3 projection methods on dead wood stock changes use modelling on basis of forest inventory information. Ideally, the models and tools to estimate the forest biomass stock changes (chapter 4.5.1.2) have also a submodel/subtool for tree mortality so that the estimates for the future biomass stock changes and for the dead wood stock changes can be carried out together.

4.5.1.4   Soil and litter

Grade 2

Tier 2 as described in the 2006 IPCC guidelines on AFOLU can be used also for projections. The prerequisites for using this approach for projections are the same as for historic reporting (see 2006 IPCC guidelines on AFOLU) - more or less, the availability of country specific soil C stocks for the most frequent forest types, soil types, climate regions and management regimes and related C stock change factors for changing from one management (disturbance) regime to another. In a next step, projections for the future changes of the forest management types and forest types and the related areas can be estimated in the stratification as listed above. On basis of these data and on basis of the related soil C stocks and soil C stock change factors projections for the future soil/litter C stock changes can be carried out using the Tier 2 equations.

Grade 3

Grade 3 projection methods on soil C stock changes including humus layer ("litter" according to the 2003 IPCC GPG on LULUCF) request the use of soil models. Several of such models exist (e.g.

CENTURY, CoupModel, Forest-DNDC, Q, ROMUL, RothC, Yasso07, see for instance compilations in Peltoniemi et al. 2007[39], Manzoni and Porporato 2009[40]) and some of them are also used to estimate the soil C stock changes in historic years for reporting under UN-FCCC. Some of them are soil C models only and some are plant-soil models. The information required for running the models depends on the model. Basically, data for the future C flux to the soil and for its composition is needed for such projections (as derived for instance on basis of projections for the litter fall and dead roots input according to the future biomass stocks and composition of the forests and on basis of the future harvest residues input due to the expected forest management operations). Also information on climate variables in the projection years in different resolution is needed. Further information on site and soil variables may be prerequisites for running the models. A sufficient fine stratification is needed according to climate types, soil types and forest and forest management types. Most accurate is to model in site resolution (e.g. for each site of the forest inventory grid) and aggregate the results to regions afterwards. The stratification must be consistent with the reporting of historic figures.

Not necessarily, estimates for the historic soil C stock changes are needed to run model projections for the future soil C stock changes. Nevertheless, for time series consistency in reporting historic and future emissions/removals from 5.A.1 such historic estimates are required. Therefore, such model projections make only sense if on basis of available input data also the historic emissions/removals from soil/litter of 5.A.1 can be estimated.

The use of the soil models for projections request the fulfilment of prerequisites as described in chapter 4.7.

Organic soils

Higher grade projections on the C stock changes of drained organic soils estimate the projected emissions with higher grade activity data projections and country specific emission factors. Grade 3 methods represent modelling approaches on basis of projections for activities likely to alter the hydrological regime, surface temperature and vegetation composition of organic soils.

4.5.2   Land converted to forest land (5.A.2)

4.5.2.1   Activity Data

Grade 2 and Grade 3

Higher grade projections on LUC areas to forest lands go beyond the extrapolation of historic trends or beyond the use of historic means for future years (grade 1, see chapter 4.4.1). They should take

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[39] Peltoniemi, M., E Thürig, S M Ogle, T Palosuo, M Shrumpf, T Wützler, K Butterbach-Bahl, O G Chertov, A S Komarov, A V Mikhailov, A Gärdenäs, C Perry, J Liski, P Smith, R Mäkipää (2007): Models in country scale carbon accounting of forest soils. *Silva Fenn.* 41: 575-602.

[40] Monzoni, S., A Porporato (2009): Soil carbon and nitrogen mineralization: Theory and models across scales. *Soil Biology and Biochemistry*, 41: 1355-1379.

into account any available information that allows more specific forecasts of the future conversions into forest land. Such impact parameters may be regional/national policies and measures that promote afforestation programs but also future incentives to convert or stop the land management in other land use categories with the consequence that forests will develop at such lands. For instance, the Kyoto-Protocol as such represented an impetus for afforestation programs in several countries. This may continue in the future with the related follow-up decisions. Also on basis of the European 20/20/20 program and its incentive for the demand of bioenergy an increase in af-/reforestation may be possible. On the other hand, there may be also desired limitations to a continued increase in forest land, for economic reasons, for securing the supply of food or for the landscape/nature protection (e.g. to prevent further "darkening" of the landscape in forest rich countries). On basis of such information on future programs, incentives and limitations more specific predictions for the future LUC activity to forests may be derived.

As for the estimates of historic emissions according to the 2003 IPCC GPG on LULUCF, higher grade projection methods for LUC areas to forest land should be specific with respect to the previous land use categories. Grade 3 projection methods should allow for a further disaggregation along climate, soil and vegetation types.

Time series consistency with the derivation of historic LUC areas is needed, particularly since the projected total area of the LUC category represents a transition period of 20 years (by default) and includes therefore also historic areas of such LUC. The same stratification as for the historic reporting is needed also for the projections.

It is important to distinguish the areas of this subcategory into lands without human intervention (changes from unmanaged land of any other category to unmanaged forestland) and lands with a previous and/or following management. Only for the second type emissions/removals and, as a consequence, projections are needed.

4.5.2.2   Biomass

Grade 2

Grade 2 methods use country specific forecasts of the emission/removal factors due to biomass changes at LUC lands to forests. The approach follows closely the related Tier 2 method for the estimates of emissions/removals according to the 2003 IPPC GPG on LULUCF and 2006 IPCC guidelines on AFOLU, but uses projections of (activity data and) emission factors instead. On basis of the higher grade activity data projections and according to their stratification (chapter 4.5.2.1), country specific losses of biomass due to the conversion (biomass stock immediately before LUC), related country specific growth rates and losses due to biomass drain (harvest and other losses within the transition period) at such lands are estimated for each of the subunit. Projections on these EFs and emissions are carried out on basis of historical EFs typical for each of the conversion type, but adjusted according to the expected future changes due to available information (e.g. changes in the growth rates at future 5.A.2 lands due to differences of the site conditions at the projected 5.A.2 lands, different species composition etc. compared to the historic LUC lands). Projections and adjustments of the EFs integrate also specific projections for all conversion/expansion steps from the volume of stem wood to the t C of the total plant (above and belowground).

Grade 3

Grade 3 follows the same approach as Grade 2 but uses solely country specific projections of the EFs, eventually based on models. EFs and emissions are projected disaggregated according to the Grade 3 AD stratification (see chapter 4.5.2.1). Models are typical tools for Grade 3 projections: Future growth (and drain) rates at the 5.A.2 lands can be estimated on basis of suitable models taking the specifics of the future LUC lands into account (e.g. climatic variables, site conditions, species composition, forest management).

4.5.2.3   Dead organic matter

Grade 2 and Grade 3

Dead wood

In most cases, no presence of dead wood can be expected before conversion to forest land, except maybe at "other land" before conversion to forest land. Country specific changes of the dead wood pool at the future 5.A.2 lands are estimated for the projected 5.A.2 lands, stratified according to the information in chapter 4.5.2.1. The EFs can be based on historic ones but need to be adjusted for the expected changes in the future activity and related conditions. Model based projections with mortality tools represent a typical Grade 3 approach.

Litter

Litter (in sense of the 2003 IPCC GPG on LULUCF) is treated together with the soil pool (chapter 4.5.2.4) because the higher grade tools for projections are the same. Frequently these tools don't provide separate results for the humus layer and the mineral soil. So, in this chapter only the dead wood pool is treated.

4.5.2.4   Soil and litter

Grade 2 and Grade 3

The methods follow the 2003 IPPC GPG on LULUCF and 2006 IPCC guidelines on AFOLU. Higher Grade methods project the future litter and soil C stock changes on basis of Grade 2 and Grade 3 AD projections, respectively, and on basis of country specific litter and soil C stocks of the previous and following land uses together with country specific adjustment factors if needed ($f_{forest\ type}$, $f_{main\ intensity}$, $f_{dist\ regime}$). This is carried out according to the AD stratification as described in chapter 4.5.2.1 depending on the projection grade that is used. Grade 3 methods use litter and soil C stock information from countrywide soil inventories. Soil C stocks change usually very slowly. So, the use of historic soil C stocks for the projections of the changes may be adequate. Nevertheless, adjustments of the average historic litter and soil C stocks of the previous and following land uses and of the historic adjustment factors (if needed) of the 5.A.2 subunits should be made on basis of any available information for expected future changes before they are used for projections (e.g. due to deviations in the vegetation, soil or climatic conditions, in the forest management of each projection subunit compared to its corresponding historic subunit).

Recently, also models are used to estimate soil C stock changes of LUC lands. The prerequisites as described in chapter 4.7 must be fulfilled before such tools can be used for the local conditions.

Organic soils

The methods are the same as those of 5.A.1 (see chapter 4.5.1.4).

4.5.3 Cropland remaining cropland (5.B.1)

4.5.3.1 Activity Data

Higher grade methods in activity data projections of subcategory 5.B.1 go beyond the extrapolation of trends or averages as described in chapter 4.4.1. Higher grade projections of the area of "cropland remaining cropland" should build on the availability of sound historic cropland areas and LUC areas to cropland (5.B.2) and a resolution of the historic activity data in line with higher tiers according to the 2003 IPCC GPG on LULUCF. After the IPCC GPG default transition period of 20 years 5.B.2 areas move to the sub category "cropland remaining cropland". So, the future change in the area of 5.B.1 is dependent on the amount of such LUC areas to cropland in the past. Besides, also information that allows a projection of future activities of such LUCs is needed if the projection period goes beyond 20 years. Frequently, LUCs to cropland happen also on basis of grassland areas. Cross compliance regulations by the EU and related national/regional decisions on the protection of grasslands may reduce or limit such conversions from permanent pasture to cropland in the future compared to previous years (see chapter 4.2). Specific information for long time projections on LUC to cropland may be regional or national long time plans for conversions to cropland and programs/measures/decisions that represent incentives for conversions to cropland (e.g. demand of biofuels due to the 20/20/20 target and the Directive of Renewable Energy by the EU, see chapter 4.2).

LUCs from cropland to other land uses also determine changes in the cropland area. Such LUCs lead immediately in the year of LUC to a loss of cropland area. Higher grade projection methods for the area changes of 5.B.1 should therefore take into account any information on the future demand of cropland for other land uses. Such demand comes frequently from the need of settlement area. Conversions to forest lands and grasslands, frequently due to economic reasons, represent further reasons for cropland losses. Higher grade methods should evaluate any information on likely future changes from cropland to other land uses, such as related political programs or decisions, documents of spatial planning, major infrastructural or construction plans, forecasts on the economic development of agricultural management, prices of agricultural products and subsidy payments and their impact on the future cropland management, etc.

So, the dependence of changes in one land management category on the future development of other land use categories ideally requires also a broad survey of potential future reasons for changes in the areas of linked land use categories. Higher grade projection methods shall take that into account.

Time series area consistency is needed with respect to the change in area of 5.B.1 and the LUC areas to and from croplands. In addition, the same disaggregation as for historic reporting is needed. This

is particularly relevant with respect to the division in annual and perennial cropland since biomass changes are, according to the 2003 IPCC GPG on LULUCF, only estimated for perennial cropland. As a consequence, future conversions from annual to perennial cropland and vice versa need to be also taken into consideration for higher grade projections. Such dynamics may arise on basis of the 20/20/20 target of the EU, as a consequence of a higher demand for energy crops. The forecasts in the soil C stock changes of 5.B.1 request a stratification according to the different cropland management types and their future changes (see for instance Table 3.3.4 of the 2003 IPCC GPG on LULUCF). Higher grade projections of biomass changes of 5.B.1 request a disaggregation into different perennial cropland types eventually further stratified according to different growth conditions (climate, soil).

4.5.3.2   Biomass

Corresponding to estimates of historic emissions only changes in perennial cropland biomass are needed to be projected for the biomass pool of subcategory 5.B.1. Time series consistency with historic reporting is of particular relevance for this pool of 5.B.1 due to the frequent long time rotation periods of perennial crops – a high share of the historic perennial cropland plantations will be the one that grows also in the projection years.

Grade 2

At least some country specific C stocks at harvest, length of rotation periods and annual biomass accumulation rates of perennial crops are used together with corresponding projections in the activity data at the same scale.

Grade 3

Grade 3 methods represent highly disaggregated projections on basis of corresponding activity data and solely country specific C stocks at harvest, length of rotation periods and annual biomass accumulation rates of the different types of perennial crops. Suitable models may be used to simulate the future biomass C stock changes of perennial crops in the projection period.

4.5.3.3   Dead organic matter

Dead organic matter and litter can be assumed to not occur in most cropland systems (except agroforestry types and certain perennial cropland types). In case, the C stocks changes will be negligible and projections can be estimated with grade 1 methods (see chapter 4.4).

4.5.3.4   Soil

Grade 2

Projections on changes in the cropland management systems and in the affiliated areas (see chapter 4.5.3.1) are used together with country specific soil C stocks and/or stock change factors (F_{LU}, F_{MG}, F_I) to estimate the future emissions/removals with the same approaches as Tier 2 for estimates of

historic ones (see related chapters for soil of this subcategory in the 2003 IPPC GPG on LULUCF and 2006 IPCC guidelines on AFOLU). Soil C stocks and stock change factors change only very slowly, so it is assumed that the use of the historic ones leads also to accurate projections, provided that projection data on the subareas of the different cropland management activities and types (eventually further stratified according to climate and soil conditions) are used. Nevertheless, the soil C stocks and/or stock change factors should be adjusted for the projections if available information on their future changes allows any such adjustments (e.g. on basis of monitoring results and extrapolation of such results to the conditions of the projection period).

Grade 3

Grade 3 projections use appropriate model-based approaches on basis of country specific historic data (e.g. soil C stocks) and projected country specific changes of the driving parameters and variables (e.g. C inputs into soil, future management system, climate variables). Several models exist for that purpose (see compilations in McGill 1996[41]; Smith et al., 1997[42]; Wattenbach et al., 2010[43]). The prerequisites according to chapter 4.7 must be fulfilled before the models can be used for the projections.

Organic soils

Higher grade projections on the C stock changes of drained organic cropland soils estimate the projected emissions with higher grade activity data and country specific emission factors. The basic Grade 2 approach is the same as the Tier 2 approach for the estimate of historic emissions (see related chapters for organic soil of this subcategory in the 2003 IPPC GPG on LULUCF and 2006 IPCC guidelines on AFOLU). Grade 3 methods represent modelling approaches as for mineral cropland soils (see chapter above).

4.5.4   Land converted to cropland (5.B.2)

4.5.4.1   Activity Data

Higher grade projections on LUC areas to cropland go beyond the extrapolation of historic trends or beyond the use of historic means for future years (grade 1, see chapter 4.4.1). They should take into account any available information that allows more specific forecasts of the future conversions into cropland. LUCs to cropland happen often on basis of grassland areas. Cross compliance regulations

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[41]   McGill W B, (1996): Review and classification of ten soil organic matter models. In: Powlson, D.S., P Smith, J U Smith (eds.): Evaluation of Soil Organic Matter Models Using Existing Long-Term Datasets. Springer-Verlag, Heidelberg: pp. 111-132.

[42]   Smith, P., D S Powlson, J U Smith, E T Elliott, (eds.) (1997): Evaluation and comparison of soil organic matter models. Special Issue, *Geoderma* 81: 1-225.

[43]   Wattenbach, M., O Sus, N Vuichard, S Lehuger, P Gottschalk, L Li, A Leip, M Williams, E Tomelleri, W L Kutsch, N Buchmann, W Eugster, D Dietiker, M Aubinet, E Ceschia, P Béziat, T Guenwald, A Hastings, B Osborne, P Ciais, P Cellier, P Smith, (2010): The carbon balance of European croplands: A cross-site comparison of simulation models. *Agriculture Ecosystems and Environment* 139: 419-453.

by the EU and related national/regional decisions on the protection of grasslands may reduce or limit such conversions from permanent pasture to cropland in the future compared to previous years. On the other hand, the demand of biofuels due to the 20/20/20 target and the Directive of Renewable Energy by the EU may represent an impetus towards conversions into cropland. Information for more specific projections on LUC to cropland may be regional or national long time plans for conversions to cropland and programs/measures/decisions that represent incentives for conversions to cropland.

As for the estimates of historic emissions according to the 2003 IPCC GPG on LULUCF, higher grade projection methods for LUC areas to cropland should be specific with respect to the previous land use categories. Grade 3 projection methods should allow for a further disaggregation along climate, soil and vegetation types.

Time series consistency with the derivation of historic LUC areas is needed, particularly since the projected total area of the LUC category represents a transition period of 20 years (by default) and includes therefore also historic areas of such LUC. The same stratification as for the historic reporting is needed also for the projections. Particularly the division into LUC into annual cropland and LUC into perennial cropland is needed because both subcategories show a rather different growth in biomass.

4.5.4.2   Biomass

Grade 2

Grade 2 methods use country specific forecasts of the emission/removal factors due to biomass changes at LUC lands to croplands. The approach follows closely the related Tier 2 method for the estimates of emissions/removals according to the 2003 IPPC GPG on LULUCF and 2006 IPCC guidelines on AFOLU, but uses projections of (activity data and) emission factors instead. On basis of the higher grade activity data projections and according to their stratification (chapter 4.5.4.1), country specific losses of biomass due to the conversion (biomass stock immediately before LUC), related country specific growth rates and losses due to biomass drain (e.g. harvest of perennial cropland biomass within the transition period) at such lands are estimated for each of the subunit. Projections on these EFs and emissions are carried out on basis of historical EFs typical for each of the conversion type, but adjusted according to the expected future changes due to available information (e.g. changes in the growth rates at future 5.B.2 lands due to differences of the site conditions at the projected 5.B.2 lands, due to different cropland types etc. compared to the historic LUC lands).

Grade 3

Grade 3 follows the same approach as Grade 2 but uses solely country specific projections of the EFs, eventually based on models. EFs and emissions are projected disaggregated according to the Grade 3 AD stratification (see chapter 4.5.4.1).

4.5.4.3   Dead organic matter

Grade 2 and Grade 3

Dead organic matter and litter changes will particularly occur if these pools had a C stock in the previous land uses because most cropland types (except agroforestry types and certain perennial cropland types) can be assumed to have no such stocks. LUC lands with previous DOM stocks may be forest lands, certain wetland and "other land" types converted to croplands.

Higher grade projections use country specific EFs according to the AD stratification (see chapter 4.5.4.1). The higher grade projection approach is consistent with the corresponding higher tier approach of the 2006 IPCC guidelines on AFOLU. Historic stocks and stock change factors (gains minus losses) of dead wood and litter may be used, but should be adjusted for the projected changes of the activities and its specifics (e.g. according to the specific vegetation, soil and management regime composition) of the projected 5.B.2 lands. Grade 3 methods use solely country specific EFs and make the projections in a fine disaggregation according to chapter 4.5.4.1.

4.5.4.4   Soil

Grade 2 and Grade 3

The methods follow the 2003 IPPC GPG on LULUCF and 2006 IPCC guidelines on AFOLU. Higher Grade methods project the future soil C stock changes on basis of Grade 2 and Grade 3 AD projections, respectively, and on basis of country specific soil C stocks of the previous and following land uses and/or stock change factors if needed (F_{LU}, F_{MG}, F_I). The projections are carried out according to the AD stratification as described in chapter 4.5.4.1 depending on the used projection grade. Grade 3 methods use soil C stock information from countrywide soil inventories. Soil C stocks change usually very slowly. So, the use of historic soil C stocks for the projections of the soil C stock changes after LUC may be adequate. Nevertheless, adjustments of the average soil C stocks of the 5.B.2 subunits (before and after LUC) and, if applicable, of the stock change factors should be made on basis of any available information for expected future changes before they are used for projections (e.g. due to deviations in the vegetation, soil or climatic conditions, in the land management of each projection subunit compared to its corresponding historic subunit).

Recently, also models are used to estimate soil C stock changes of LUC lands. The prerequisites as described in chapter 4.7 must be fulfilled before such tools can be used for the local conditions.

Organic soils

The methods are the same as those of 5.B.1 (see chapter 4.5.3.4).

4.5.5   Grassland remaining grassland (5.C.1)

4.5.5.1   Activity Data

Higher grade methods in activity data projections of subcategory 5.C.1 use further information than historic results (see chapter 4.5.4.1 for grade 1 method) for the area projections. But, the availability of sound historic grassland areas and LUC areas to grassland (5.C.2) and a resolution of the historic activity data in line with higher tiers according to the 2003 IPCC GPG on LULUCF should be the starting point for higher grade projections of the area of 5.C.1. After the IPCC GPG default transition period of 20 years 5.C.2 areas move to the sub category "grassland remaining grassland". So, the future change in the area of 5.C.1 is dependent on the amount of such LUC areas to grassland in the past. Besides, also information that allows a projection of future activities of such LUCs is needed if the projection period goes beyond 20 years. Specific information for long time projections on LUC to grassland may be regional or national long time plans for conversions to grassland and programs/measures/decisions that represent incentives for conversions to grassland.

The second reason for changes in the 5.C.1 area is a loss of grassland due to LUCs from grassland to other land uses. Such LUCs have an immediate impact on the 5.C.1 area in the year of LUC. Higher grade projection methods for the area changes of 5.C.1 should therefore take into account any information on the future demand of grassland for other land uses. Such demand comes frequently from the need of settlement area. Historically also LUCs from grassland to cropland represented an important reason for grassland losses. Cross compliance regulations by the EU and related national/regional decisions on the protection of grasslands may reduce or limit such conversions from permanent pasture to cropland in the future (see chapter 4.2). Conversions to forest lands, frequently due to economic reasons, represent further reasons for grassland losses. Higher grade methods should evaluate any information on likely future LUCs from grassland to other land uses, such as related political programs or decisions, documents of spatial planning, major infrastructural or construction plans, forecasts on the economic development of agricultural management, prices of agricultural products and subsidy payments and their impact on the future grassland management.

So, the dependence of changes in one land management category on the future development of other land use categories ideally requires also a broad survey of potential future reasons for changes in the areas of linked land use categories. Higher grade projection methods shall take that into account.

Time series area consistency is needed with respect to the change in area of 5.C.1 and the LUC areas to and from grasslands. In addition, the same disaggregation as for historic reporting is needed. This may be a division into intensively and extensively managed grassland which have different C stocks (particularly in soil). Higher grade forecasts in the soil C stock changes of 5.C.1 request also stratification according to the different grassland management types and their future changes (see for instance Table 3.4.5 of the 2003 IPCC GPG on LULUCF). A division into managed and unmanaged grassland consistent with the historic reporting is needed because emission/removal estimates and projections are only requested for the first type.

4.5.5.2   Biomass

The projection approach follows closely the related Tier 2 method for the estimates of historic emissions/removals according to the 2003 IPPC GPG on LULUCF and 2006 IPCC guidelines on AFOLU, but uses projections of (activity data and) emission factors instead.

Grade 2

At least some country specific data are available, like typical biomass growth and loss or biomass stock changes and expansion factors for belowground biomass of country specific grassland and management types. Such historic values are adjusted according to expected changes in the projected 5.C.1 lands (e.g. changes in the growth and site conditions, climate and management of the 5.C.1 lands). The projections of the emissions/removals are carried out according to the stratification of the corresponding projections in the activity data.

Grade 3

Grade 3 methods represent highly disaggregated projections on basis of corresponding activity data and solely country specific C stocks and/or biomass growth and loss rates and expansion factors. Suitable models may be used to simulate the future biomass C stock changes of grassland biomass in the projection period.

4.5.5.3   Dead organic matter

Dead organic matter and litter can be assumed to not occur in grassland remaining grassland (except grassland types with perennial plants). In case, the C stocks changes will be negligible and projections can be estimated with grade 1 methods (see chapter 4.4).

4.5.5.4   Soil

Grade 2

Projections on changes in the grassland management systems and their areas (see chapter 4.5.5.14.5.3.1) are used together with country specific soil C stocks and/or stock change factors (F_{LU}, F_{MG}, F_I) to estimate the future emissions/removals with the same approaches as Tier 2 for estimates of historic ones (see related chapters for soil of this subcategory in the 2003 IPPC GPG on LULUCF and 2006 IPCC guidelines on AFOLU). Soil C stocks and stock change factors change only very slowly, so it is assumed that the use of the historic ones leads also to accurate projections, provided that projection data on the subareas of the different grassland management regimes and types (eventually further stratified according to climate and soil conditions) are used. Nevertheless, the soil C stocks and/or stock change factors should be adjusted for the projections if available information on their future changes allows any such adjustments (e.g. on basis of monitoring results and extrapolation of such results to the conditions of the projection period).

Grade 3

Grade 3 projections use appropriate model-based approaches on basis of country specific historic data (e.g. soil C stocks) and projected country specific changes of the driving parameters and variables (e.g. C inputs into soil, future management system, climate variables). The prerequisites according to chapter 4.7 must be fulfilled before the models can be used for the projections.

Organic soils

Higher grade projections on the C stock changes of drained organic grassland soils estimate the projected emissions with higher grade activity data and country specific emission factors. The basic Grade 2 approach is the same as the Tier 2 approach for the estimate of historic emissions (see related chapters for organic soil of this subcategory in the 2003 IPPC GPG on LULUCF and 2006 IPCC guidelines on AFOLU). Grade 3 methods represent modelling approaches as for mineral grassland soils (see chapter above).

4.5.6   Land converted to grassland (5.C.2)

4.5.6.1   Activity Data

Higher grade projections on LUC areas to grassland go beyond the extrapolation of historic trends or beyond the use of historic means for future years (grade 1, see chapter 4.4.1). They should take into account any available information that allows more specific forecasts of the future conversions into grassland. LUCs to grassland happen often on basis of forestland or cropland areas, frequently due to economic reasons. It should be noted that short time changes between cropland and grassland should not be accounted as LUC. Information for more specific projections on LUC to grassland may be regional or national long time plans for conversions to grassland and programs/measures/decisions that represent incentives for conversions to grassland.

As for the estimates of historic emissions according to the 2003 IPCC GPG on LULUCF, higher grade projection methods for LUC areas to grassland should be specific with respect to the previous land use categories. Grade 3 projection methods should allow for a further disaggregation along climate, soil and vegetation types.

Time series consistency with the derivation of historic LUC areas is needed, particularly since the projected total area of the LUC category represents a transition period of 20 years (by default) and includes therefore also historic areas of such LUC. The same stratification as for the historic reporting is needed also for the projections.

It is important to distinguish the areas of this subcategory into lands without human intervention (changes from unmanaged land of any other category to unmanaged grassland) and lands with a previous and/or following management. Only for the second type emissions/removals and, as a consequence, projections must be estimated.

4.5.6.2　　　Biomass

Grade 2

Grade 2 methods use country specific forecasts of the emission/removal factors due to biomass changes at LUC lands to grasslands. The approach follows closely the related Tier 2 method for the estimates of emissions/removals according to the 2003 IPPC GPG on LULUCF and 2006 IPCC guidelines on AFOLU, but uses projections of (activity data and) emission factors instead. On basis of the higher grade activity data projections and according to their stratification (chapter 4.5.6.1), country specific losses of biomass due to the conversion (biomass stock immediately before LUC), related country specific growth rates and losses due to biomass drain (e.g. harvest of perennial grassland biomass within the transition period) at such lands are estimated for each of the subunit. Projections on these EFs and emissions are carried out on basis of historical EFs typical for each of the conversion type, but adjusted according to the expected future changes due to available information (e.g. changes in the growth rates at future 5.C.2 lands due to differences of the site conditions at the projected 5.C.2 lands, due to different grassland types etc. compared to the historic LUC lands).

Grade 3

Grade 3 follows the same approach as Grade 2 but uses solely country specific projections of the EFs, eventually based on models. EFs and emissions are projected disaggregated according to the Grade 3 AD stratification (see chapter 4.5.6.1).

4.5.6.3　　　Dead organic matter

Grade 2 and Grade 3

Dead organic matter and litter changes will particularly occur if these pools had a C stock in the previous land uses because most grassland types (except some with perennial plants) can be assumed to have no such stocks. LUC lands with previous DOM stocks may be forest lands, certain wetland and "other land" types converted to grasslands.

Higher grade projections use country specific EFs according to the AD stratification (see chapter 4.5.6.1). The higher grade projection approach is consistent with the corresponding higher grade approach of the 2006 IPCC guidelines on AFOLU. Historic stocks and stock change factors (gains minus losses) of dead wood and litter may be used, but should be adjusted for the projected changes of the activities and its specifics (e.g. according to the specific vegetation, soil and management regime composition) of the projected 5.C.2 lands. Grade 3 methods use solely country specific EFs and make the projections in a fine disaggregation according to chapter 4.5.6.1.

4.5.6.4	Soil

Grade 2 and Grade 3

The methods follow the 2003 IPPC GPG on LULUCF and 2006 IPCC guidelines on AFOLU. Higher Grade methods project the future soil C stock changes on basis of Grade 2 and Grade 3 AD projections, respectively, and on basis of country specific soil C stocks of the previous and following land uses and/or stock change factors if needed (F_{LU}, F_{MG}, F_I). The projections are carried out according to the AD stratification as described in chapter 4.5.6.1 depending on the used projection grade. Grade 3 methods use soil C stock information from countrywide soil inventories. Soil C stocks change usually very slowly. So, the use of historic soil C stocks for the projections of the soil C stock changes after LUC may be adequate. Nevertheless, adjustments of the average soil C stocks of the 5.C.2 subunits (before and after LUC) and, if applicable, of the stock change factors should be made on basis of any available information for expected future changes before they are used for projections (e.g. due to deviations in the vegetation, soil or climatic conditions, in the land management of each projection subunit compared to its corresponding historic subunit).

Recently, also models are used to estimate soil C stock changes of LUC lands. The prerequisites as described in chapter 4.7 must be fulfilled before such tools can be used for the local conditions.

Organic soils

The methods are the same as those of 5.C.1 (see chapter 4.5.5.4).

4.5.7   Wetlands remaining wetlands (5.D.1)

This subcategory is voluntary to be estimated and reported except the emissions due to peat extraction in wetland remaining wetland. Therefore no projection guidelines for 5.D.1 beside peat extraction are provided here.

The future area of "wetlands remaining wetlands" (which is needed for area consistency reasons) can be estimated on basis of the historic wetland areas and the projected LUC areas to and from wetlands.

Generally, the 2006 IPCC guidelines on AFOLU provide more specific advice on how to estimate the emissions/removals in the wetland category than the 2003 IPCC GPG on LULUCF. Currently, the IPCC developed/provided new draft guidelines on estimating anthropogenic emissions and removals from wetlands (the „2013 Supplement to the IPCC Guidelines on National Greenhouse Gas Inventories: Wetlands"). So, a major revision of the methods for estimating the historic emissions of wetlands can be expected in the near future. The projection methods for wetlands will need a revision then on basis of these new guidelines for wetlands.

4.5.7.1   Activity data for peat extraction

Grade 2 and Grade 3

Higher grade projections should provide more specific future data on national peat production and the corresponding peat land areas than the extrapolation of trends or use of historic means for future years. PAMs by the national institutions or peat enterprises/peat industry associations as well as changes of the economic framework conditions with an impact on the future peat extraction should be taken into account.

The same disaggregation as for historic reporting is needed for the forecasts. These are stratifications according to soil fertility due to the different EFs. Further elements of disaggregation include: i) areas of organic soils to be managed for peat extraction in the projection years and no more managed (abandoned or with site restoration measures); ii) future peat production data; iii) local moisture content that will reflect ambient conditions at the time of peat extraction; and iv) country-specific carbon content, preferably by peat type. For time series consistency higher grade projection methods may further separate into types of peat extraction technology, peat types and extraction depths. Consistent with historic reporting, estimates of future emissions due to the off-site fate of extracted horticultural peat may be required, as a consequence also data for such activity in the future.

4.5.7.2   Emission factors for peat extractions and emissions

The approach follows closely the 2006 IPCC guidelines for AFOLU on estimating the corresponding historic emissions with higher tiers, but uses projections of activity data according to chapter 4.5.7.1 and historic emission factors, if possible adjusted according to expected changes on parameters and variables that influence the EFs and related monitoring results.

Grade 2

Country-specific emission factors and parameters, spatially disaggregated to reflect regionally important practices and dominant ecological dynamics, are used for the projections. EFs and emissions are estimated according to the activity subdivision described in chapter 4.5.7.1 (into extraction practices, peat fertility and composition as influenced by previous vegetation cover and the carbon fraction of air-dry peat under local climates.

Grade 3

Grade 3 projections are estimated on basis of comprehensive understanding and representation of the dynamics of CO_2 emissions and removals on managed peat lands, including the effect of site characteristics, peat type and depth, extraction technology, and the phases of peat extraction. The methodology will include all the known on-site sources of CO_2.

4.5.8   Land converted for peat extraction (5.D.2)

4.5.8.1   Activity data

Grade 2 and Grade 3

Higher grade methods provide specific forecasts on the future conversions of lands for peat extraction disaggregated by nutrient status (or fertility). Possible sources of information for such future activities or related PAMs are peat extraction enterprises, peat industry associations and the responsible public institutions. Higher grade projections should also stratify these activities according to the previous land use, peat type and peat fertility of the lands being converted. Consistency with reporting of historic figures is a prerequisite.

4.5.8.2   Emission factors and emissions

Grade 2 and Grade 3

The projection method follows the method of estimating the corresponding historic emissions according to the 2006 IPPC guidelines on AFOLU, but uses projections of activity data in their disaggregation (chapter 4.5.8.1) and EFs, adjusted for the projected changes of impact parameters (e.g. differences in the plant biomass of the future LUC lands before conversion compared to the historic ones). Country specific EFs are used (for Grade 3 all EFs are country specific). The methods for projections are equal to those in the subchapters with similar activities (e.g., for biomass losses at forest land converted for peat extraction in chapters dealing with LUCs from forest lands; for emissions from the soil due to drainage with the methods in chapter 4.5.7.2), but the shorter default transition period according to the 2006 IPCC guidelines on AFOLU for this subcategory should be taken into account (5 years instead of 20).

Grade 3 projections are estimated on basis comprehensive understanding and representation of the dynamics of CO2 emissions and removals on *Land Being Converted for Peat Extraction*, including the effect of peat type and fertility, site characteristics such as blanket or raised bogs, and previous land-use or land cover, on basis of appropriate emission factors and/or process-based models.

4.5.9   Land converted to wetlands – flooded land (5.D.2)

4.5.9.1   Activity data

Higher grade methods go beyond the solely use of historic figures for projections (see grade 1 method in chapter 4.4.1). Wetlands typically have a trend of increase in many countries. Important reasons are the construction of hydropower plants or water ponds for agricultural irrigation. The historic trend for construction of new hydro power plants may change in the future due to the demand to substitute other forms of energy supply (e.g. 20/20/20 target of the EU) or, in the opposite direction, due to limitations for further construction of such power plants (e.g. limitations of available waters for such plants or due to reasons of nature protection). Therefore, it is important to inspect carefully all potential reasons for changes of such activities in the future when carrying out projections for such LUCs.

For consistency reasons, the same stratification of LUCs as for historic reporting is needed. Higher grade methods disaggregate the LUCs to wetlands according to the previous land use. At highest grade a further division along climate, soil and vegetation types is carried out.

It is important to distinguish the areas of this subcategory into lands without human intervention (changes from unmanaged land of any other category to unmanaged wetlands) and lands with a previous and/or following management. Only for the second type emissions/removals and, as a consequence, projections must be estimated.

4.5.9.2   Emission factors and emission

Grade 2 and Grade 3

There is only very limited information on estimating emissions/removals of this subcategory in the 2006 IPCC guidelines on AFOLU. Further methodological information can be expected in the near future with the new IPCC guidelines on estimating anthropogenic emissions and removals from wetlands (the „2013 Supplement to the IPCC Guidelines on National Greenhouse Gas Inventories: Wetlands"). After that, more specific methods on the projections for this subcategory can be developed consistent with the methods for calculating the historic emissions. For the moment, it is adequate to say that higher grade methods use country specific emission factors for the stratified activity data according to chapter 4.5.9.1. Country specific biomass (and other) stocks before and after LUC or stock change factors due to conversion are used for the estimates.

4.5.10   Settlements remaining settlements (5.E.1)

This subcategory is voluntary to be estimated and reported. Therefore no projection guidelines are provided here.

The future area of "settlements remaining settlements" (which is needed for area consistency reasons) can be estimated on basis of the historic settlement areas and the projected LUC areas to and from settlements.

4.5.11   Land converted to settlements (5.E.2)

4.5.11.1   Activity Data

Higher grade methods for projections use further information than the historic areas of such LUCs (see grade 1 method in chapter 4.4.1). Settlement areas steadily increase in many countries due to the demand of such areas for housing and infrastructure needs (e.g. roads). The historic trend may change in the future due to changes in the demographic constitution of the people, changes in the needs for housing, changes in the construction trends (flat vs. high-rise buildings), changes in the economic determinants for construction (e.g. prices for land and building costs), changes in the demand for new roads and train lines among others. Higher grade methods adjust their projections on information about such impact parameters for the future LUCs to settlement areas.

For consistency reasons, the same stratification of LUCs as for historic reporting is needed. The projected total area of the LUC category represents a transition period of 20 years (by default) and includes therefore also historic areas of such LUC. Higher grade methods disaggregate the LUCs to settlements according to the previous land use. At highest grade a further division along climate, soil and vegetation types as well as on the following settlement type is carried out. The share of sealed area varies from settlement type to settlement type which has an impact on the EFs at such LUC areas.

4.5.11.2   Biomass

Grade 2

Country-specific carbon stocks before and after conversion or growth rates are used together with projections of activity data disaggregated according to chapter 4.5.11.1. Historic EFs can be used, but should be adjusted for any deviation of the future LUC lands compared to the corresponding historic LUC lands with respect to biomass stocks and growth rates (e.g., different biomass stocks of the lands before conversion; different settlement types with different shares of unsealed area and plant cover at the unsealed settlement area).

Grade 3

At Grade 3 projections, countries can use the stock difference method (like for Grade 2) together with solely country specific EFs, but also other advanced estimation methods that may involve complex models and highly disaggregated activity data projections.

4.5.11.3   Dead organic matter

Grade 2 and Grade 3

Dead organic matter and litter changes will particularly occur if these pools had a C stock in the previous land uses because most settlement types (except parks with forest like subareas) can be assumed to have no such stocks. LUC lands with previous DOM stocks may be forest lands, certain wetland and "other land" types converted to settlement.

The higher grade projection approach is consistent with the corresponding higher tier approach of the 2006 IPCC guidelines on AFOLU. Higher grade projections use country specific EFs according to the AD stratification (see chapter 4.5.11.1). Historic stocks and stock change factors (gains minus losses) of dead wood and litter may be used, but should be adjusted for the projected changes of the activities and for the specifics of the projected 5.E.2 lands (e.g. according to the DOM specifics of the ecosystems projected to be converted to settlement). Grade 3 methods use solely country specific EFs and make the projections in a fine disaggregation according to chapter 4.5.11.1.

4.5.11.4   Soil

Grade 2 and Grade 3

The methods follow the corresponding 2006 IPCC guidelines on AFOLU. Higher Grade methods project the future soil C stock changes on basis of Grade 2 and Grade 3 AD projections, respectively, and on basis of country specific soil C stocks of the previous and following land uses and/or stock change factors if needed (F_{LU}, F_{MG}, F_I). The projections are carried out according to the AD stratification as described in chapter 4.5.11.1 depending on the used projection grade. Soil C stocks change usually very slowly. So, the use of historic soil C stocks for the projections of the soil C stock changes after LUC may be adequate. Nevertheless, adjustments of the average soil C stocks of the 5.E.2 subunits (before and after LUC) and, if applicable, of the stock change factors should be made on basis of any available information for expected future changes before they are used for projections (e.g. due to deviations in the ecosystem types, soil or climatic conditions, in the land management, in the building and follow-up settlement structure of each projection subunit compared to its corresponding historic subunit). Grade 3 projections use country-specific models and/or measurement-based approaches that are capable of representing transitions over time from other land uses. Models used to estimate soil C stock changes of the projected LUC lands must fulfil the prerequisites according to chapter 4.7 before being used.

Organic soils

Settlements are unlikely to be built on deep organic soils. If such LUCs are expected, the basic Grade 2 and Grade 3 approaches are the same as for the estimate of historic emissions (see related chapters for organic soil of this subcategory in 2006 IPCC guidelines on AFOLU). Higher grade projections on the C stock changes of organic soils converted to settlement use higher grade activity data (see chapter 4.5.11.1) and country specific emission factors. Grade 3 approaches use suitable models for the projections.

4.5.12   Other land remaining other land (5.F.1)

This subcategory is voluntary to be estimated and reported. Therefore no projection guidelines are provided here.

The future area of "Other land remaining other land" (which is needed for area consistency reasons) can be estimated on basis of the historic areas of "Other land remaining other land" and the projected LUC areas to and from "other land".

4.5.13   Land converted to other land (5.F.2)

4.5.13.1   Activity Data

Higher grade methods for projections of LUCs to "other land" use further information than the historic areas of such activities (see grade 1 method in chapter 4.4.1). LUCs to "other land" are often the consequence of a deterioration of the conditions for the previous land management

(economically, ecologically). Higher grade projections try to assess future influences in other categories that may lead to such stops of previous land management that result - due to the ecological and site conditions – in "other land".

For consistency reasons, the same stratification of LUCs as for historic reporting is needed. The projected total area of the LUC category represents a transition period of 20 years (by default) and includes therefore also historic areas of such LUC. Higher grade methods disaggregate the LUCs to "other land" according to the previous land use. At highest grade a further division along climate, soil and vegetation types is carried out.

It is important to distinguish the areas of this subcategory into lands without human intervention (changes from unmanaged land of any other category to unmanaged "other land") and lands with a previous and/or following management. Only for the second type emissions/removals and, as a consequence, projections must be estimated.

4.5.13.2 Biomass

Grade 2

Grade 2 methods use country specific forecasts of the emission/removal factors due to biomass changes at LUC lands to "other land". The approach follows closely the related Tier 2 method for the estimates of emissions/removals according to the 2006 IPCC guidelines on AFOLU, but uses projections of (activity data and) emission factors instead. On basis of the higher grade activity data projections and according to their stratification (chapter 4.5.13.1), country specific losses of biomass due to the conversion (biomass stock immediately before LUC), related country specific growth rates and losses due to biomass drain (e.g. harvest of perennial biomass at "other land" within the transition period) are estimated for each of the subunit of LUCs to other land. Projections on these EFs and emissions are carried out on basis of historical EFs typical for each of the conversion type, but adjusted according to the expected future changes due to available information (e.g. differences in the C stocks before LUC and growth rates due to differences of the site conditions at the projected 5.F.2 lands, due to different other land types etc. compared to the historic LUC lands).

Grade 3

Grade 3 follows the same approach as Grade 2 but uses solely country specific projections of the EFs, eventually based on models. EFs and emissions are projected disaggregated according to the Grade 3 AD stratification (see chapter 4.5.13.1).

4.5.13.3 Dead organic matter

Grade 2 and Grade 3

Dead organic matter and litter changes will particularly occur if these pools had a C stock in the previous land uses. LUC lands with previous DOM stocks may be forest lands and certain wetland types converted to "other land".

Higher grade projections use country specific EFs according to the AD stratification (see chapter 4.5.13.1). Historic stocks and stock change factors (gains minus losses) of dead wood and litter may be used, but should be adjusted for the projected changes of the activities and for the specifics of the projected 5.F.2 lands (e.g. according to the DOM specifics of the ecosystems projected to be converted to "other land"). Grade 3 methods use solely country specific EFs and make the projections in a fine disaggregation according to chapter 4.5.13.1.

4.5.13.4   Soil

Grade 2 and Grade 3

The higher grade projection methods follow closely the 2006 IPCC guidelines on AFOLU. Higher Grade methods project the future soil C stock changes on basis of Grade 2 and Grade 3 AD projections, respectively, and on basis of country specific soil C stocks of the previous and following land uses and/or stock change factors if needed (F_{LU}, F_{MG}, F_I). The projections are carried out according to the AD stratification as described in chapter 4.5.13.1 depending on the used projection grade. Soil C stocks change usually very slowly. So, the use of historic soil C stocks for the projections of the soil C stock changes after LUC may be adequate. Nevertheless, adjustments of the average soil C stocks of the 5.F.2 subunits (before and after LUC) and, if applicable, of the stock change factors should be made on basis of any available information for expected future changes before they are used for projections (e.g. due to deviations in the vegetation, soil or climatic conditions, in the land management of each projection subunit compared to its corresponding historic subunit). Grade 3 projections use country-specific models and/or measurement-based approaches that are capable of representing transitions over time from other land uses. Models used to estimate soil C stock changes of the projected LUC lands must fulfil the prerequisites according to chapter 4.7 before being used.

4.5.14   N fertilization of forest land (N₂O emissions) (5(I))

The projection methods use the same approaches as the estimates of historic emissions according to the 2003 IPPC GPG on LULUCF and 2006 IPCC guidelines on AFOLU.

4.5.14.1   Activity Data

Grade 2 and Grade 3

Projections on the future application of synthetic fertiliser nitrogen and organic fertiliser nitrogen in forests are made. The projections are based on related historic experience in the country, advices for fertilising forests (e.g. forest and site types, amounts applied), future PAMs that provide incentives for/against fertilising, management plans of major forest enterprises and future changes in the forest composition and their impact on the forest fertilisation (changes in the forest areas that need/are suited for N fertilisation).

4.5.14.2   Emission factors and emissions

Grade 2 and Grade 3

Country specific emission factors (Grade 2) or suited models (Grade 3) are used to estimate the future N_2O emissions on basis of the projected activity data.

4.5.15   Drainage of soils and wetlands (non CO_2 emissions) (5(II))

The projection methods use the same approaches as the estimates of historic emissions according to the 2006 IPCC guidelines on AFOLU.

The derivation of future drainage areas and activity data is described in chapters 4.5.7.1 and 4.5.8.1.

4.5.15.1   Emission factors and emissions

Grade 2 and Grade 3

Country specific emission factors are used together with the future drainage areas and their stratification projected with higher grades (chapters 4.5.7.1 and 4.5.8.1). Estimates should be stratified for site characteristics, peat type, fertility and depth, extraction technology, the phases of peat extraction and other relevant variables. The used approach should be consistent with the methods for CO2 emissions (chapters 4.5.7.1 and 4.5.8.1).

4.5.16   Land-use conversion to cropland (N_2O emissions from disturbance) (5(III))

The projection methods use the same approaches as the estimates of historic emissions according to the 2003 IPPC GPG on LULUCF and 2006 IPCC guidelines on AFOLU.

Projection methods for the activity data (future LUC areas to croplands) are described in chapter 4.5.4.1.

4.5.16.1   Emission factors and emissions

Grade 2 and Grade 3

Country specific information to adjust the N_2O EFs on basis of the C losses in these soils, like C/N ratios of the soils of the previous land uses before conversion, is used for the projections together with activity data stratified according to chapter 4.5.4.1. Grade 3 methods estimate the future N_2O emissions of this activity on basis of suited process models.

4.5.17 Agricultural lime application (5(IV))

The projection methods use the same approaches as the estimates of historic emissions according to the 2003 IPPC GPG on LULUCF and 2006 IPCC guidelines on AFOLU.

4.5.17.1 Activity data

Grade 2 and Grade 3

Projections on the future application of calcic limestone or dolomite are made. The projections are based on related historic experience in the country, advices for liming the different lands (e.g., land use types, vegetation and site types, amounts applied), future PAMs that provide incentives for/against liming, expected changes in the soil conditions and plans of major enterprises and stakeholder organisations.

4.5.17.2 Emission factors and emissions

Grade 2 and Grade 3

Country specific emission factors per lime type are used together with the stratified future activities to estimate the future emissions. Grade 3 projections use models and/or specific information from comprehensive monitoring sites (information to estimate carbonate mineral formation/dissolution, leaching and transport of inorganic C) to estimate the emissions in a fine stratification.

4.5.18 Biomass burning (5(V))

The projection methods use the same approaches as the estimates of historic emissions according to the 2003 IPPC GPG on LULUCF and 2006 IPCC guidelines on AFOLU.

4.5.18.1 Activity data

Grade 2 and Grade 3

Higher grade projections use any information to derive the future activity of biomass burning (controlled burning) and wildfires. The impact of PAMs on the future burning of biomass and on the amount and size of wildfires is estimated (e.g., future laws that forbid or limit controlled biomass burning, constructions or belts to prevent wildfires, measures to accelerate the put out of fires; or the opposite, expected deteriorations of the circumstances to reduce biomass burning). Impacts of climate change maybe a further reason for future changes in the number and size of wildfires. Historic figures for biomass burning are adjusted with such information to get more appropriate figures for the amount of biomass burning in the projection years. The activity data are stratified according to the (subcategories) chapters 4.5.1 to 4.5.13.

4.5.18.2   Emission factors and emissions

Grade 2 and Grade 3

Higher Grade projection methods estimate on basis of country specific EFs (e.g. mass of available fuel, combustion efficiency, emission factor) together with the stratified activity data. Historic EF values from field measurements may be used, eventually adjusted according to the changes in the expected differences of this activity in the projection years. Grade 3 methods project solely on basis of country specific information together with advanced models/methods.

4.5.19   Harvested Wood Products (HWPs)

The projection methods use the same approaches as the estimates of historic emissions/removals of the HWP pool according to the 2006 IPCC guidelines on AFOLU with the specifications as decided in Durban (UN-FCCC 2011, Decision2/CMP7[44]). Further guidelines and subsequent clarifications with respect to the estimates of historic emissions/removals of HWP are drafted and decided in the near future which may request related adjustments of the proposed projection methods below.

4.5.19.1   Activity data

Grade 2 and Grade 3

Higher grade activity data projections take possible impacts on the future HWP productions from domestic wood into account. There may be several such impacts. The Durban decision itself (UN-FCCC 2011, Decision2/CMP7) may lead to various national PAMs that support an increase in the amount of HWPs (e.g. incentives for building with wood). On the other hand, competition with other wood uses (e.g. for energy supply) may arise due to other PAMs (e.g. 20/20/20 EU targets) that lead to a decrease in the HWP pools due to less wood available for HWPs. Of course, the economic framework conditions (future trend of timber prices and wood product prices and prices of substitute products) may cause changes in the trends of the single HWP pools. Future changes of removals/emissions from the HWP pool may arise from a reduced availability of domestic wood due to requirements from sustainable forest management or due to changes in the import of wood from abroad (which is accounted in the producing country if applicable). Higher grade projection methods take all these various influences into account for the projections. Grade 3 methods represent suited model approaches that allow accurate forecasts according to the country-specific conditions for the future production/demand of HWPs and their stratification and the related import/export trend. Several such models exist and are used, for instance for the derivation of the HWP reference levels of the individual countries for the Durban Decision2/CMP7 (see at http://unfccc.int/bodies/awg-kp/items/5896.php partly long half-lives the past HWPs have an impact on the future emissions/removals. This requests full time series consistency of the HWP projections and consistency of the projection methods with those of reporting historic emissions/removals. The basic stratification of HWPs according to Decision2/CMP7 is a prerequisite, but higher grade methods use

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[44] UN-FCCC 2011: Decision2/CMP7 for the second commitment period (Durban Decision on Land use, land-use change and forestry). http://unfccc.int/resource/docs/2011/cmp7/eng/10a01.pdf

a more detailed stratification according to the different available country-specific EFs of HWPs. Consistency of the assumed future change of the harvested wood products pool with the projections of wood harvests and their assortment according to chapter 4.5.1.2 but also with the expected use of domestic wood as bioenergy is needed.

4.5.19.2   Emission factors and emissions

Grade 2 and Grade 3

Country specific half-lives and decay rates of HWPs (in the production country and/or in the importing country, respectively) are used together with the higher grade activity data projections. Projections may be carried out on more complex country specific approaches/models ("…in accordance with the definitions and estimation methodologies on the most recently adopted IPCC guidelines and any subsequent clarifications agreed by the Conference of the Parties, provided that verifiable and transparent activity data are available and that the methodologies used are at least as detailed or accurate as those prescribed above." Decision2/CMP7 – "above" refers to the method description in paragraph 29 of Decision2/CMP7: "…the first order decay function[45] with default half-lives of two years for paper, 25 years for wood panels and 35 years for sawn wood.").

4.6   Issues for LULUCF projections arising from Kyoto Protocol and from post-Kyoto-Protocol-Decisions

The projection methods for emissions/removals of eligible activities under Kyoto-Protocol and under decisions related to the second commitment period are basically equal to the related projection approaches as described in the chapters 4.4 and 4.5. But, the projection methods for these eligible activities take the differences in the areas of activity due to Art. 3.3 and 3.4 of the Kyoto-Protocol and related decisions and guidelines and due to the Decision2/CMP7 for the second commitment period (Durban Decision on LULUCF[46]) and related follow-up decisions into account. According to these fundamentals for eligibility and accounting, the areas for eligible LULUCF activities (may) deviate to those for UN-FCCC reporting and as a further consequence also the EFs and emissions/removals at these lands. The limitations, deviations and specifics for eligible activities are not repeated here, but can be read in chapter 4 of the 2003 IPCC GPG on LULUCF and, with respect to the second commitment period, in a future specific document to be developed for that purpose.

So, projections of the emissions/removals eligible under Kyoto-Protocol and/or for the follow-up commitment periods use the projection advice for the corresponding subcategories in chapters 4.4 and 4.5, but with a focus on the eligible ADs, and their specific EFs and emissions and on related impact parameters.

In addition, the specific rules of accounting must be taken into account for the projections. For instance, Art.3.3 activities eligible under the Kyoto-Protocol are, in principal, similar to activities of

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[45]   Equation 12.1 of the 2006 IPCC guidelines on AFOLU
[46]   UN-FCCC 2011: Decision2/CMP7 for the second commitment period (Durban Decision on Land use, land-use change and forestry). http://unfccc.int/resource/docs/2011/cmp7/eng/10a01.pdf

LUC to and from forest lands to be reported under UN-FCCC, but must fulfil certain requirements to be accounted ("since 1990", "direct human induced", etc.) and never change to a different category (like LUC lands after the transition period). As a consequence, also the area of forest management and the related emissions/removals differ to those of subcategory 5.A.1. Another example: Forest management under Kyoto-Protocol is accounted gross/net with a cap, but in the second commitment period in relation to a reference level and with a different cap and eventually with the harvested wood pool included. The reference level needs to be continuously adjusted for consistency reasons with the estimates of historic emissions, which may be also an issue to be taken into consideration for the projections. A further example: Accounting of cropland and grassland management is based on a net/net approach in comparison to the 1990 emissions/removals of these activities.

Therefore, projections of the emissions/removals of LULUCF activities eligible under Kyoto-Protocol or follow-up decisions need to consider and integrate the specifics of eligibility and accounting to allow accurate projections of the future contributions of these activities to the fulfilment of emission reduction commitments.

4.7   LULUCF specific QA/QC

General QA/QC issues are described in General Guidance – Part A Chapter A.8: Quality Assurance and Quality Control (QA/QC). LULUCF specific QA/QC issues for estimating and reporting historic LULUCF emissions can be found in the 2003 IPCC GPG on LULUCF and in the 2006 IPCC guidelines on AFOLU. In principle, the specific QA/QC recommendations listed there are also valid for LULUCF projections, so there is no need to repeat them here.

With respect to LULUCF projections, the following QA/QC issues should deserve particular attention:

Out of the five general TACCC principles, consistency and transparency are the two utmost principles when making LULUCF projections. Their fulfillment should have highest priority.

Area consistency: Also the projected area statistics must be consistent so that the changes of areas of subcategories are covered by related land use changes and the totals of all areas equal to the area of the country.

Area and its stratifications: The areas for the projected land use statistic and their stratifications must be the same as for the estimates of the projected emissions.

Time series consistency: Are the projected AD and EF figures realistic? For instance, certain limitations may exist for further land-use changes according to the historic development. Extrapolated trend of EF may be limited due to regional circumstances, like limitations due to growth conditions. Outlier analysis and comparison with historic EFs or EFs from other similar regions should be carried out to check for that. Major deviations of projected ADs or EFs to historic ADs or EFs (in magnitude and trend) are suspicious at first glance. If they occur – which can be only the result of higher grade projection methods – the reasoning for these discontinuities should be explained thoroughly.

Consistency across (sub-)sectors: assumptions on the evolution of key parameters (e.g. biomass harvest) must be transparent and consistent with the assumptions done in other (sub-)sectors (e.g.: in the biomass used for bioenergy, in the change of the harvested wood products pool). Particularly for such interlinkages there is a need to provide sound and transparent reasoning behind any assumption done.

Higher grade methods: thorough documentation of all input variables and parameters used for the estimates and of the underlying future changes and impact of the parameters to the projected ADs and EFs. Description of all possible impact parameters (listed in these guidelines) that were not taken into consideration for the projections and explanations for doing so. Reasoning for assumed non-impacts by non-considered impact parameters should be given.

Higher grade projection methods are often on basis of models. The pre-requisites of using such models as well as the related QA/QC issues as described in the 2003 IPCC GPG on LULUCF and in the 2006 IPCC guidelines on AFOLU are of equal validity for projections. Models must be suited, parameterized, calibrated, verified and validated for the used conditions (also on basis of data independent from those used for the model calibration). These critical issues should be reported and documented transparently, and a list of such elements to be reported for that purpose are given in [47] and to some extent also in [48]. If the used models do no perform well in meeting the historic data in quantity and/or trend they should not be used or should be further developed before being used for projections. Or, if sound projections of the input variables and parameters for the models are not possible the models should not be used for the projections. In any of these two cases the use of models would not lead to more accurate/appropriate figures of the future emissions in LULUCF than lower grade methods and the related spending of resources would not be justified by the results. Meanwhile, forecasts should be carried out on lower grade methods.

Models use data from historical sources and assumptions on future evolution of these data. Historical data used by models for the projections must be consistent with data used in GHG inventories. Recent decisions on LULUCF in Cancun and Durban further underline this prerequisite [49,50].

Estimates and projections of the LULUCF emissions and removals are typically accompanied by high uncertainties. Making a uncertainty analysis of LULUCF projections is challenging, but sensitivity analysis is easier and would be very informative (e.g. on assessing the impact of a given assumption on the final results).

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[47]   IPCC 2011: Use of models and facility-level data in greenhouse gas inventories. IPCC Task Force on National Greenhouse Gas Inventories, Technical Support Unit, c/o Institute for Global Environmental Strategies, Kamiyamaguchi, Hayama, Kanagawa, Japan

[48]   UN-FCCC 2000: Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part II: UNFCCC reporting guidelines on national communications. http://unfccc.int/resource/docs/cop5/07.pdf

[49]   UN-FCCC 2010: The Cancun Agreements: Land use, land-use change and forestry. UN, CCC/KP/CMP/2010/12/Add. 1, http://unfccc.int/resource/docs/2010/cmp6/eng/12a01.pdf - page=5

[50]   UN-FCCC 2011: Decision2/CMP7 for the second commitment period (Durban Decision on Land use, land-use change and forestry). http://unfccc.int/resource/docs/2011/cmp7/eng/10a01.pdf

Verification activities: although verifying projections is strictly speaking impossible, comparison of the expected future change of parameters and PaM with independent studies and discussion of commonalities / discrepancies can help in increasing the confidence in the projection.

B.5 Waste (IPCC sector 6)

5.1   Introduction

5.1.1   Source description

The sources of emission in the waste sector are listed in the table below. The most important source is the landfilling of waste at Solid Waste Disposal Sites (SWDS). In addition emissions from waste incineration, waste water, anaerobic digestion (AD) and composting are covered in these guidelines. When considering waste incineration, recovery of methane from SWDS, waste water treatment and Anaerobic Digestion in projected emissions, care should be taken to ensure that emissions resulting from the generation of electricity are accounted for in the Energy sector and not double counted.

Table 55 Sector split for Waste.

IPCC source category		Description	Re-port
4A	Solid Waste Disposal	Methane is produced from anaerobic microbial decomposition of organic matter in solid waste disposal sites. Carbon dioxide (CO_2) is also produced but CO_2 from biogenic or organic waste sources is covered by the AFOLU Sector. Emissions of halogenated gases should be accounted in IPPU. Long-term storage of carbon in SWDS is reported as an information item.	☑
4B	Biological Treatment of Solid Waste	Solid waste composting and other biological treatment. Emissions from biogas facilities (anaerobic digestion) with energy production are reported in the Energy Sector (1A4).	☑
4C	Incineration and Open Burning of Waste	Incineration of waste and open burning waste, not including waste-to-energy facilities. Emissions from waste burnt for energy are reported under the Energy Sector, 1A. Emissions from burning of agricultural wastes should be reported under AFOLU (3C1). All non-CO_2 greenhouse gases as well as CO_2 from fossil waste should be reported here for incineration and open burning.	☑
4D	Wastewater Treatment and Discharge	Methane is produced from anaerobic decomposition of organic matter by bacteria in sewage facilities and from food processing and other industrial facilities during wastewater treatment. N_2O is also produced by bacteria (denitrification and nitrification) in wastewater treatment and discharge.	☑
4E	Other (please specify)	Release of GHGs from other waste handling activities than listed in categories 4A to 4D.	☑

Source: IPCC (2006)

5.1.2   Policies and Measures

A number of specific policies and measures will have an effect on waste emissions in the future. Table 55 presents the EU legislation which are the source of policies and measures in this sector. MS evaluation and implementation of these policies and measures will mean that relevant studies and assumptions on parameters and variables may be available for emission projection

estimation from technical projects assessing the impact of certain policies, measures and strategies.

Table 56 Policies and Measures and related parameters affected by implementation of particular PAM in Waste sector.

Sector	Description	Legislation	Parameters/Variables
Cross-cutting	European Energy programme for Recovery	Directive 2009/663/EC	*Methane recovery, Sludge removal, waste incinerated, Waste open burned*
	Biofuels directive	Directive 2009/28/EC	*Energy efficiency, Methane recovery Share of renewables in electricity generation, Sludge removal, Waste water sludge removal for energy generation, Waste incinerated, Waste open burned*
	Integrated pollution prevention and control (IPPC) recast	2008/1/EC	*SWD Waste composition SWD total waste (kg) by type of site Methane recovery SWDS types Sludge removal Wastewater % population utilisation of waste water treatment Share of total waste water going to different pathways Waste incinerated Waste open burned*
	Kyoto Protocol project mechanisms	Directive 2004/101/EC	*Emission factors*
	Emissions trading scheme	Directive 2003/87/EC	
	National Emission Ceilings for certain pollutants (NEC Directive)	Directive 2001/81/EC	*Emission ceilings for air pollutants*
	Electricity from Renewables	Directive 2001/77/EC	*Methane recovery, Share of renewables in electricity generation, Share of renewables in energy production, Sludge removal Waste incinerated Waste open burned*
	Decision:		
	Effort Sharing Decision	Decision 406/2009/EC	*Share of different forms of energy*

Sector	Description	Legislation	Parameters/Variables
Waste	Waste Management Framework Directive	2008/98/EC	*SWD Waste composition* *SWD total waste by type of site* *Methane recovery* *SWDS types* *Sludge removal* *Wastewater generated* *% population utilisation of waste water treatment* *Share of total waste water going to different pathways* *Waste incinerated* *Waste open burned*
	Directive on waste	Directive 2006/12/EC	*% population utilisation of waste water treatment,* *Methane recovery* *Share of waste water going to different pathways* *Sludge recovery* *Sludge removal* *SWD total waste by type of site* *SWDS types* *SWDS waste composition* *Waste incinerated* *Waste open burned* *Wastewater generated*
	Packaging and packaging waste	Directive 2005/20/EC	*SWD Waste composition*
		Directive 2004/12/EC	
		Directive 94/62/EC	
	Waste electrical and electronic equipment Directive	Directive 2002/95/EC	*Disposal of domestic refrigerators*
	Water Framework Directive	Directive 2000/60/EC	
	Landfill Directive	Directive 1999/31/EC	*Disposal of domestic refrigerators* *Methane recovery* *Sludge removal* *SWD Waste composition* *SWD total waste by type of site* *SWDS types*
	Urban waste water treatment	Directive 91/271/EEC	*% population utilisation of waste water treatment,* *N removed with sludge,*

Sector	Description	Legislation	Parameters/Variables
			Share of total waste water going to different pathways, Wastewater generated

5.1.3   Parameters for Waste sector

Table 57 presents an overview of parameters needed for each Grade to estimate GHG projections from Waste sub sectors. The Parameters and associated data sources are described in each subsection below. Each approach is described further in this chapter.

Table 57 Overview of parameters per Grade needed for Waste sector

Grade	Parameters
Solid waste disposal on land (IPCC 6.A)	
Grade 3	SWD Waste composition + SWD total waste (kg) by type of site or (**Future Population Growth** & per capita waste generation + % of waste going to landfill)+ % or quantity of methane recovery and flared => *Grade 3*
Grade 2	SWD total waste (kg) by type of site or (**Future Population Growth** & per capita waste generation + % of waste going to landfill)+ % or quantity of methane recovery and flared => *Grade 2*
Grade 1	**Future Population Growth** & per capita waste generation + % of waste going to landfill => *Grade 1*
1.3 BIOLOGICAL TREATMENT OF SOLID WASTE (IPCC 6.a)	
Grade 3	Biologically treated organic waste (kg) by type of treatment + % or quantity of methane recovery and flared => *Grade 3*
Grade 2	Biologically treated total waste (kg) by type of treatment + % or quantity of methane recovery and flared => *Grade 2*
Grade 1	**Future Population Growth & per capita generation** => *Grade 1*
1.4 Wastewater handling (IPCC 6.B)	
1.4.2 Industrial Wastewater (IPCC 6.B.1)	
Grade 3	Total industrial product (t) by type projected using **Economic forecasts of GVA** + sludge removal and recovery of generated methane rates + wastewater generated (m^3/t) per unit product + COD (kg/m^3) for each wastewater stream + fraction of COD anaerobically treated (MCF) + industry specific maximum CH4 production capacity (kgCH4/kg COD). => *Grade 3*
Grade 2	Total industrial product (t) by type projected using **Economic forecasts of GVA** + sludge removal and recovery of generated methane rates => *Grade 2*
Grade 1	**Future Population Growth** => *Grade 1*
1.4.3 Domestic Wastewater (IPCC 6.B.2)	
a) Methane	
Grade 3	**Future Population Growth** + share of total waste water going to different pathways (MCF) + maximum CH4 production capacity (kgCH4/kg BOD) + sludge removal and recovery of generated methane rates + Assumptions on the biochemical oxygen demand (kg BOD/person/year). => *Grade 3*
Grade 2	**Future Population Growth** + share of total waste water going to different pathways (MCF) + maximum CH4 production capacity (kgCH4/kg BOD) + sludge removal and recovery of generated methane rates => *Grade 2*
Grade 1	**Future Population Growth** + % population utilisation of waste water treatment => *Grade 1*
b) Nitrous Oxide	

Grade 3	**Future Population Growth** + nitrogen removed with sludge (kg N/yr) + annual per capita protein consumption (kg/person/yr) + fraction of non-consumed protein added to the wastewater + fraction of industrial and commercial co-discharged protein into the sewer system. => *Grade 3*
Grade 2	**Future Population Growth** + nitrogen removed with sludge (kg N/yr) => *Grade 2*
Grade 1	**Future Population Growth** => **Grade** *1*
1.5 Waste incineration (IPCC 6.C)	
Grade 3	total waste incinerated and Total open-burned waste + fossil carbon content + MSW waste composition + type of waste + CH4/N2O emission factors + oxidation factor => *Grade 3*
Grade 2	total waste incinerated / Total open-burned waste + fossil carbon content + MSW waste composition + type of waste + CH4/N2O emission factors => *Grade 2*
Grade 1	Future Population Growth => **Grade** *1*

5.2   Solid waste disposal on land (IPCC 2006 4.A)

5.2.1   Source description

Solid Waste Disposal Sites (SWDS) can produce significant quantities of methane (CH_4), biogenic carbon dioxide (CO_2) (which is not included in national totals), non-methane volatile organic compounds (NMVOCs) as well as smaller amounts of nitrous oxide (N_2O), nitrogen oxides (NO_x) and carbon monoxide (CO). Policies for waste minimisation, recycling/reuse, diversion from solid waste disposal, landfill gas flaring and waste management practices to dispose of waste in larger deeper sites will impact on emissions from SWDS.

Table 58 Detailed sector split for Solid Waste Disposal.

IPCC source category		Description	Re-port
4A	Solid Waste Disposal	Methane is produced from anaerobic microbial decomposition of organic matter in solid waste disposal sites. Carbon dioxide (CO2) is also produced but CO2 from biogenic or organic waste sources is covered by the AFOLU Sector. Emissions of halogenated gases should be accounted in IPPU. Long-term storage of carbon in SWDS is reported as an information item.	☑
4A1	Managed Waste Disposal Sites	A managed solid waste disposal site must have controlled placement of waste (i.e. waste directed to specific deposition areas, a degree of control of scavenging and fires) and will include at least one of the following: cover material; mechanical compaction; or leveling of the waste. This category can be subdivided into aerobic and anaerobic.	☑
4A2	Unmanaged Waste Disposal Sites	These are all other solid waste disposal sites that do not fall into the above category. This category can be subdivided into deep and shallow.	☑
4A3	Uncategorised Waste Disposal Sites	Mixture of above 4 A1 and 4 A2. Countries that do not have data on division of managed/unmanaged may use this category.	☑

Source: IPCC (2006)

5.2.1.1   Emissions projections

Grades and Decision Tree

Figure B.5-1 presents decision tree for selecting grades to estimate GHG emission projections from solid waste disposal on land.
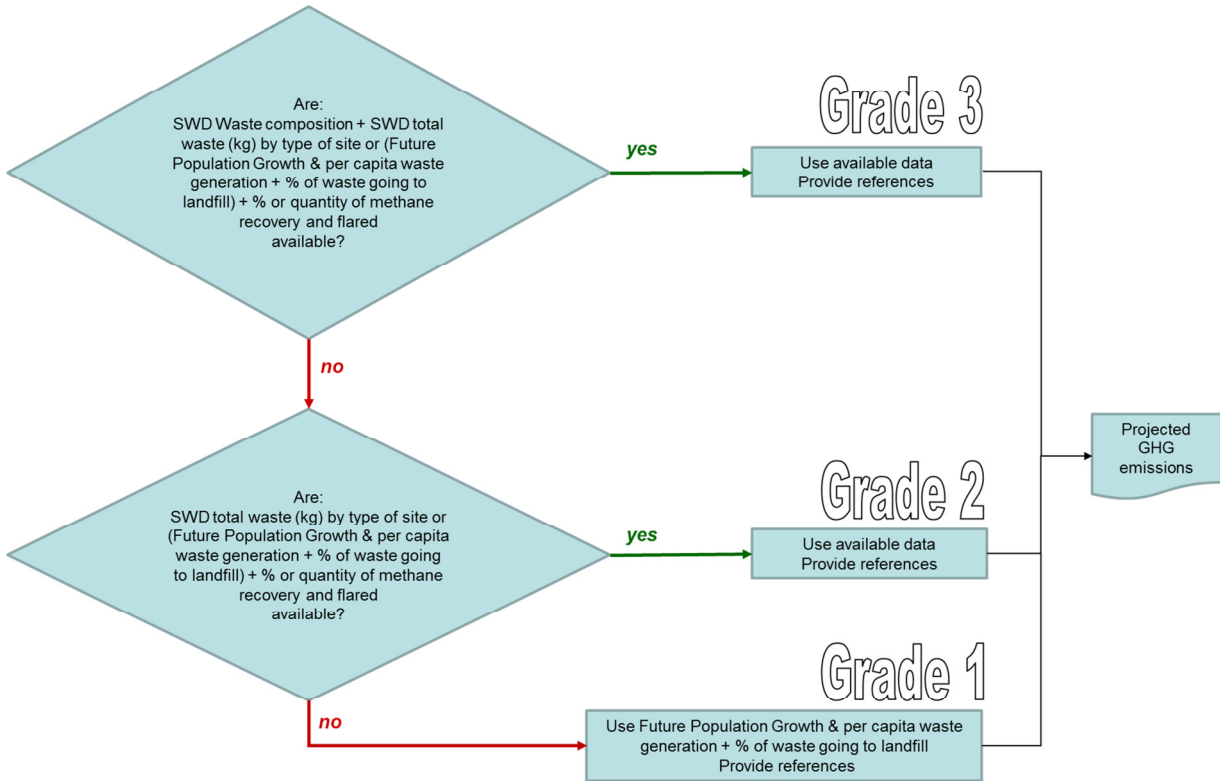
Figure B.5-1 Decision tree for GHG emission projections from solid waste disposal on land.

Data Sources.

Details of data sources, for each of the parameters needed to estimate projected emissions, are presented below. Official national analysis and strategies relating to waste production, minimisation, SWDS management and disposal (including assumptions on methane recovery and flaring) should be used as the basis for providing parameters and assumptions to derive AD and EFs for national projections. Where detailed national data are not available data and analysis supporting MS responses to, and implementation of, EU wide legislation could be used to derive projected parameters for emission estimation.

per capita waste generation, % of waste going to landfill, SWD Waste composition: and SWD total waste (kg) by type of site: *(Grade 2 & 3)*

o   National policies and measures and regulator/industry data on projected waste disposal.

o   In addition, strategies and/or analysis associated with the EU's Landfill Directive (Directive 1999/31/EC), Directive on waste (Directive 2006/12/EC), Waste Framework Directive 2006/12/EC, Waste Management Framework Directive 2008/98/EC should provide some data and assumptions on the on quantities of waste disposed of at different types of SWDS and on the composition of that waste.

o   MS packaging and packaging waste (Directive 94/62/EC, 2004/12/EC, 2005/20/EC) responses should providing insights to future waste composition.

o   Include details of the amount of waste disposed of by type of site (shallow and deep SWDS) allows the methane conversion factor to be adjusted for more accurate estimation.

% or quantity of methane recovery and flared: *(Grade 2 & 3)*

o   National policies and measures and regulator/industry data on projected waste disposal.

o   MS European Energy programme for Recovery (Directive 2009/663/EC); Promotion of the use of energy from renewable sources (Directive 2009/28/EC); Electricity from Renewables (Directive 2001/77/EC) responses should provide details of expected landfill gas recovery for renewable energy generation.

o   In addition MS responses to and implementation of Landfill Directive (Directive 1999/31/EC), Directive on waste (Directive 2006/12/EC), Waste Framework Directive 2006/12/EC, Waste Management Framework Directive 2008/98/EC may provide additional information on methane captured and flaring.

Future Population Growth: *(Grade 1)*

o   Use national Population Projections that is consistent with harmonised assumptions across the EU.

Grade 1

o   Use Future Population Growth to "factor" SWDS activity data (AD) from the latest historical inventory year (total waste going to SWDS) to estimate AD for future years. Assumes that the emission factors for the latest historical year apply for future years unchanged.

Grade 1 assumes that all other parameters including methane recovery, SWDS DOC composition and the type of SWDS remain unchanged for projected years. If using Grade 1, highlight clearly whether changes in the methane recovery rates and degradable organic carbon (DOC) are expected resulting from the implementation of known policies (see tier 3 below) (e.g. Landfill Directive targets (Directive 1999/31/EC)) and how these may affect projected emissions even if they are excluded from the estimates.

Grade 2

1. Use projections of <u>SWD total waste (kg) by type of site</u> to provide future SWDS activity by type of site[51]. Where data on total waste going to SWDS is not available use <u>Future Population Growth</u> as a driver for projecting the latest historical estimates to future years total waste going to SWDS.

2. Use expert judgement to estimate the projected <u>per capita waste generation</u> and apply this to the projected AD based on <u>Future Population Growth.</u>

3. Also, apply <u>% or quantity of methane recovery and flared</u> assumptions to the emission factors to take account for future expectations on methane recovery and destruction.

Grade 2 assumes that all other parameters including SWDS DOC composition remain unchanged for projected years. If using Grade 2, highlight clearly whether changes in the degradable organic carbon (DOC) are expected resulting from the implementation of known policies (e.g. Landfill Directive targets (Directive 1999/31/EC)) and how these may affect projected emissions even if they are excluded from the estimates.

Grade 3

Grade 3 should include sufficiently detailed parameters to be able to model future SWDS emissions using the First Order Decay approach recommended by IPCC (see IPCC 2006 Guidelines) for the historic emission estimates. The following parameters should be included:

1. Use projections of <u>SWD total waste (kg) by type of site</u> to provide future SWDS activity by type of site. Where data on total waste going to SWDS is not available use population projections as a driver for projecting the latest historical estimates to future years total waste going to SWDS.

2. Use expert judgement to estimate the projected <u>per capita waste generation</u> and apply this to the projected AD based on <u>Future Population Growth.</u>

3. Use <u>SWD Waste composition</u> data to introduce details of the different proportions of waste types in projected years to the FOD model to derive country specific Mg of degradable organic component (degradable organic carbon, DOC) disposed of in SWDS.

4. Apply <u>% or quantity of methane recovery and flared</u> to the model to include emissions reduction due to methane recovery and flaring.

---

[51]   Determining the amount of waste disposed of by type of site (shallow and deep SWDS) allows the methane conversion factor to be adjusted for more accurate estimation.

5.2.2　Policies and Measures

The influence of PAMs has been considered in Section 5.1.2.

5.2.3　Source Specific QA/QC

General QA/QC should be undertaken for projection estimates (see Part A general QA/QC)

In addition check:

- o　that waste generation and disposal, population growth and renewable energy assumptions are consistent with national and EU assumptions.

- o　Check that waste generation assumptions that follow population growth and general economic trends are realistic.

- o　That specific policy commitments affecting SWDSs such as the Landfill Directive targets (Directive 1999/31/EC) can be represented in the emission trends. E.g. Reductions in waste disposal to SWDS.

- o　That information on CH4 recovery is consistent with commonly agreed assumptions on renewable etc.

5.3　BIOLOGICAL TREATMENT OF SOLID WASTE (IPCC 2006 4B)

5.3.1　Source description

Composting and anaerobic digestion use natural processes to decompose organic waste such as food waste, garden (yard) and park waste and sludge. Biological treatment is common both in developed and developing countries.

Composting is an aerobic process where a large fraction of the degradable organic carbon (DOC) in the waste material is converted into carbon dioxide (CO_2). The CO_2 emissions are of biogenic origin, and should be reported only as an information item. CH_4 is only formed in anaerobic sections of the compost, but it is oxidised to a large extent in the aerobic sections of the compost. The estimated CH_4 released into the atmosphere ranges from less than 1 percent to a few per cent of the initial carbon content in the material. Composting can also produce emissions of N_2O. The range of the estimated emissions varies from less than 0.5 percent to 5 percent of the initial nitrogen content of the material. Poorly worked/managed composts are likely to produce increased quantities of CH_4 and N_2O.

Anaerobic digestion of organic waste is the natural decomposition of organic material without oxygen. Generated CH_4 can be used to produce heat and/or electricity. Where energy is generated reporting of emissions from the process should be done in the Energy Sector. The CO_2 emissions are of biogenic origin, and should be reported only as an information item. Emissions of CH_4 from such facilities due to unintentional leakages during process disturbances or other unexpected events will generally be between 0 and 10 percent of the amount of CH_4 generated. In the absence of further

information, use 5 percent as a default value for CH_4 emissions. Where technical standards for biogas plants ensure that unintentional CH_4 emissions are flared, CH_4 emissions are likely to be close to zero. N_2O emissions from the process are assumed to be negligible.

Table 59 Sector description of Biological Treatment of Solid Waste.

IPCC source category		Description	Report
4B	Biological Treatment of Solid Waste	Solid waste composting and other biological treatment. Emissions from biogas facilities (anaerobic digestion) with energy production are reported in the Energy Sector (1A4).	☑

5.3.2 Emissions projections

Grades and Decision Tree

Figure B.5-2 presents decision tree for selecting grades to estimate GHG emission projections from biological treatment of solid waste.
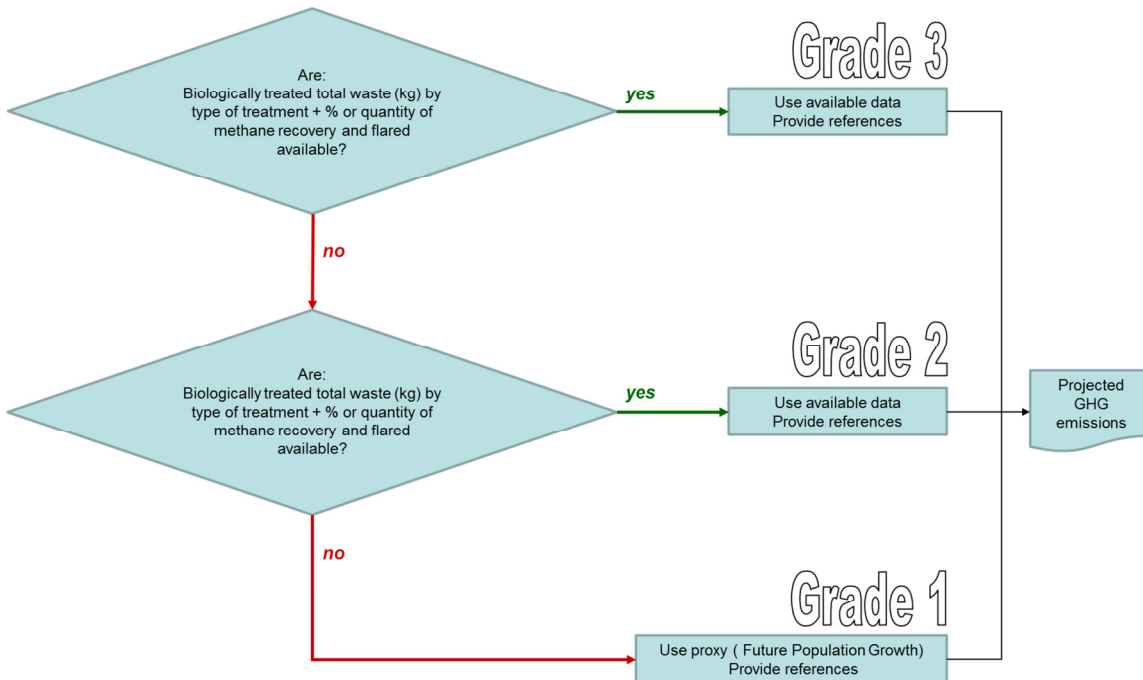
Figure B.5-2 Decision tree for GHG emission projections from biological treatment of solid waste.

Data sources

Details of data sources, for each of the parameters needed to estimate projected emissions are presented below. Official national analysis and strategies relating to future waste production,

minimisation, management and disposal (including assumptions on methane recovery and flaring) should be used as the basis for providing parameters and assumptions to derive AD and EFs for national projections. Where detailed national data are not available, data and analysis supporting MS responses to, and implementation of, EU wide legislation could be used to derive projected parameters for emission estimation.

Biologically treated total waste (kg) by type of treatment *(Grade 2 & 3)*

o   National strategies and/or analysis associated with the EU's Landfill Directive (Directive 1999/31/EC), Directive on waste (Directive 2006/12/EC), Waste Framework Directive 2006/12/EC, Waste Management Framework Directive 2008/98/EC should provide some data and assumptions on the on quantities of waste biologically treated using different types of treatment.

% or quantity of methane recovery and flared: *(Grade 2 & 3)*

o   MS European Energy programme for Recovery (Directive 2009/663/EC); Promotion of the use of energy from renewable sources (Directive 2009/28/EC); Electricity from Renewables (Directive 2001/77/EC) responses should provide details of expected gas utilisation for renewable energy generation.

Future Population Growth: *(Grade 1)*

o   Use national Population Projections that is consistent with harmonised assumptions across the EU.

Grade 1

1.   Use Future Population Growth to "factor" total biological waste treatment activity data (AD) from the latest historical inventory year (total waste biologically treated) to estimate AD for future years.
2.   Assumes that the emission factors for the latest historical year apply for future years unchanged.

Anaerobic digestion of solid waste can be assumed to be zero where no data are available.

Grade 2

Grade 2 approaches for projected emissions can use equation 4.1 (CH4) and 4.2 (N2O) in IPCC 2006 http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_4_Ch4_Bio_Treat.pdf. For each type of biological waste treatment (Anaerobic Digestion or composting) calculate projected emissions:

1.   Using projected data on Biologically treated total waste (kg) by type of treatment. Where projected Biologically treated total waste (kg) by type of treatment is not

available use Future Population Growth to "factor" total biological waste treatment activity data (AD) from the latest historical inventory year (total waste biologically treated) to estimate AD for future years.

2. Use historical country-specific emission factors where industry/expert judgement on projected emission factors is not available.
3. Subtract the amount of CH4 captured or flared using % or quantity of methane recovery and flared, to estimate net annual CH4 emissions, when CH4 emissions from anaerobic digestion are recovered.

Grade 3

Grade 3 approaches for projected emissions can use equation 4.1 (CH4) and 4.2 (N2O) in IPCC 2006 http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_4_Ch4_Bio_Treat.pdf. For each type of biological waste treatment (Anaerobic Digestion or composting) calculate projected emissions:

1. Using projected data on Biologically treated total waste (kg) by type of treatment and by site.
2. Using historical site-specific emission factors where industry/expert judgement on projected emission factors is not available.
3. Subtract the amount of CH4 captured or flared using % or quantity of methane recovery and flared, to estimate net annual CH4 emissions, when CH4 emissions from anaerobic digestion are recovered.

5.3.3 Policies and Measures

Policies and Measures for Waste sector are introduced in section 5.1.2.

5.3.4 Source Specific QA/QC

General QA/QC should be undertaken for projection estimates (see Part A general QA/QC)

In addition check:

o that biological waste and population growth assumptions are consistent with national and EU assumptions.

o that specific policy & regulatory commitments affecting biological waste can be represented in the emission trends. E.g. Reductions in waste disposal methods.

o Any sensitivity tests for projection parameters should be documented highlighting the most important/sensitive variables.

o   all electricity generation from biological waste are included under 1A and that there is
no double counting or missing emissions between estimates reported under Waste and
Energy.

o   country specific CH_4 and N_2O Emission Factors are justifiable when compared to IPCC
2006 defaults see IPCC 2006 Table 4.1.

o   Consistency between CH_4 and N_2O emissions from composting or anaerobic treatment
of sludge and emissions from treatment of sludge reported in the Wastewater
Treatment and Discharge category should be checked.

o   When sludge from wastewater treatment is transferred to an anaerobic facility which is
co-digesting sludge with solid municipal or other waste, check that any related CH_4 and
nitrous oxide (N_2O) emissions are reported under this category, biological treatment of
solid waste.

o   The estimated CH_4 released from composting into the atmosphere ranges between 1
percent to a few per cent of the initial carbon content in the material.

o   The estimated N_2O released from composting into the atmosphere range from less than
0.5 percent to 5 percent of the initial nitrogen content of the material.

o   The unintentional AD leakages of CH_4 during process disturbances or other unexpected
events is generally between 0 and 10 percent of the amount of CH_4 generated.

5.4   Wastewater handling (IPCC 2006 4D)

5.4.1   Source description

Methane emissions from on-site industrial wastewater treatment and domestic wastewater streams
are a function of the amount of organic waste in the wastewater and how the wastewater is treated
(the majority of CH_4 is generated in anaerobic pathways). For example, deep lagoons without mixing
or aeration are high producers of CH_4. Shallow lagoons, less than 1 metre in depth, generally provide
aerobic conditions and little or no CH_4 is likely to be produced. Lagoons deeper than about 2-3
metres will generally provide anaerobic environments and significant CH_4 production can be
expected.

The principal parameters for CH_4 emissions are the amount of degradable organic material in the
wastewater, the amount of anaerobic waste water treatment and levels of methane recovery and
sludge removal.

Nitrous oxide is associated with the degradation of nitrogen components in the wastewater, e.g.,
urea, nitrate and protein. Domestic wastewater includes human sewage mixed with other household
wastewater, which can include effluent from shower drains, sink drains, washing machines, etc.
Centralized wastewater treatment systems may include a variety of processes, ranging from

lagooning to advanced tertiary treatment technology for removing nitrogen compounds. After being processed, treated effluent is typically discharged to a receiving water environment (e.g., river, lake, estuary, etc.). Direct emissions of N_2O may be generated during both nitrification and denitrification of the nitrogen present. Both processes can occur in the plant and in the water body that is receiving the effluent. Nitrification is an aerobic process converting ammonia (NH_3) and other nitrogen compounds into nitrate (NO_3^-), while denitrification occurs under anoxic conditions (without free oxygen), and involves the biological conversion of nitrate into dinitrogen gas (N_2). Nitrous oxide can be an intermediate product of both processes, but is more often associated with denitrification.

The principal parameters for **Nitrous oxide (N_2O)** are associated with the concentration and **degradation of nitrogen** components in **centralised the wastewater.**

The principal factor in determining the CH_4 generation potential of wastewater is the amount of degradable organic material in the wastewater. Common parameters used to measure the organic component of the wastewater are the Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). Under the same conditions, wastewater with higher COD, or BOD concentrations will generally yield more CH_4 than wastewater with lower COD (or BOD) concentrations.

The BOD concentration indicates only the amount of carbon that is aerobically biodegradable. The standard measurement for BOD is a 5-day test, denoted as BOD5. The term 'BOD' in this chapter refers to BOD5. The COD measures the total material available for chemical oxidation (both biodegradable and non-biodegradable). 2 Since the BOD is an aerobic parameter, it may be less appropriate for determining the organic components in anaerobic environments. Also, both the type of wastewater and the type of bacteria present in the wastewater influence the BOD concentration of the wastewater. Usually, BOD is more frequently reported for domestic wastewater, while COD is predominantly used for industrial wastewater.

Details of methods for projected emissions from wastewater treatment are provided in the following sections. Where emissions from wastewater for industrial and domestic sources are not separated or cannot be separated for projected estimates then apply Future Population Growth parameter to "factor" the latest historic years emission estimates to estimate future emissions.

Table 60 Detailed sector split for Wastewater Treatment and Discharge.

IPCC source category		Description	Re-port
4D	Wastewater Treatment and Discharge	Methane is produced from anaerobic decomposition of organic matter by bacteria in sewage facilities and from food processing and other industrial facilities during wastewater treatment. N_2O is also produced by bacteria (denitrification and nitrification) in wastewater treatment and discharge.	☑
4D1	Domestic Wastewater Treatment and Discharge	Treatment and discharge of liquid wastes and sludge from housing and commercial sources (including human waste) through: wastewater sewage systems collection and treatment systems, open pits / latrines, anaerobic lagoons, anaerobic reactors and discharge into surface waters. Emissions from sludge disposed at SWDS are reported under category 4A.	☑

IPCC source category		Description	Re-port
4D2	Industrial Wastewater Treatment and Discharge	Treatment and discharge of liquid wastes and sludge from industrial processes such as: food processing, textiles, or pulp and paper production. This includes anaerobic lagoons, anaerobic reactors, and discharge into surface waters. Industrial wastewater released into domestic wastewater sewage should be included under 4D1.	☑

Source: IPCC (2006)

5.4.2   Industrial Wastewater (IPCC 2006 4D2)

5.4.2.1   Source description

Industrial wastewater may be treated on site or released into domestic sewer systems. If it is released into the domestic sewer system, the emissions are to be included with the domestic wastewater emissions. This section deals with estimating CH_4 emissions from on-site industrial wastewater treatment. Only industrial wastewater with significant carbon loading that is treated under intended or unintended anaerobic conditions will produce CH_4. Organics in industrial wastewater are often expressed in terms of COD, which is used here.

Assessment of CH_4 production potential from industrial wastewater streams is based on the concentration of degradable organic matter in the wastewater, the volume of wastewater, and the propensity of the industrial sector to treat their wastewater in anaerobic systems. Using these criteria, major industrial wastewater sources with high CH_4 gas production potential can be identified as follows in60:

Table 61 Industry types relevant for waste water treatment.

Industry type	Description
pulp and paper manufacture,	Processing and manufacture of paper and board from wood with processes involving large quantities of water and organic matter.
meat and poultry processing (slaughterhouses),	Processing and manufacture of meat products with processes involving large quantities of water for cleaning & preparing carcases resulting in high organic matter in wastewater.
alcohol, beer, starch production,	Processing of grain, other crops and starchy products with processes involving large quantities of water for cleaning resulting in high organic matter in wastewater.
organic chemicals production,	Production of bulk organic chemicals with processes involving large quantities of water and organic matter.

Industry type	Description
other food and drink processing (dairy products, vegetable oil, fruits and vegetables, canneries, juice making,etc.)	Processing of foods involving large quantities of water for cleaning resulting in high organic matter in wastewater.

5.4.2.2   Emissions projections

Grades and Decision Tree

Figure B.5-3 presents decision tree for selecting grades to estimate GHG emission projections from industrial wastewater.
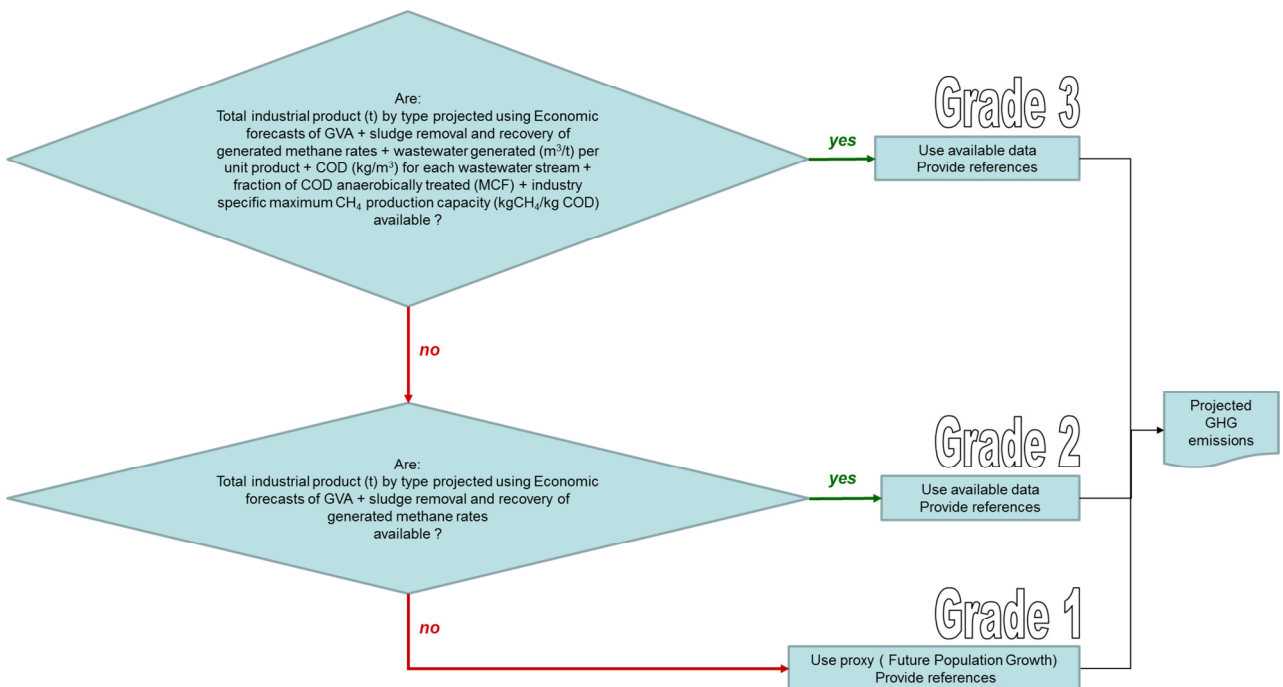
Figure B.5-3 Decision tree for GHG emission projections from industrial wastewater.

The recommended projection parameters for Wastewater handling are listed in parameters for Projection Models. The table identifies the Parameters required for each tiered method below.

Data sources.

Total industrial product (t) by type *(Grade 3 & 2)*

o   Industry specific or regulator data may be available to provide projected estimates of total production by type of industry for the relevant sectors listed in table above.

Economic forecasts (GVA) *(Grade 3 & 2)*

o   Where production forecasts are not available, national economic projections could provide economic growth factors for the relevant individual industrial sectors (in table above). If detailed source category splits are not available then general sectoral GVA forecasts could be applied to historical sectoral breakdowns.

o   Where national economic projections are not available, European Commission, DG Economic and Financial Affairs: 2009 Ageing Report: Economic and budgetary projections for the EU-27 Member States (2008-2060). EUROPEAN ECONOMY 2|2009: http://ec.europa.eu/economy_finance/publications/publication14992_en.pdf. The "baseline" scenario of this report has been established by the DG Economic and Financial Affairs, the Economic Policy Committee, with the support of Member States experts, and has been endorsed by the ECOFIN Council.

Sludge removal & recovery of generated methane rates *(Grade 3 & 2)*

o   Future sludge removal and recovery of generated methane rates assumptions and datasets could be gathered from industrial regulation information on a site by site basis, national policies on energy (utilisation of sludge and recovered methane) and/or analysis associated with the EU's Promotion of the use of energy from renewable sources (Directive 2009/28/EC).

o   Future sludge removal assumptions and datasets could be gathered from national policies on waste management and different sludge disposal to Landfill options and/or analysis associated with the EU's *Waste Management Framework Directive (2008/98/EC), Directive on waste (Directive 2006/12/EC) & Landfill Directive (Directive 1999/31/EC)*

o   Future sludge removal and recovery of generated methane rates assumptions and datasets could be gathered from national strategies on Industrial waste water treatment and/or analysis associated with the EU's IPPC Directive (2008/1/EC) focussing on waste water treatment plant, Water Framework Directive (2000/60/EC) focussing on discharge constraints and *Urban waste water treatment (Directive 91/271/EEC) regulating industrial WW from certain industrial sectors of biodegradable industrial WW not entering urban WW treatment plants*

Wastewater generated (m^3/t) per unit product, COD (kg/m^3) for each wastewater stream, fraction of COD anaerobically treated (MCF) and industry specific maximum CH_4 production capacity (kgCH_4/kg COD) *(Grade 3 & 2)*

o   Future assumptions and/or parameters could be gathered from the industrial experts and the regulator (under IPPC) with knowledge of planned capacity for wastewater systems, discharge pathways, future industrial process changes and/or national regulation to protect downstream water bodies.

o   Future data on limits/changes to water consumption for specific industries could also be used to derive projected parameters for Wastewater generated (m^3/t) per unit product.

Future Population Growth: *(Grade 1)* Use national Population Projections that is consistent with harmonised assumptions across the EU.

Grade 1

1. Use <u>Future Population Growth</u> to "factor" the Industrial Wastewater activity data (AD) from the latest historical inventory year to estimate AD for future years. Assume that the emission factors for the latest historical year apply for future years unchanged.

Grade 1 assumes that all other parameters including wastewater generated (m^3/t), the COD (kg/m^3), the type of treatment and discharge pathway or system (used to determine MCF based on the fraction of COD anaerobically treated), the industry specific maximum CH_4 production capacity (kgCH_4/kg COD) and sludge removal and recovery of generated methane rates remain unchanged for projected years. If using Grade 1, highlight clearly whether changes in the chemical oxygen demand (COD) generation rate, fraction of COD anaerobically treated, and the fraction of methane recovery are lightly resulting from the implementation of known policies (see tier 3 below) (e.g. Landfill Directive targets (Directive 1999/31/EC)) and how these may affect projected emissions even if they are excluded from the estimates.

Grade 2

Grade 2 follows equation 6.4 of the <u>IPCC 2006</u> guidelines:

1. Use estimated future <u>total industrial product (t) by type of industry</u>[52] on a site by site or economic sector basis to project historic industrial wastewater treatment activity data total organically degradable material in wastewater for industry (TOW). Where future <u>total industrial product (t) by type of industry</u> is unavailable use historical data and project it forward using sector specific <u>Economic forecasts (GVA)</u>.

2. Use details of future <u>sludge removal</u> to modify TOW used for projected estimates to account for different amounts of organic component removed.

3. Apply assumptions on total <u>recovery of generated methane rates</u> to provide estimate methane recovered to subtract from the estimates emissions.

Document clearly whether changes in the chemical oxygen demand (COD) generation rate and the fraction of COD anaerobically treated are lightly resulting from the implementation of known policies (e.g. Landfill Directive targets (Directive 1999/31/EC)) and how these may affect projected emissions even if they are excluded from the estimates.

Grade 3

Use the tier 3 method described in <u>IPCC 2006</u> to estimate projected emissions using equations 6.4, 6.5 and 6.6. The parameters required for these equations are as follows:

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[52]   Where future <u>total industrial product (t) by type of industry</u> is unavailable use historical data and project it forward using sector specific <u>Economic forecasts (GVA)</u>.

1. Use IPCC 2006 Equation 6.6: Calculate the total organically degradable material in wastewater for industry (TOW) for each industrial sector using data on future total industrial product (t) by type of industry[53] * projected assumptions on wastewater generated (m^3/t) per unit product * COD (kg/m^3) for each wastewater stream (using IPCC 2006 table 6.9 if necessary to select typical COD for different wastewater types.

2. Use IPCC 2006 Equation 6.5: Calculate the emission factor (EF) for each treatment/discharge pathway using industry/regulator assumptions on the industry specific maximum CH_4 production capacity (kgCH_4/kg COD) and fraction of COD anaerobically treated (MCF) (See IPCC 2006 Table 6.8. for details of different MCF depending on disposal pathways)

3. Use IPCC 2006 Equation 6.4: For each treatment/discharge pathway estimate emissions using the TOW (equation 6.6) after subtracting future sludge removal, and then applying the EF (equation 6.5) and removing estimated methane recovered using assumptions on total recovery of generated methane rates.

4. Aggregate emissions for all industrial sectors.

5.4.2.3   Policies and Measures

Policies and Measures for Waste sector are introduced in section 5.1.2.

5.4.2.4   Source Specific QA/QC

General QA/QC should be undertaken for projection estimates (see Part A general QA/QC)

In addition check:

- o that wastewater generation and disposal, population growth and renewable energy (methane recovery from waste water treatment) assumptions are consistent with national and EU assumptions.

- o that the wastewater treatment assumptions do not exceed expected installed waste water capacity available.

- o the trend in wastewater generation in relation to general economic/Population trends are justifiable.

- o That specific policy & regulatory commitments affecting industrial wastewater treatment and discharge can be represented in the emission trends. E.g. Reductions in water consumption and BOD/COD loading on receiving water bodies.

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[53]   Where future total industrial product (t) by type of industry is unavailable use historical data and project it forward using sector specific Economic forecasts (GVA).

- o that any changes in COD rates and MCF are consistent with industry assumptions or other international data and within the ranges given in IPCC GPG and 2006.

- o that methane recovery rates are consistent with recovery rates assumed by the industry and in renewables policies.

- o Any sensitivity tests for projection parameters should be documented highlighting the most important/sensitive variables.

5.4.3   Domestic Wastewater (IPCC 2006 4D1)

5.4.3.1   Source description

CH_4 from domestic wastewater streams is based on the concentration of degradable organic matter in the wastewater, the maximum CH_4 producing potential (Bo) of that degradable organic matter, the volume of wastewater, and the propensity of the domestic waste water treatment industry to treat wastewater in anaerobic systems The Methane Correction Factor (MCF) provides a measure of the extent to which the CH_4 production capacity (Bo) is realised in each type of treatment and discharge pathway and system. Thus, it is an indication of the degree to which the system is anaerobic.

Nitrous oxide emissions can occur as direct emissions from treatment plants or from indirect emissions from wastewater after disposal of effluent into waterways, lakes or the sea. Direct emissions from nitrification and denitrification at wastewater treatment plants may be considered as a minor source. Direct estimates of N_2O are less significant than for effluent emissions and only important for countries that have advanced centralized wastewater treatment plants with nitrification and denitrification steps. This may mean that new minor N_2O estimates will need to be introduced for projections where a country has a strategy to introduce additional advanced centralized wastewater treatment capacity with nitrification and denitrification.

Projections estimates will be closely linked to population and assumptions from industry, regulators and waste strategies on the treatment pathways (whether they are aerobic (non CH_4 generating) or anaerobic (CH_4 generating) and on the removal of sludge and recovery of methane.

5.4.3.2   Emissions projections

Grades and Decision Tree

a) Methane

Figure B.5-4 presents decision tree for selecting grades to estimate CH_4 emission projections from domestic wastewater.
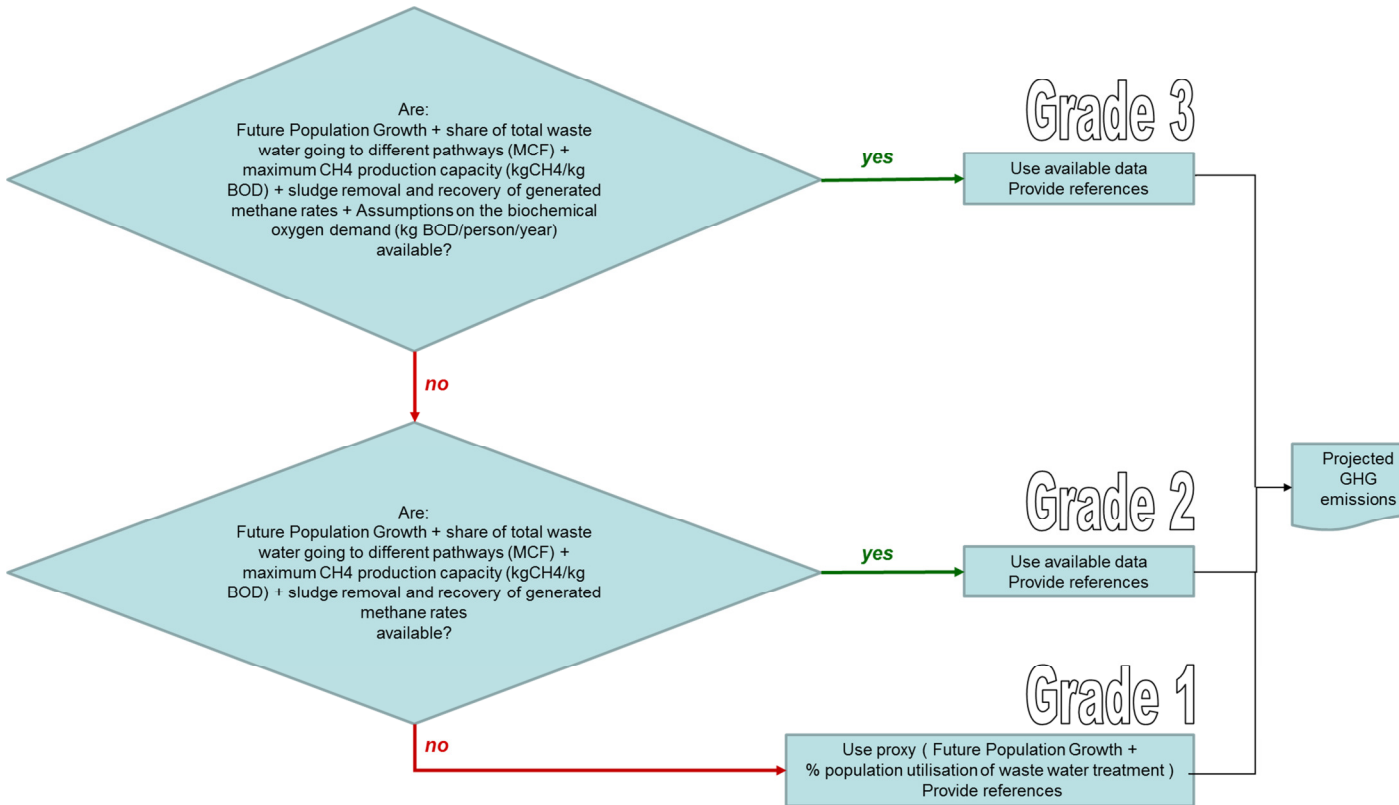
Figure B.5-4 Decision tree for CH$_4$ emission projections from domestic wastewater.

b) Nitrous Oxide

Figure B.5-5 presents decision tree for selecting grades to estimate N$_2$O emission projections from domestic wastewater.
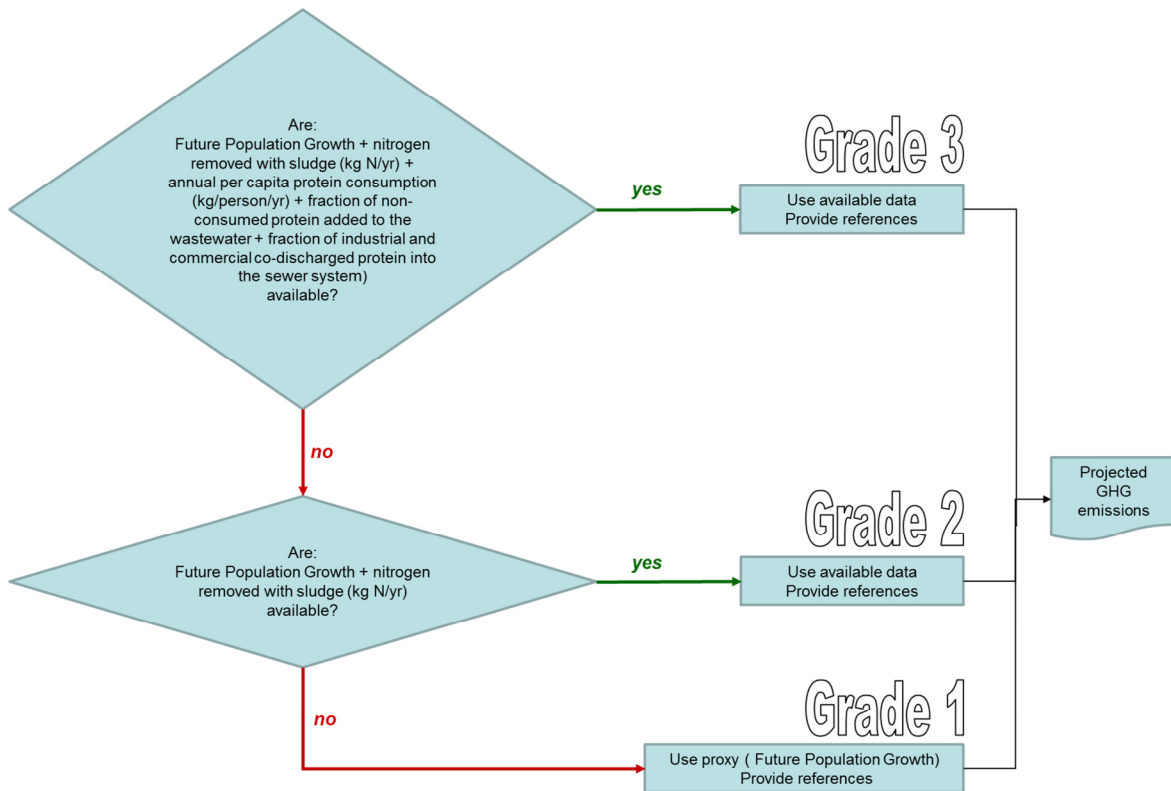
Figure B.5-5 Decision tree for N$_2$O emission projections from domestic wastewater.

Data Sources.

% population utilisation of waste water treatment *(Grade 1)*

o Simple estimates of the future proportion waste water treated could be provided through specific policies or strategies on waste water treatment or environmental protection or from Expert Judgement through discussions with the waste water treatment industry and the regulator.

Sludge removal & recovery of generated methane rates *(Grade 3 & 2)*

o See Industrial waste water data sources section above.

Share of total wastewater going to different pathways (MCF) + changes in maximum CH4 production capacity (kgCH4/kg BOD) + Assumptions on the changes in biochemical oxygen demand (kg BOD/person/year), annual per capita protein consumption (kg/person/yr), fraction of non-consumed protein added to the wastewater + fraction of industrial and commercial co-discharged protein into the sewer system *(Grade 3 & 2)*

o Projected parameters could be gathered from industry, regulators, national strategies on waste water treatment and/or analysis associated with the EU's IPPC Directive (2008/1/EC) focussing on waste water treatment plant, Water Framework Directive (2000/60/EC) focussing on waste

water discharge constraints and *Urban waste water treatment (Directive 91/271/EEC) regulating industrial WW from certain industrial sectors of biodegradable industrial WW not entering urban WW treatment plants*

<u>Future Population Growth:</u> *(Grade 1)* Use national Population Projections that is consistent with harmonised assumptions across the EU.

Grade 1

a) <u>Methane & Nitrous Oxide</u>

1. Use <u>Future Population Growth</u> to "factor" the domestic Wastewater activity data (TOW) from the latest historical inventory year to estimate AD for future years.

2. Use projected assumptions on <u>population utilisation of waste water treatment</u> to modify the weighting of methane correction factor (fraction), (See IPCC 2006 Table 6.3) applied to estimate future emission factors EFs.

Grade 1 assumes that all other parameters including biological oxygen demand (kg BOD/person/year), the proportion of domestic waste water that is from industries and establishments (e.g., restaurants, butchers or grocery stores), total waste water treatment/discharge for different pathways, the maximum CH_4 production capacity (kgCH$_4$/kg BOD) and sludge removal and recovery of generated methane rates, annual per capita protein consumption (kg/person/yr), fraction of non-consumed protein added to the wastewater, fraction of industrial and commercial co-discharged protein into the sewer system and the change in nitrogen removed with sludge (kg N/yr) remain unchanged for projected years. If using Grade 1, highlight clearly whether changes in the biochemical oxygen demand (BOD) generation rate, fraction of BOD anaerobically treated, and the fraction of methane recovery are lightly resulting from the implementation of known policies (see tier 3 below) (e.g. Landfill Directive targets (Directive 1999/31/EC)) and how these may affect projected emissions even if they are excluded from the estimates.

Grade 2

a) <u>Methane</u>

Grade 2 approaches for projected emissions can use equation 6.1 - 6.3 in IPCC 2006 of http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf. This approach should include industry expert, regulator and or policy based assumptions on a number of parameters that will affect CH_4 emissions from domestic waste water treatment including:

1. Estimate projected TOW (Activity data) by applying <u>Future Population Growth</u> to "P" (see equation 6.3) and then removing TOW removed through projected <u>sludge removal</u>.

2. Estimate the future emission factor EF using industry, regulator, Expert Judgement or policy projected assumptions on the <u>share of total waste water going to different pathways (MCF)</u> and <u>maximum CH4 production capacity (kgCH$_4$/kg BOD)</u> (see equation 6.2).

o Estimate emissions using in equation 6.1 with the results of 1 and 2 and then subtract estimated methane recovered using assumptions on total <u>recovery of generated methane rates</u>.

Document clearly whether changes in the biochemical oxygen demand (BOD) generation rate is lightly resulting from the implementation of known policies and how these may affect projected emissions even if they are excluded from the estimates.

b) <u>Nitrous Oxide</u>

Grade 2 approaches for projected emissions can use equation 6.7 - 6.8 in IPCC 2006 of http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf. This approach should include industry expert, regulator and or policy based assumptions on a number of parameters that will affect N2O emissions from domestic waste water treatment including:

o Estimate projected Nitrogen in effluent (N$_{effluent}$) by applying <u>Future Population Growth</u> to "P" (see IPCC 2006 equation 6.8) and then removing any Nitrogen removed through projected <u>sludge removal</u>.

o Calculate emissions by applying IPCC 2006 equation 6.7 to the results of (1) above assuming that the emission factor for N$_2$O from discharges to wastewater is the same as that for historic estimates.

Grade 3

a) <u>Methane</u>

Grade 3 approaches for projected emissions can use equation 6.1 - 6.3 in IPCC 2006 of http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf. It is similar to the Grade 2 approach with the addition of knowledge of country specific and changes in future biochemical oxygen demand (kg BOD/person/year). This approach should include industry expert, regulator and or policy based assumptions on a number of parameters that will affect CH$_4$ emissions from domestic waste water treatment

1. Estimate projected TOW (Activity data) by applying <u>Future Population Growth</u> to "P" and revised projected assumptions for <u>biochemical oxygen demand (kg BOD/person/year)</u> (see IPCC 2006 Table 6.4) for BOD (see equation 6.3) and then adjusting for TOW removed through projected <u>sludge removal</u>.

2. Estimate the future emission factor EF using industry, regulator, Expert Judgement or policy projected assumptions on the <u>share of total waste water going to different pathways (MCF)</u> and <u>maximum CH$_4$ production capacity (kgCH4/kg BOD)</u> (see equation 6.2).

3. Estimate final projected emissions using in equation 6.1 with the results of 1 and 2 and then subtract estimated methane recovered using assumptions on total <u>recovery of generated methane rates</u>.

b) <u>Nitrous Oxide</u>

Grade 3 approaches for projected emissions can use equation 6.7 - 6.8 in IPCC 2006 of <u>http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf</u> . This approach should include industry expert, regulator and or policy based assumptions on a number of parameters that will affect N_2O emissions from domestic waste water treatment including:

o   Estimate projected Nitrogen in effluent ($N_{effluent}$) by applying <u>Future Population Growth</u> to "P", assumptions on changes in <u>annual per capita protein consumption (kg/person/yr)</u> to "Protein", assumptions on the <u>fraction of non-consumed protein added to the wastewater</u> to "$F_{Non-Con}$" and assumptions on projected changes to the <u>fraction of industrial and commercial co-discharged protein into the sewer system</u> to "$F_{IND-COM}$" and then removing any Nitrogen removed through projected <u>sludge removal </u>(see IPCC 2006 equation 6.8).

o   Calculate emissions by applying IPCC 2006 equation 6.7 to the results of (1) above assuming that the emission factor for N2O from discharges to wastewater is the same as that for historic estimates.

5.4.3.3   Policies and Measures

Policies and Measures for Waste sector are introduced in section 5.1.2.

5.4.3.4   Source Specific QA/QC

General QA/QC should be undertaken for projection estimates (see Part A general QA/QC)

In addition check:

o   that wastewater generation and disposal, population growth and renewable energy (methane recovery from waste water treatment) assumptions are consistent with national and EU common assumptions.

o   the trend in wastewater generation in relation to general economic/Population trend are justifiable.

o   That specific policy & regulatory commitments affecting domestic wastewater treatment and discharge can be represented in the emission trends. E.g. Reductions in water consumption, changes in diet, wastewater treatment systems and pathways and BOD/COD loading on receiving water bodies.

o   that any changes in BOD rates and MCF are consistent with domestic wastewater treatment industry assumptions or other international data and within the ranges given in IPCC GPG and 2006.

o   that methane recovery rates are consistent with recovery rates assumed by the industry and in renewables policies.

o   Any sensitivity tests for projection parameters should be documented highlighting the most important/sensitive variables.

5.5   Waste incineration (IPCC 2006 4C)

5.5.1   Source description

Emissions from waste burnt for energy are reported under the Energy Sector, 1A. Emissions from burning of agricultural wastes should be reported under AFOLU (3C1). All non-CO_2 greenhouse gases as well as CO_2 from fossil waste should be reported here for incineration and open burning. Waste incineration includes the combustion of solid and liquid waste in controlled incineration facilities. Emissions occur primarily for CO_2 from fossil based liquids or materials in combusted waste. Parameters that will influence projected emissions will include the amount of waste going to be incinerated, the oxidation factors which depend on the combustion technology. Types of waste incinerated include municipal solid waste (MSW), industrial waste, hazardous waste, clinical waste and sewage sludge. The practice of MSW incineration is currently more common in developed countries, while it is common for both developed and developing countries to incinerate clinical waste.

5.5.2   Emissions projections

Grades and Decision Tree

Figure B.5-6 presents decision tree for selecting grades to estimate GHG emission projections from waste incineration.
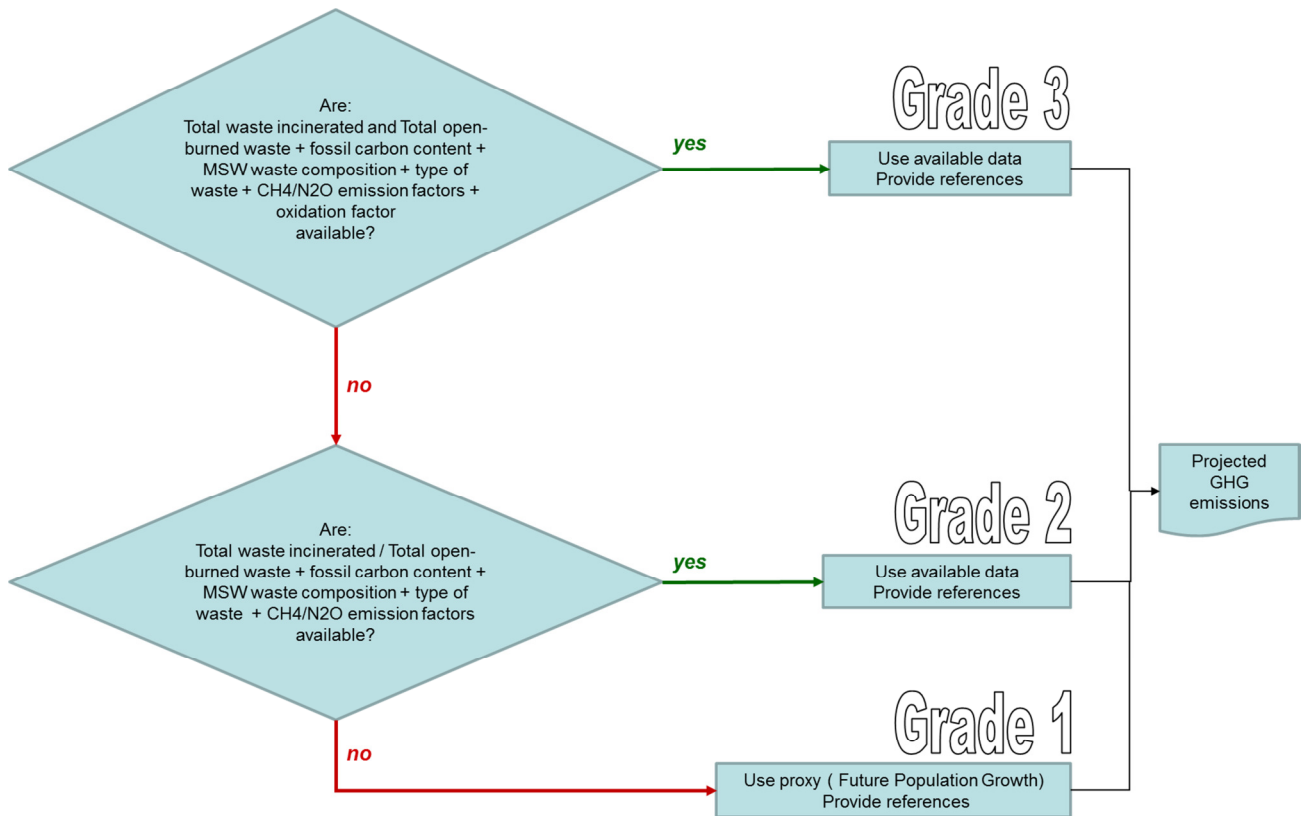
Figure B.5-6 Decision tree for GHG emission projections from waste incineration.

Data Sources.

Oxidation factor *(Grade 3)*

o   parameters could be gathered from industry and/or regulators on the type of installation, operating mode, size and carbon content of ash.

Total waste incinerated, type of waste , fossil carbon content, MSW waste composition and Total open-burned waste *(Grade 2 & 3)*

o   National strategies on waste incineration, open burning, waste disposal routes (e.g. type of waste; MSW, Clinical, Industrial, Sludge)) should be considered for data and assumptions for these parameters. In addition analysis associated with the EU's IPPC Directive (2008/1/EC), Landfill Directive (Directive 1999/31/EC), Directive on waste (Directive 2006/12/EC), Waste Framework Directive 2006/12/EC, Waste Management Framework Directive 2008/98/EC should provide some data and assumptions on commitments on quantities of waste disposed of using different methods including incineration and on the composition of that waste.

o   National strategies and analysis associated with increase incentives to divert biodegradable wastes from SWDS to incinerators and other energy generation systems. (e.g. in response to the

EUs Promotion of the use of energy from renewable sources (Directive 2009/28/EC))should be considered for additional data and assumptions for parameters.

o   Data on planned future incineration capacities from waste disposal or waste to energy plans could be used to check/control assumptions on the total waste incinerated.

Future Population Growth: *(Grade 1)*

o   Use national Population Projections that is consistent with harmonised assumptions across the EU.

Grade 1

Use Future Population Growth to "factor" waste incineration activity data (AD) from the latest historical inventory year (total waste going to incineration) to estimate AD for future years. Assumes that the emission factors for the latest historical year apply for future years unchanged and that no additional energy generation is introduced for waste incineration.

Grade 1 assumes that all other parameters including waste composition used to derive fossil carbon content and proportion of each type (MSW, Clinical, Industrial, Sludge) of waste incinerated (including technology used for incineration) remain unchanged for projected years.

Grade 2

Grade 2 approaches for projected emissions can use equation 5.1, 5.2 and 5.3 for CO2 and 5.4 and 5.5 for CH4 and N2O in IPCC 2006 http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_5_Ch5_IOB.pdf. For each type of waste (MSW, Clinical, chemical, Industrial, Sludge) calculate projected:

1.   Activity Data: using projected data on the total waste incinerated or Total open-burned waste[54] to modify the projected amount of waste incinerated (AD).

2.   Emission Factors: for non MSW CO2 estimates use assumptions on the total fossil carbon content to modify the dry matter, carbon fraction and/or fossil carbon fraction variables to provide projected Emission Factors.

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[54] Where specific AD on the projected total waste incinerated or Total open-burned waste is unavailable use Future Population Growth applied to historical waste AD to estimate projected activity data.

3. Emission Factors: For CO2 estimates from MSW use equation 5.2 and apply projected <u>MSW waste composition</u> assumptions to derive projected <u>fossil carbon content</u> estimates.

4. Emission Factors: for <u>CH4/N2O emission factors</u>, use historic country specific emission factors applying Expert Judgement to estimate projected changes due to increased abatement.

Grade 3

Grade 3 approaches for projected emissions should use the same approach as Grade 2 above using the tier 2 5.1, 5.2 and 5.3 for CO2 and 5.4 and 5.5 for CH4 and N2O in IPCC 2006 http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_5_Ch5_IOB.pdf. Where possible site/country specific data should be use to provide <u>fossil carbon content</u> (<u>MSW waste composition</u> for MSW sites) and <u>oxidation factor</u>. Where projected data is not available this can be based on historical data with expert judgement applied.

1. Grade 3 requires the inclusion of <u>oxidation factor</u> to provide a more accurate picture of emissions resulting from specific type of installation, operating mode, size and carbon content of ash.

2. Grade 3 requires the inclusion of country specific <u>CH4/N2O emission factors</u> to provide a more accurate picture of emissions resulting from specific type of installation, abatement technologies, operating mode and size.

5.5.3   *Policies and Measures*

Policies and Measures for Waste sector are introduced in section 5.1.2.

5.5.4   *Source Specific QA/QC*

General QA/QC should be undertaken for projection estimates (see Part A general QA/QC)

In addition check:

- o that waste incineration and population growth assumptions are consistent with national and EU common assumptions.

- o that the total waste incinerated does not exceed limits relative to the planned future total installed incineration capacity.

- o That specific policy & regulatory commitments affecting incineration can be represented in the emission trends. E.g. Reductions in waste disposal methods.

- o Any sensitivity tests for projection parameters should be documented highlighting the most important/sensitive variables.

o   Ensure all electricity generation from waste incineration are included under 1A.

o   Check that there is no double counting or missing emissions between estimates reported under Waste and Energy.

o   Check country specific CH4 and N2O Emission Factors are justifiable when compared to IPCC 2006 defaults see IPCC 2006 Section 5.4.2 and 5.4.3 respectively.

Annex B.5.I   Analysis of MS PAMs relating to waste from 2009 submissions.

Table 62 Summary of PAMs reported by MS for waste related emissions.

EU policy addressed by / related to the PAM	AT	BE	BG	CY	CZ	DE	DK	EE	ES	FI	FR	GR	HU	IE	IT	LT	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK	Total
Choose.......		1	1	4	2		5		1		2		1			3					1	2	6			1	31
Cross-cut: Integrated pollution prevention and control (IPCC) (Dir 96/61/EC)					1					1										1	1						4
Cross-cut: Kyoto Protocol project mechanisms (Dir 2004/101/EC)										1							1										2
En. consumption: End-use efficiency and energy services (Dir 2006/32/EC)					1																						1
En. supply: Electricity production from renewable energy sources (Dir 2001/77/EC)																			1								1
En. supply: emissions from large combustion plants (Dir 88/609/EEC)															1												1
Waste: Directive on waste (Dir 2006/12/EC)				2		1			1	1	3					2	1	3		3	1					1	19
Waste: Landfill Directive (Dir 1999/31/EC)	4	3		2	1		3	3	2	1	2		1			2	1	3	1	1		2	2		2		39
Waste: Packaging and packaging waste (Dir 94/62/EC, 2004/12/EC, 2005/20/EC)	1				1			2	1	1	1										1					1	9
Total	4	5	1	8	6	1	10	7	6	6	3	2	1	1	2	6	5	5	1	5	3	3	9	2	1	4	107

policyShort	AT	BE	BG	CY	CZ	DE	DK	EE	ES	FI	FR	GR	HU	IE	IT	LT	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK	Total
Biological Treatment of Waste Promotion	1							1		1		1				1	1										6
CH4 Recovery	1	2	1	2	1				1	1	1	1				2		2		1		1	2				19
General Act/Strategy			1		4		3	3	1	1			1			2	2	1				2	5				26
Increased Incineration	1						1																				2
IPPC										1										1							2
Landfill Ban																						1					1
Landfill waste minimisation and Improvements (e.g. L	2			2			1	2					1		1	1	1	1	1						1		14
Minimisation of Incineration							2																				2
Minimisation of Waste (Recovery & Recycling)		1		2	1		1	1	3	1	2				2	1	2		1	1		2			1	2	24
Packaging							2			1										1						1	5
Renewables & Alternative fuels				2																							2
WW Treatment							1					1							2								4
Total	4	5	1	8	6	1	10	7	6	6	3	2	1	1	2	6	5	5	1	5	3	3	9	2	1	4	107

Table 63 PAMs reported in 2009 EUMM projections reporting and included in national projections.

EU policy addressed by / related to the PAM	policyShort	Name of PAM	MS
Unassigned to CCPM	**CH4 Recovery**	Collecting of methane	SE
		Energy from waste	LT
		Methane recovery (WAM)	CY
		Methane recovery (WEM)	CY
		Utilization of the captured methane for production of electricity	BG
	General Act/Strategy	Act XLIII of 2000 on waste management	HU
		Clean air act	CZ
		Climate change awareness	BE
		Climate Information Campaign	SE
		Climate Investment Programme (KLIMP)	SE
		Law on Environmental Pollution Tax	LT
		Local Investment Programme (LIP)	SE
		National programme for mitigation of consequences of climate change in the CR	CZ
		National strategy for sustainable development	RO

		National Strategy for the Implementation of the UNFCCC till 2012	LT
		Plan for urgent measures	ES
		Policy on National Research	MT
		Producer responsibility	SE
		Strategy on the national research-development and innovation for 2007–2013	RO
		Subsidy programme – Enterprise Scheme (special scheme for businesses)	DK
		Subsidy programme for cleaner products	DK
		Support for (construction of facilities for) gas recovery at landfill sites3Origin:	DK
	Landfill waste minimisation and Improvements (e.g. Landfill Directive and Management of uncontrolled Sites)	modernization of the landfilling of solid waste	PL
	Minimisation of Incineration	Energy and CO2 tax on waste incineration	DK
		The waste tax on incineration of waste	DK
	Minimisation of Waste (Recovery & Recycling)	Group of measures aiming at the reduction of household waste by 7 % in the next five years and increasing the recycling rate to 45 %	FR
		Municipal waste plans	SE
		Waste prevention plan	FR
		Waste Strategy for England	UK
	Renewables & Alternative fuels	Use of alternative fuels in industry (WEM)	CY
Cross-cut: Integrated pollution prevention and control (IPCC) (Dir 96/61/EC)	**General Act/Strategy**	Integrated national programme for emission reduction in the Czech Republic	CZ
		The Environ mental Code	SE
	IPPC	Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control (IPPC). (law 16/2002, 1 July, for the integrated prevention and control of contamination. (BOE nº 157 de 2 de julio de 2002.))	ES
		IPPC Directive (Integrated Prevention and Pollution Control) in Waste Sector	PT
Cross-cut: Kyoto Protocol project mechanisms	**General Act/Strategy**	Joint Implementation	EE
		Participation in Kyoto protocol flexible mechanisms	LV

(Dir 2004/101/EC)			
En. consumption: End-use efficiency and energy services (Dir 2006/32/EC)	**General Act/Strategy**	Operational Programme Environment	CZ
En. supply: Electricity production from renewable energy sources (Dir 2001/77/EC)	**CH4 Recovery**	Biogas from Urban Waste Water Treatment	MT
En. supply: emissions from large combustion plants (Dir 88/609/EEC)	**Landfill waste minimisation and Improvements (e.g. Landfill Directive and Management of uncontrolled Sites)**	New methods for landfilling of oil shale ash	EE
Waste: Directive on waste (Dir 2006/12/EC)	**Biological Treatment of Waste Promotion**	Processing biologically degradable waste	LV
		Promoting digestion: feed-in-tariff for the electricity produced by bio- and landfillgas plants	FI
	Minimisation of Waste (Recovery & Recycling)	Directive 2006/12/EC on Waste	SK
		Extension of separate collection	IT
		Law on waste management	LV
		National Integrated Plan for Residual Waste 2008-2012 (PNIR)	ES
		National Plan for waste management (2003-2012)	LV
		National Strategic Waste Management Plan	LT
		National waste management strategy and National waste management plan	RO
		recovery and recycling of waste	PL
		Recycling (WAM)	CY
		Recycling (WEM)	CY
		Reduction of landfilled waste (recycling)	EE
		Separate collection	IT
		Waste Act (1072/1993), National Waste Plan to the 2016	FI

	WW Treatment	implementation of biological wastewater treatment processes	PL
		Improvement of waste water management in sparsely-populated areas	FI
		Reduction of CH4 and N2O emissions in the waste sector	DE
		reduction of energy intensity in wastewater treatment processes	PL
Waste: Landfill Directive (Dir 1999/31/EC)	**Biological Treatment of Waste Promotion**	Action plan for biodegradable waste 2007-2013	EE
		Guideline for trhe Mechanical Biological Treatment of Waste (BMLFUW 2002)	AT
		Recovery of organic waste	GR
		Sant' Antnin Biological Treatment Plant	MT
	CH4 Recovery	biomass content flows	BE
		Degasification of landfills and energy exploitaion or conmbustion of gas	SI
		flaring of landfill gases	BE
		Gas Management at Ta' Zwejra and Ghallis Non-Hazardous Landfills	MT
		Minimising the CH4-emissions from the landfills: Promoting waste incineration and digestion and measures aiming at stop delivery of biowaste in landfills	FI
		Obligation of methane harnessing in landfills and dumps and purchase rates for electricity produced from biogas	FR
		Recovery of biogas	GR
		Recuperation of biogas in landfills	ES
		Reduction of biodegradable waste disposed of in landfills	LT
		Reduction of share of biodegradable waste in landfills	SI
		Remediation of Contaminated Sites Act Federal Legal Gazette No 299/1989	AT
		Utilisation of sewage gas and landfill gas	CZ
		utilization of landfill gas and biogas for energy production	PL
	General Act/Strategy	Government decision on landfills (861/1997), Biowaste strategy (2004)	FI
		National waste management plan 2008-2013	EE
		Restoration of small municipal dumpsites not meeting environmental requirements	LV
	Increased Incineration	Obligation to send combustible waste to incineration (in practice a ban on landfilling).	DK
	Landfill waste	Aerial Emissions Works at Closed landfill sites	MT

	minimisation and Improvements (e.g. Landfill Directive and Management of uncontrolled Sites)		
		Ban on landfills	SE
		Implementation of the EU landfill directive3Origin:	DK
		Landfill Allowance Trading Scheme (LATS)	UK
		Landfill Directive	PT
		Landfill Directive	IE
		Landfill ordinance (collection and drainage of landfill gas) (BGBl.Nr. 164/1996)	AT
		Landfill ordinance (deposition of untreated biodegradable waste) (BGBl.Nr. 164/1996)	AT
		Landfill policy	NL
		Management of uncontrolled disposal sites (WAM)	CY
		Management of uncontrolled disposal sites (WEM)	CY
		Municipal waste management systems	LT
		New requirements for landfills	EE
	Minimisation of Waste (Recovery & Recycling)	Landfill tax escaltor	UK
		minimise quantity of waste into landfill	BE
		RD 1481/2001 concerning the elimination of residual waste by storage on landfills	ES
		The waste tax	DK
		Waste tax	SE
Waste: Packaging and packaging waste (Dir 94/62/EC, 2004/12/EC, 2005/20/EC)	**General Act/Strategy**	Waste act	EE
	Increased Incineration	optimization of new waste incineration (incinerators)	BE
	Minimisation of Waste (Recovery & Recycling)	Act on embalage and wastes	CZ
		RD 252/2006 for the revision of recycling and utilsation objectives established in law 11/1997	ES
	Packaging	Directive on Packaging and Packaging Waste	PT
		Government decision on packaging and packaging waste 962/1997, 1025/2000, 987/2004, 817/2005	FI
		Increased recycling of waste plastic packaging3Origin:	DK
		Packaging Recovery Note (PRN) scheme	UK
		Weight-and-volume-based packaging taxes	DK

Annex B.5.II   IPCC 2006 and IPCC 1996 Source categories

Table 64 IPCC 2006 and IPCC 1996 Source categories.

IPCC 2006 source category		Description	IPCC 1996
1	ENERGY	This category includes all GHG emissions arising from combustion and fugitive releases of fuels. Emissions from the non-energy uses of fuels are generally not included here, but reported under Industrial Processes and Product Use Sector.	
1A	Fuel Combustion Activities	Emissions from the intentional oxidation of materials within an apparatus that is designed to raise heat and provide it either as heat or as mechanical work to a process or for use away from the apparatus.	1A
1A1	Energy Industries	Comprises emissions from fuels combusted by the fuel extraction or energy-producing industries.	1A1
1A1a	Main Activity Electricity and Heat Production	Sum of emissions from main activity producers of electricity generation, combined heat and power generation, and heat plants. Main activity producers (formerly known as public utilities) are defined as those undertakings whose primary activity is to supply the public. They may be in public or private ownership. Emissions from own on-site use of fuel should be included. Emissions from autoproducers (undertakings which generate electricity/heat wholly or partly for their own use, as an activity that supports their primary activity) should be assigned to the sector where they were generated and not under 1 A 1 a. Autoproducers may be in public or private ownership.	1A1a
1A1ai	Electricity Generation	Comprises emissions from all fuel use for electricity generation from main activity producers except those from combined heat and power plants.	1A1a i
1A1aii	Combined Heat and Power Generation (CHP)	Emissions from production of both heat and electrical power from main activity producers for sale to the public, at a single CHP facility.	1A1a ii
1A1aiii	Heat Plants	Production of heat from main activity producers for sale by pipe network.	1A1a iii
1A1b	Petroleum Refining	All combustion activities supporting the refining of petroleum products including on-site combustion for the generation of electricity and heat for own use. Does not include evaporative emissions occurring at the refinery. These emissions should be reported separately under 1 B 2 a.	1A1b
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Combustion emissions from fuel use during the manufacture of secondary and tertiary products from solid fuels including production of charcoal. Emissions from own on-site fuel use should be included. Also includes combustion for the generation of electricity and heat for own use in these industries.	1A1c
1A1ci	Manufacture of Solid Fuels	Emissions arising from fuel combustion for the production of coke, brown coal briquettes and patent fuel.	1A1c i
1A1cii	Other Energy Industries	Combustion emissions arising from the energy-producing industries own (on-site) energy use not mentioned above or for which separate data are not available. This includes the emissions from own-energy use for the production of charcoal, bagasse, saw dust, cotton stalks and carbonizing of biofuels as well as fuel used for coal mining, oil and gas extraction and the processing and upgrading of natural gas. This category also includes emissions from pre-combustion processing for CO_2 capture and storage. Combustion emissions from pipeline transport should be reported under 1 A 3 e.	1A1c ii
1A2	Manufacturing Industries and	Emissions from combustion of fuels in industry. Also includes combustion for the generation of electricity and heat for own use in these industries.	1A2

IPCC 2006 source category		Description	IPCC 1996
	Construction	Emissions from fuel combustion in coke ovens within the iron and steel industry should be reported under 1 A 1 c and not within manufacturing industry. Emissions from the industry sector should be specified by sub-categories that correspond to the International Standard Industrial Classification of all Economic Activities (ISIC). Energy used for transport by industry should not be reported here but under Transport (1 A 3). Emissions arising from off-road and other mobile machinery in industry should, if possible, be broken out as a separate subcategory. For each country, the emissions from the largest fuel-consuming industrial categories ISIC should be reported, as well as those from significant emitters of pollutants. A suggested list of categories is outlined below.	
1A2a	Iron and Steel	ISIC Group 271 and Class 2731.	
1A2b	Non-Ferrous Metals	ISIC Group 272 and Class 2732.	1A2b
1A2c	Chemicals	ISIC Division 24.	1A2c
1A2d	Pulp, Paper and Print	ISIC Divisions 21 and 22.	1A2d
1A2e	Food Processing, Beverages and Tobacco	ISIC Divisions 15 and 16	1A2e
1A2f	Non-Metallic Minerals	ISIC Division 26.. Includes products such as glass ceramic, cement, etc.	1A2f
1A2g	Transport Equipment	ISIC Divisions 34 and 35.	
1A2h	Machinery	Includes fabricated metal products, machinery and equipment other than transport equipment. ISIC Divisions 28, 29, 30, 31 and 32.	1A2f
1A2i	Mining (excluding fuels) and Quarrying	ISIC Divisions 13 and 14.	NA
1A2j	Wood and Wood Products	ISIC Division 20.	NA
1A2k	Construction	ISIC Division 45.	1A2f
1A2l	Textile and Leather	ISIC Divisions 17, 18 and 19.	NA
1A2m	Non-specified Industry:	Any manufacturing industry/construction not included above or for which separate data are not available. Includes ISIC Divisions 25, 33, 36 and 37.	NA
1A3	Transport	Emissions from the combustion and evaporation of fuel for all transport activity (excluding military transport), regardless of the sector, specified by sub-categories below. Emissions from fuel sold to any air or marine vessel engaged in international transport (1 A 3 a i and 1 A 3 d i) should as far as possible be excluded from the totals and subtotals in this category and should be reported separately.	1A3
1A3a	Civil Aviation	Emissions from international and domestic civil aviation, including take-offs and landings. Comprises civil commercial use of airplanes, including: scheduled and charter traffic for passengers and freight, air taxiing, and general aviation. The international/domestic split should be determined on the basis of departure and landing locations for each flight stage and not by the nationality of the airline. Exclude use of fuel at airports for ground transport which is reported under 1 A 3 e Other Transportation. Also exclude fuel for stationary combustion at airports; report this information under the	1A3a

IPCC 2006 source category		Description	IPCC 1996
		appropriate stationary combustion category.	
1A3ai	International Aviation (International Bunkers)	Emissions from flights that depart in one country and arrive in a different country. Include take-offs and landings for these flight stages. Emissions from international military aviation can be included as a separate sub-category of international aviation provided that the same definitional distinction is applied and data are available to support the definition.	1A3a i
1A3aii	Domestic Aviation	Emissions from civil domestic passenger and freight traffic that departs and arrives in the same country (commercial, private, agriculture, etc.), including take-offs and landings for these flight stages. Note that this may include journeys of considerable length between two airports in a country (e.g. San Francisco to Honolulu). Exclude military, which should be reported under 1 A 5 b.	1A3a ii
1A3b	Road Transportation	All combustion and evaporative emissions arising from fuel use in road vehicles, including the use of agricultural vehicles on paved roads.	1A3b
1A3bi	Cars	Emissions from automobiles so designated in the vehicle registering country primarily for transport of persons and normally having a capacity of 12 persons or fewer.	1A3b i
1A3bi	Passenger Cars With 3-way Catalysts	Emissions from passenger car vehicles with 3-way catalysts.	1A3b i
1A3bi	Passenger Cars Without 3-way Catalysts	Passenger car emissions from vehicles without 3-way catalysts.	1A3b i
1A3bii	Light-duty Trucks	Emissions from vehicles so designated in the vehicle registering country primarily for transportation of light-weight cargo or which are equipped with special features such as four-wheel drive for off-road operation. The gross vehicle weight normally ranges up to 3500-3900 kg or less.	1A3b ii, 1A3b i
1A3bii	Light-duty Trucks With 3-way Catalysts	Emissions from light duty trucks with 3-way catalysts.	1A3b ii
1A3bii	Light-duty Trucks Without 3-way Catalysts	Emissions from light duty trucks without 3-way catalysts.	1A3b ii
1A3biii	Heavy-duty Trucks and Buses	Emissions from any vehicles so designated in the vehicle registering country. Normally the gross vehicle weight ranges from 3500-3900 kg or more for heavy duty trucks and the buses are rated to carry more than 12 persons.	1A3b iii
1A3biv	Motorcycles	Emissions from any motor vehicle designed to travel with not more than three wheels in contact with the ground and weighing less than 680 kg.	1A3b iv
1A3bv	Evaporative Emissions from Vehicles	Evaporative emissions from vehicles (e.g. hot soak, running losses) are included here. Emissions from loading fuel into vehicles are excluded.	1A3b v
1A3bvi	Urea-based Catalysts	CO_2 emissions from use of urea-based additives in catalytic converters (non-combustive emissions).	
1A3c	Railways	Emissions from railway transport for both freight and passenger traffic routes.	1A3c
1A3d	Water-borne Navigation	Emissions from fuels used to propel water-borne vessels, including hovercraft and hydrofoils, but excluding fishing vessels. The international/domestic split should be determined on the basis of port of departure and port of arrival, and not by the flag or nationality of the ship.	1A3d
1A3di	International Water-borne	Emissions from fuels used by vessels of all flags that are engaged in international water-borne navigation. The international navigation may take	1A3d i

IPCC 2006 source category		Description	IPCC 1996
	Navigation (International Bunkers)	place at sea, on inland lakes and waterways and in coastal waters. Includes emissions from journeys that depart in one country and arrive in a different country. Exclude consumption by fishing vessels (see Other Sector - Fishing). Emissions from international military water-borne navigation can be included as a separate sub-category of international water-borne navigation provided that the same definitional distinction is applied and data are available to support the definition.	
1A3dii	Domestic Water-borne Navigation	Emissions from fuels used by vessels of all flags that depart and arrive in the same country (exclude fishing, which should be reported under 1 A 4 c iii, and military, which should be reported under 1 A 5 b). Note that this may include journeys of considerable length between two ports in a country (e.g. San Francisco to Honolulu).	1A3d ii
1A3e	Other Transportation	Combustion emissions from all remaining transport activities including pipeline transportation, ground activities in airports and harbours, and off-road activities not otherwise reported under 1 A 4 c Agriculture or 1 A 2. Manufacturing Industries and Construction. Military transport should be reported under 1 A 5 (see 1 A 5 Non-specified).	1A3de
1A3ei	Pipeline Transport	Combustion related emissions from the operation of pump stations and maintenance of pipelines. Transport via pipelines includes transport of gases, liquids, slurry and other commodities via pipelines. Distribution of natural or manufactured gas, water or steam from the distributor to final users is excluded and should be reported in 1 A 1 c ii or 1 A 4 a.	1A3e
1A3eii	Off-road	Combustion emissions from Other Transportation excluding Pipeline Transport.	1A3e
1A4	Other Sectors	Emissions from combustion activities as described below, including combustion for the generation of electricity and heat for own use in these sectors.	1A4
1A4a	Commercial/Institutional	Emissions from fuel combustion in commercial and institutional buildings; all activities included in ISIC Divisions 41,50, 51, 52, 55, 63-67, 70-75, 80, 85, 90-93 and 99.	1A 4 a
1A4b	Residential	All emissions from fuel combustion in households.	1A4b
1A4c	Agriculture/Forestry/Fishing/Fish Farms	Emissions from fuel combustion in agriculture, forestry, fishing and fishing industries such as fish farms. Activities included in ISIC Divisions 01, 02 and 05. Highway agricultural transportation is excluded.	1A4c
1A4ci	Stationary	Emissions from fuels combusted in pumps, grain drying, horticultural greenhouses and other agriculture, forestry or stationary combustion in the fishing industry.	1A4ci
1A4cii	Off-road Vehicles and Other Machinery	Emissions from fuels combusted in traction vehicles on farm land and in forests.	1A3e
1A4ciii	Fishing (mobile combustion)	Emissions from fuels combusted for inland, coastal and deep-sea fishing. Fishing should cover vessels of all flags that have refuelled in the country (include international fishing).	1A4ciii
1A5	Non-Specified	All remaining emissions from fuel combustion that are not specified elsewhere. Include emissions from fuel delivered to the military in the country and delivered to the military of other countries that are not engaged in multilateral operations Emissions from fuel sold to any air or marine vessel engaged in multilateral operation pursuant to the Charter of the United Nations should be excluded from the totals and subtotals of the military transport, and should be	1A5

IPCC 2006 source category		Description	IPCC 1996
		reported separately.	
1A5a	Stationary	Emissions from fuel combustion in stationary sources that are not specified elsewhere.	1A5a
1A5b	Mobile	Emissions from vehicles and other machinery, marine and aviation (not included in 1 A 4 c ii or elsewhere).	1A5b
1A5bi	Mobile (Aviation Component)	All remaining aviation emissions from fuel combustion that are not specified elsewhere. Include emissions from fuel delivered to the country's military not otherwise included separately in 1 A3 a i as well as fuel delivered within that country but used by militaries of other countries that are not engaged in multilateral operation pursuant to the Charter of the United Nations.	
1A5bii	Mobile (Water-borne Component)	All remaining water-borne emissions from fuel combustion that are not specified elsewhere. Include emissions from fuel delivered to the country's military not otherwise included separately in 1 A3 d i as well as fuel delivered within that country but used by militaries of other countries that are not engaged in multilateral operation pursuant to the Charter of the United Nations.	
1A5biii	Mobile (Other)	All remaining emissions from mobile sources not included elsewhere.	
1A5c	Multilateral Operations	Emissions from fuel sold to any air or marine vessel engaged in multilateral operations pursuant to the Charter of the United Nations should be excluded from the totals and subtotals of the military transport, and should be reported separately.	
1B	Fugitive Emissions from Fuels	Includes all intentional and unintentional emissions from the extraction, processing, storage and transport of fuel to the point of final use.	
1B1	Solid Fuels	Includes all intentional and unintentional emissions from the extraction, processing, storage and transport of fuel to the point of final use.	1B
1B1a	Coal Mining and Handling	Includes all fugitive emissions from coal.	1B1
1B1ai	Underground Mines	Includes all emissions arising from mining, post-mining, abandoned mines and flaring of drained methane.	1B1a
1B1ai	Mining	Includes all seam gas emissions vented to atmosphere from coal mine ventilation air and degasification systems.	1B1a i
1B1ai	Post-mining Seam Gas Emissions	Includes methane and CO_2 emitted after coal has been mined, brought to the surface and subsequently processed, stored and transported.	1B1a i
1B1ai	Abandoned Underground Mines	Includes methane emissions from abandoned underground mines.	1B1a i
1B1ai	Flaring of Drained Methane or Conversion of Methane to CO_2	Methane drained and flared, or ventilation gas converted to CO_2 by an oxidation process should be included here. Methane used for energy production should be included in Volume 2, Energy, Chapter 2 'Stationary Combustion'.	1B1a i
1B1aii	Surface Mines	Includes all seam gas emissions arising from surface coal mining.	1B1a i
1B1aii	Mining	Includes methane and CO_2 emitted during mining from breakage of coal and associated strata and leakage from the pit floor and high wall.	1B1a ii
1B1aii	Post-mining Seam Gas Emissions	Includes methane and CO_2 emitted after coal has been mined, subsequently processed, stored and transported.	
1B1b	Uncontrolled Combustion,	Includes fugitive emissions of CO_2 from uncontrolled combustion in coal.	1B1a ii

IPCC 2006 source category		Description	IPCC 1996
	and Burning Coal Dumps		
1B1c	Solid Fuel Transformation	Fugitive emissions arising during the manufacture of secondary and tertiary products from solid fuels.	1B1c
1B2	Oil and Natural Gas	Comprises fugitive emissions from all oil and natural gas activities. The primary sources of these emissions may include fugitive equipment leaks, evaporation losses, venting, flaring and accidental releases.	1B1b
1B2a	Oil	Comprises emissions from venting, flaring and all other fugitive sources associated with the exploration, production, transmission, upgrading, and refining of crude oil and distribution of crude oil products.	1B2
1B2ai	Venting	Emissions from venting of associated gas and waste gas/vapour streams at oil facilities.	1B2a
1B2aii	Flaring	Emissions from flaring of natural gas and waste gas/vapour streams at oil facilities.	
1B2aiii	All Other	Fugitive emissions at oil facilities from equipment leaks, storage losses, pipeline breaks, well blowouts, land farms, gas migration to the surface around the outside of wellhead casing, surface casing vent bows, biogenic gas formation from tailings ponds and any other gas or vapour releases not specifically accounted for as venting or flaring.	
1B2aiii	Exploration	Fugitive emissions (excluding venting and flaring) from oil well drilling, drill stem testing, and well completions.	
1B2aiii	Production and Upgrading	Fugitive emissions from oil production (excluding venting and flaring) occur at the oil wellhead or at the oil sands or shale oil mine through to the start of the oil transmission system. This includes fugitive emissions related to well servicing, oil sands or shale oil mining, transport of untreated production (i.e , well effluent, emulsion, oil shale and oilsands) to treating or extraction facilities, activities at extraction and upgrading facilities, associated gas re-injection systems and produced water disposal systems. Fugitive emission from upgraders are grouped with those from production rather than those from refining since the upgraders are often integrated with extraction facilities and their relative emission contributions are difficult to establish. However, upgraders may also be integrated with refineries, co-generation plants or other industrial facilities and their relative emission contributions can be difficult to establish in these cases.	1B2a i
1B2aiii	Transport	Fugitive emissions (excluding venting and flaring) related to the transport of marketable crude oil (including conventional, heavy and synthetic crude oil and bitumen) to upgraders and refineries. The transportation systems may comprise pipelines, marine tankers, tank trucks and rail cars. Evaporation losses from storage, filling and unloading activities and fugitive equipment leaks are the primary sources of these emissions.	1B2a ii
1B2aiii	Refining	Fugitive emissions (excluding venting and flaring) at petroleum refineries. Refineries process crude oils, natural gas liquids and synthetic crude oils to produce final refined products (e.g., primarily fuels and lubricants). Where refineries are integrated with other facilities (for example, upgraders or co-generation plants) their relative emission contributions can be difficult to establish.	1B2a iii
1B2aiii	Distribution of Oil Products	This comprises fugitive emissions (excluding venting and flaring) from the transport and distribution of refined products, including those at bulk terminals and retail facilities. Evaporation losses from storage, filling and unloading activities and fugitive equipment leaks are the primary sources of	1B2a iv

IPCC 2006 source category		Description	IPCC 1996
		these emissions.	
1B2aiii	Other	Fugitive emissions from oil systems (excluding venting and flaring) not otherwise accounted for in the above categories. This includes fugitive emissions from spills and other accidental releases, waste oil treatment facilities and oilfield waste disposal facilities.	1B2a v
1B2b	Natural Gas	Comprises emissions from venting, flaring and all other fugitive sources associated with the exploration, production, processing, transmission, storage and distribution of natural gas (including both associated and non-associated gas).	1B2a vi
1B2bi	Venting	Emissions from venting of natural gas and waste gas/vapour streams at gas facilities.	1B2b
1B2bii	Flaring	Emissions from flaring of natural gas and waste gas/vapour streams at gas facilities.	
1B2biii	All Other	Fugitive emissions at natural gas facilities from equipment leaks, storage losses, pipeline breaks, well blowouts, gas migration to the surface around the outside of wellhead casing, surface casing vent bows and any other gas or vapour releases not specifically accounted for as venting or flaring.	
1B2biii	Exploration	Fugitive emissions (excluding venting and flaring) from gas well drilling, drill stem testing and well completions.	
1B2biii	Production	Fugitive emissions (excluding venting and flaring) from the gas wellhead through to the inlet of gas processing plants, or, where processing is not required, to the tie-in points on gas transmission systems. This includes fugitive emissions related to well servicing, gas gathering, processing and associated waste water and acid gas disposal activities.	1Bb i
1B2biii	Processing	Fugitive emissions (excluding venting and flaring) from gas processing facilities.	1Bb ii
1B2biii	Transmission and Storage	Fugitive emissions from systems used to transport processed natural gas to market (i.e., to industrial consumers and natural gas distribution systems). Fugitive emissions from natural gas storage systems should also be included in this category. Emissions from natural gas liquids extraction plants on gas transmission systems should be reported as part of natural gas processing (Sector 1.B.2.b.iii.3). Fugitive emissions related to the transmission of natural gas liquids should be reported under Category 1.B.2.a.iii.3.	1Bb iii
1B2biii	Distribution	Fugitive emissions (excluding venting and flaring) from the distribution of natural gas to end users.	1B2b ii
1B2biii	Other	Fugitive emissions from natural gas systems (excluding venting and flaring) not otherwise accounted for in the above categories. This may include emissions from well blowouts and pipeline ruptures or dig-ins.	NA
1B3	Other Emissions from Energy Production	Other fugitive emissions for example, from geo thermal energy production, peat and other energy production not included in 1.B.2.	1B2 c
1C	Carbon Dioxide Transport and Storage	Carbon dioxide (CO_2) capture and storage (CCS) involves the capture of CO_2 from anthropogenic sources, its transport to a storage location and its long-term isolation from the atmosphere. Emissions associated with CO_2 transport, injection and storage are covered under category 1C. Emissions (and reductions) associated with CO_2 capture should be reported under the IPCC Sector in which capture takes place (e.g. Fuel Combustion or Industrial Activities).	
1C1	Transport of CO_2	This comprises fugitive emissions from the systems used to transport captured CO_2 from the source to the injection site. These emissions may comprise losses due to fugitive equipment leaks, venting and releases due to pipeline ruptures or other accidental releases (e.g., temporary storage).	

IPCC 2006 source category		Description	IPCC 1996
1C1a	Pipelines	Fugitive emissions from the pipeline system used to transport CO_2 to the injection site.	
1C1b	Ships	Fugitive emissions from the ships used to transport CO_2 to the injection site.	
1C1c	Other (please specify)	Fugitive emissions from other systems used to transport CO_2 to the injection site and temporary storage	
1C2	Injection and Storage	Fugitive emissions from activities and equipment at the injection site and those from the end containment once the CO_2 is placed in storage.	
1C2a	Injection	Fugitive emissions from activities and equipment at the injection site.	
1C2b	Storage	Fugitive emissions from the end equipment once the CO_2 is placed in storage.	
1C3	Other	Any other emissions from CCS not reported elsewhere.	
2	INDUSTRIAL PROCESSES AND PRODUCT USE	Emissions from industrial processes and product use, excluding those related to energy combustion (reported under 1A), extraction, processing and transport of fuels (reported under 1B) and CO_2 transport, injection and storage (reported under 1C).	
2A	Mineral Industry		
2A1	Cement Production	Process-related emissions from the production of various types of cement (ISIC: D2694).	2A
2A2	Lime Production	Process-related emissions from the production of various types of lime (ISIC: D2694).	2A1
2A3	Glass Production	Process-related emissions from the production of various types of glass (ISIC: D2610).	2A2
2A4	Other Process Uses of Carbonates	Includes limestone, dolomite and other carbonates etc. Emissions from the use of limestone, dolomite and other carbonates should be included in the industrial source category where they are emitted. Therefore, for example, where a carbonate is used as a flux for iron and steel production, resultant emissions should be reported under 2C1 "Iron and Steel Production" rather than this subcategory.	2A3, 2A4
2A4a	Ceramics	Process-related emissions from the production of bricks and roof tiles, vitrified clay pipes, refractory products, expanded clay products, wall and floor tiles, table and ornamental ware (household ceramics), sanitary ware, technical ceramics, and inorganic bonded abrasives (ISIC: D2691, D2692 and D2693).	2A3, 2A4
2A4b	Other Uses of Soda Ash	This should include emissions from soda ash use that are not included elsewhere. For example, soda ash used for glass should be reported in 2A3.	2A3
2A4c	Non Metallurgical Magnesia Production	This source category should include emissions from magnesia production that are not included elsewhere. For example, where magnesia production is used for primary and secondary magnesium production, emissions should be reported in relevant source category in Metals.	2A4
2A4d	Other (please specify)	Process-related emissions reported under this sub-category should include all other miscellaneous uses of limestone, dolomite and other carbonates, except from uses already listed in the sub-categories above, and uses as fluxes or slagging agents in the Metals and Chemicals industries, or for the liming of soils and wetlands in Agriculture, Forestry and Other Land Uses (ISIC D269).	2A3
2A5	Other (please specify)		2A3
2B	Chemical Industry		2A7
2B1	Ammonia Production	Ammonia (NH3) is a major industrial chemical and the most important nitrogenous material produced. Ammonia gas is used directly as a fertilizer, in heat treating, paper pulping, nitric acid and nitrates manufacture, nitric acid	2B, 2A4, 3C

IPCC 2006 source category	Description	IPCC 1996
	ester and nitro compound manufacture, explosives of various types, and as a refrigerant. Amines, amides, and miscellaneous other organic compounds, such as urea, are made from ammonia. The main greenhouse gas emitted from NH3 production is CO_2. CO_2 used in the production of urea, a downstream process, should be subtracted from the CO_2 generated and accounted for in the AFOLU Sector.	
2B2	Nitric Acid Production	Nitric acid is used as a raw material mainly in the manufacture of nitrogenous-based fertiliser. 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. The main greenhouse gas emitted from HNO3 production is nitrous oxide.	2B1
2B3	Adipic Acid Production	Adipic acid is used in the manufacture of a large number 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. The main greenhouse gas emitted from adipic acid production is nitrous oxide.	2B2
2B4	Caprolactam, Glyoxal and Glyoxylic Acid Production	Most of the annual production of caprolactam (NH(CH2)5CO) is consumed as the monomer for nylon-6 fibres and plastics, with a substantial proportion of the fibre used in carpet manufacturing. All commercial processes for the manufacture of caprolactam are based on either toluene or benzene. This subcategory also covers production of glyoxal (ethanedial) and glyoxylic acid production. The main greenhouse gas emitted from this subcategory is nitrous oxide.	2B3
2B5	Carbide Production	The production of carbide can result in emissions of CO_2, CH4, CO and SO2. Silicon carbide is a significant artificial abrasive. It is produced from silica sand or quartz and petroleum coke. Calcium carbide is used in the production of acetylene, in the manufacture of cyanamide (a minor historical use), and as a reductant in electric arc steel furnaces. It is made from calcium carbonate (limestone) and carbon-containing reductant (petroleum coke).	2B5
2B6	Titanium Dioxide Production	Titanium dioxide (TiO2) is the most important white pigment. The main use is in paint manufacture followed by paper, plastics, rubber, ceramics, fabrics, floor covering, printing ink, and other miscellaneous uses. The main production process is the chloride route, giving rise to CO_2 emissions that are likely to be significant. This category also includes synthetic rutile production using the Becher process, and titanium slag production, both of which are reduction processes using fossil fuels and resulting in CO_2 emissions. Synthetic rutile is the major input to TiO2 production using the chloride route.	2B4
2B7	Soda Ash Production	Soda ash (sodium carbonate, Na2CO3) is a white crystalline solid that is used as a raw material in a large number of industries including glass manufacture, soap and detergents, pulp and paper production and water treatment. Emissions of CO_2 from the production of soda ash vary dependent on the manufacturing process. Four different processes may be used to produce soda ash. Three of these processes, monohydrate, sodium sesquicarbonate (trona) and direct carbonation, are referred to as natural processes. The fourth, the Solvay process, is classified as a synthetic process.	2B5
2B8	Petrochemical and Carbon Black Production		2A4
2B8a	Methanol	Methanol production covers production of methanol from fossil fuel feedstocks [natural gas, petroleum, coal] using steam reforming or partial oxidation processes. Production of methanol from biogenic feedstocks (e.g., by fermentation) is not included in this source category.	2B5
2B8b	Ethylene	Ethylene production covers production of ethylene from fossil fuel-derived	2B5

IPCC 2006 source category		Description	IPCC 1996
		feedstocks at petrochemical plants by the steam cracking process. Production of ethylene from processes situation within the boundaries of petroleum refineries is not included in this source category. The greenhouse gases produced from ethylene production are carbon dioxide and methane.	
2B8c	Ethylene Dichloride and Vinyl Chloride Monomer	Ethylene dichloride and vinyl chloride monomer production covers production of ethylene dichloride by direct oxidation or oxychloination of ethylene, and the production of vinyl chloride monomer from ethylene dichloride. The greenhouse gases produced from production of ethylene dichloride production and vinyl chloride monomer production are carbon dioxide and methane.	2B5
2B8d	Ethylene Oxide	Ethylene oxide production covers production of ethylene oxide by reaction of ethylene and oxygen by catalytic oxidation. The greenhouse gases produced from ethylene oxide production are carbon dioxide and methane.	2B5
2B8e	Acrylonitrile	Acrylonitrile production covers production of acrylonitrile from ammoxidation of propylene, and associated production of acetonitrile and hydrogen cyanide from the ammoxidation process. The greenhouse gases produced from production of acrylonitrile are carbon dioxide and methane.	2B5
2B8f	Carbon Black	Carbon black production covers production of carbon black from fossil fuel-derived feedstocks (petroleum or coal-derived carbon black feedstock, natural gas, acetylene). Production of carbon black from biogenic feedstocks is not included in this source category.	2B5
2B9	Fluorochemical Production		2B5, 3C
2B9a	By-product Emissions	Fluorochemical Production covers the complete range of fluorochemicals, whether or not the principal products are greenhouse gases. Emissions encompass HFCs, PFCs, SF6 and all other halogenated gases with global warming potential listed in IPCC assessment reports. The most significant by-product emission is that of HFC-23 from the manufacture of HCFC-22 and this is described separately.	2E
2B9b	Fugitive Emissions	These are emissions of the principal product from the process to manufacture it and so fluorochemical production in this context is limited to HFCs, PFCs, SF6 and other halogenated gases with global warming potential listed in IPCC assessment reports.	2
2B10	Other (Please specify)	For example, gases with global warming potential listed in IPCC assessment reports that do not fall within any categories above could be reported here, if they are estimated.	2
2C	Metal Industry		2B5
2C1	Iron and Steel Production	Carbon dioxide is the predominant gas emitted from the production of iron and steel. The sources of the carbon dioxide emissions include that from carbon-containing reducing agents such as coke and pulverized coal, and, from minerals such as limestone and dolomite added.	2C
2C2	Ferroalloys Production	Ferroalloys production covers emissions from primary metallurgical reduction production of the most common ferroalloys, i.e. ferro-silicon, silicon metal, ferro-manganese, silicon manganese, and ferro-chromium, excluding those emissions relating to fuel use. From the production of these alloys, carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH4) originating from ore- and reductant raw materials, is emitted.	2C1
2C3	Aluminium Production	Aluminium Production covers primary production of aluminium, except the emissions related to the use of fuel. Carbon dioxide emissions result from the electrochemical reduction reaction of alumina with a carbon-based anode. Tetrafluoromethane (CF4) and hexafluoroethane (C2F6) are also produced	2C2

IPCC 2006 source category		Description	IPCC 1996
		intermittently. No greenhouse gases are produced in recycling of aluminium other than from the fuels uses for metal remelting. Sulphur hexafluoride (SF6) emissions are not associated with primary aluminium production; however, casting of some high magnesium containing alloys does result in SF6 emissions and these emissions are accounted for in Section 2C4, Magnesium Production.	
2C4	Magnesium Production	Magnesium production covers GHG emissions related to both primary magnesium production as well as oxidation protection of magnesium metal during processing (recycling and casting), excluding those emissions relating to fuel use. In the primary production of magnesium, carbon dioxide (CO_2) is emitted during calcination of dolomite and magnesite raw materials. Primary production of magnesium from non-carbonate raw materials does not emit carbon dioxide. In the processing of liquid magnesium, cover gases containing carbon dioxide (CO_2), sulphur hexafluoride (SF6), the hydrofluorocarbon HFC 134a or the fluorinated ketone FK 5-1-12 (C3F7C(O)C2F5) may be used. Partial thermal decomposition and/or reaction between these compounds and liquid magnesium generates secondary compounds such as perfluorocarbons (PFCs), which are emitted in addition to unreacted cover gas constituents.	2C3
2C5	Lead Production	Lead production covers production by the sintering/smelting process as well as direct smelting. Carbon dioxide emissions result as a product of the use of a variety of carbon-based reducing agents in both production processes.	2C4
2C6	Zinc Production	Zinc production covers emissions from both primary production of zinc from ore as well as recovery of zinc from scrap metals, excluding emissions related to fuel use. Following calcination, zinc metal is produced through one of three methods; 1-electro-thermic distillation, 2-pyro-metallurgical smelting or 3-electrolysis. If method 1 or 2 is used, carbon dioxide (CO_2) is emitted. Method 3 does not result in carbon dioxide emissions. Recovery of zinc from metal scrap often uses the same methods as primary production and may thus produce carbon dioxide emissions, which is included in this section.	
2C7	Other (please specify)		2C5
2D	Non-Energy Products from Fuels and Solvent Use	The use of oil products and coal-derived oils primarily intended for purposes other than combustion.	2C5
2D1	Lubricant Use	Lubricating oils, heat transfer oils, cutting oils and greases.	2C5
2D2	Paraffin Wax Use	Oil-derived waxes such as petroleum jelly, paraffin waxes and other waxes.	1, 2A5, 2A6, 3
2D3	Solvent Use	NMVOC emissions from solvent use e.g. in paint application, degreasing and dry cleaning should be contained here. Emissions from the use of HFCs and PFCs as solvents should be reported under 2F5.	1, 3
2D4	Other (please specify)	For example, CH4, CO and NMVOC emissions from asphalt production and use (including asphalt blowing), as well as NMVOC emissions from the use of other chemical products than solvents should be contained here, if relevant.	1, 3
2E	Electronics Industry		3A, 3B
2E1	Integrated Circuit or Semiconductor	Emissions of CF4, C2F6, C3F8, c-C4F8, C4F6, C4F8O, C5F8, CHF3, CH2F2, NF3 and SF6 from uses of these gases in Integrated Circuit (IC) manufacturing in rapidly evolving ways and in varying amounts, which depend on product (e.g., memory or logic devices) and equipment manufacturer.	2A5, 2A6, 3D
2E2	TFT Flat Panel Display	Uses and emissions of predominantly CF4, CHF3, NF3 and SF6 during the fabrication of thin-film transistors (TFTs) on glass substrates for flat panel	2F6

IPCC 2006 source category		Description	IPCC 1996
		display manufacture. In addition to these gases, C2F6, C3F8 and c-C4F8 may also be used and emitted during the manufacture of thin and smart displays.	
2E3	Photovoltaics	Photovoltaic cell manufacture may use and emit CF4 and C2F6 among others.	2F6
2E4	Heat Transfer Fluid	Heat transfer fluids, which include several fully fluorinated carbon compounds (either in pure form or in mixtures) with six or more carbon atoms, used and emitted during IC manufacture, testing and assembly. They are used in chillers, temperature shock testers and vapour phase reflow soldering.	2F6
2E5	Other (please specify)		2F6
2F	Product Uses as Substitutes for Ozone Depleting Substances		2F6
2F1	Refrigeration and Air Conditioning	Refrigeration and air-conditioning systems are usually classified in six application domains or categories. These categories utilise different technologies such as heat exchangers, expansion devices, pipings and compressors. The six application domains are domestic refrigeration, commercial refrigeration, industrial processes, transport refrigeration, stationary air conditioning, mobile air-conditioning systems. For all these applications, various HFCs are selectively replacing CFCs and HCFCs. For example, in developed countries, HFC-134a has replaced CFC-12 in domestic refrigeration and mobile air conditioning systems, and blends of HFCs such as R-407C (HFC-32/HFC-125/HFC-134a) and R-410A (HFC-32/HFC-125) are replacing HCFC-22 mainly in stationary air conditioning. Other, non HFC substances are used to replace CFCs and HCFCs such as iso-butane in domestic refrigeration or ammonia in industrial refrigeration. HFC-152a is also being considered for mobile air conditioning in several regions.	2F6
2F1a	Refrigeration and Stationary Air Conditioning	The application domains are domestic refrigeration, commercial refrigeration, industrial processes, stationary air conditioning.	2F
2F1b	Mobile Air Conditioning	The application domains are transport refrigeration, mobile air-conditioning systems.	2F1
2F2	Foam Blowing Agents	HFCs are being used as replacements for CFCs and HCFCs in foams, particularly in closed-cell insulation applications. Compounds that are being used include HFC-245fa, HFC-365mfc, HFC-227ea, HFC-134a, and HFC-152a. The processes and applications for which these various HFCs are being used include insulation boards and panels, pipe sections, sprayed systems and one-component gap filling foams. For open-cell foams, such as integral skin products for automotive steering wheels and facials, emissions of HFCs used as blowing agents are likely to occur during the manufacturing process. In closed-cell foam, emissions not only occur during the manufacturing phase, but usually extend into the in-use phase and often the majority of emission occurs at the end-of-life (de-commissioning losses). Accordingly, emissions can occur over a period of up to 50 years or even longer.	
2F3	Fire Protection	There are two general types of fire protection (fire suppression) equipment that use greenhouse gases as partial replacements for halons: portable (streaming) equipment, and fixed (flooding) equipment. The non-ozone depleting, industrial gases HFCs, PFCs and more recently a fluoroketone are mainly used as substitutes for halons, typically halon 1301, in flooding equipment. PFCs played an early role in halon 1301 replacement but current	2F1

IPCC 2006 source category		Description	IPCC 1996
		use is limited to replenishment of previously installed systems. HFCs in portable equipment, typically replacing halon 1211, are available but have achieved very limited market acceptance due primarily to their high cost. PFC use in new portable extinguishers is currently limited to a small amount (few percent) in an HCFC blend.	
2F4	Aerosols	Most aerosol packages now contain hydrocarbon (HC) as propellants but, in a small fraction of the total, HFCs and PFCs may be used as propellants or solvents. Emissions from aerosols usually occur shortly after production, on average six months after sale. During the use of aerosols, 100% of the chemical is emitted. The 5 main sources are metered dose inhalers (MDIs), 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 contact, lubricants, pipe-freezers) and other general products (e.g. silly string, tire inflators, claxons), although in some regions the use of such general products is restricted. The HFCs currently used as propellants are HFC 134a, HFC 227ea, and HFC 152a. The substance HFC 43 10mee and a PFC, perfluorohexane, are used as solvents in industrial aerosol products.	2F1
2F5	Solvents	HFCs and, to a much lesser extent PFCs, are being used as substitutes for ozone depleting substances (most notably CFC-113). Typical HFCs used are HFC-365mfc and HFC-43-10mee. Use of these fluorinated replacements is much less widespread than the ozone depleting substances they replace. Re-capture and re-use is also much more widely practiced The primary areas of use are precision cleaning, electronics cleaning, metal cleaning and deposition applications. Emissions from aerosols containing solvents should be reported under category 2F4 "Aerosols" rather than under this category.	2F2
2F6	Other Applications (please specify)	The properties of ozone depleting substances have made them attractive for a variety of niche applications not covered in other sub-source categories. These include electronics testing, heat transfer, dielectric fluid and medical applications. The properties of HFCs and PFCs are equally attractive in some of these sectors and they have been adopted as substitutes. There are also some historical uses of PFCs, as well as emerging use of HFCs, in these applications. These applications have leakage rates ranging from 100% emissive in year of application to around 1% per annum.	2F3
2G	Other Product Manufacture and Use		2F4
2G1	Electrical Equipment	Electrical equipment is used in the transmission and distribution of electricity above 1 kV. SF6 is used in gas-insulated switchgear (GIS), gas circuit breakers (GCB), gas-insulated transformers (GIT), gas-insulated lines (GIL), outdoor gas-insulated instrument transformers, reclosers, switches, ring main units and other equipment.	2F5
2G1a	Manufacture of Electrical Equipment		2F6
2G1b	Use of Electrical Equipment		
2G1c	Disposal of Electrical Equipment		2F6, 3D
2G2	SF6 and PFCs		2F6

IPCC 2006 source category		Description	IPCC 1996
	from Other Product Uses		
2G2a	Military Applications	Military applications include AWACS, which are military reconnaissance planes of the Boeing E-3A type. In AWACS (and possibly other reconnaissance planes), the SF6 is used as an insulating gas in the radar system.	2F6
2G2b	Accelerators	Particle accelerators are used for research purposes (at universities and research institutions), for industrial applications (in cross-linking polymers for cable insulation and for rubber parts and hoses), and in medical (radiotherapy) applications.	2F6
2G2c	Other (please specify)	This source includes adiabatic uses, sound-proof glazing, PFCs used as heat transfer fluids in consumer and commercial applications, PFCs used in cosmetic and medical applications, and PFCs and SF6 used as tracers.	2F6
2G3	N_2O from Product Uses		2F6
2G3a	Medical Applications	This source covers evaporative emissions of nitrous oxide (N_2O) that arise from medical applications (anaesthetic use, analgesic use and veterinary use). N_2O is used during anaesthesia for two reasons: a) as an anaesthetic and analgesic and as b) a carrier gas for volatile fluorinated hydrocarbon anaesthetics such as isoflurane, sevoflurane and desflurane.	2F6
2G3b	Propellant for Pressure and Aerosol Products	This source covers evaporative emissions of nitrous oxide (N_2O) that arise from use as a propellant in aerosol products primarily in food industry. Typical usage is to make whipped cream, where cartridges filled with N_2O are used to blow the cream into foam.	2F6
2G3c	Other (Please specify)		2F6
2G4	Other (Please specify)		3D
2H	Other		3D
2H1	Pulp and Paper Industry		3D
2H2	Food and Beverages Industry		3D
2H3	Other (please specify)		2F6, 3D
3	AGRICULTURE, FORESTRY, AND OTHER LAND USE	Emissions and removals from forest land, cropland, grassland, wetlands, settlements, and other land. Also includes emissions from livestock and manure management, emissions from managed soils, and emissions from liming and urea application. Methods to estimate annual harvested wood product (HWP) variables are also covered in this category.	2D1, 2D2, 2G
3A	Livestock	Methane emissions from enteric fermentation, and methane and nitrous oxide emissions from manure management.	2D1
3A1	Enteric Fermentation	Methane emissions from herbivores as a by-product of enteric fermentation (a digestive process by which carbohydrates are broken down by micro-organisms into simple molecules for absorption into the bloodstream). Ruminant animals (e.g., cattle, sheep) are major sources with moderate amounts produced from non-ruminant animals (e.g., pigs, horses).	2D2
3A1a	Cattle	Methane emissions from dairy cows and other cattle.	2G
3A1ai	Dairy Cows	Methane emissions from cattle producing milk for commercial exchange and from calves and heifers being grown for dairy purposes.	4A1a
3A1aii	Other Cattle	Methane emissions from all non-dairy cattle including: cattle kept or grown	4A1b

IPCC 2006 source category		Description	IPCC 1996
		for meat production, draft animals, and breeding animals.	
3A1b	Buffalo	Methane emissions from buffalo.	4A2
3A1c	Sheep	Methane emissions from sheep.	4A3
3A1d	Goats	Methane emissions from goats.	4A4
3A1e	Camels	Methane emissions from camels.	4A5
3A1f	Horses	Methane emissions from horses.	4A6
3A1g	Mules and Asses	Methane emissions from mules and asses.	4A7
3A1h	Swine	Methane emissions from swine.	4A8
3A1j	Other (please specify)	Methane emissions from other livestock (e.g. alpacas, llamas, deer, reindeer, etc.).	4A10
3A2	Manure Management	Methane and nitrous oxide emissions from the decomposition of manure under low oxygen or anaerobic conditions. These conditions often occur when large numbers of animals are managed in a confined area (e.g. dairy farms, beef feedlots, and swine and poultry farms), where manure is typically stored in large piles or disposed of in lagoons and other types of manure management systems.	4B
3A2a	Cattle	Methane and nitrous oxide emissions from the decomposition of manure from cattle.	4B1
3A2ai	Dairy Cows	Methane and nitrous oxide emissions from the decomposition of manure from dairy cows.	4B1a
3A2aii	Other Cattle	Methane and nitrous oxide emissions from the decomposition of manure from other cattle.	
3A2b	Buffalo	Methane and nitrous oxide emissions from the decomposition of manure from buffalo.	4B2
3A2c	Sheep	Methane and nitrous oxide emissions from the decomposition of manure from sheep.	4B3
3A2d	Goats	Methane and nitrous oxide emissions from the decomposition of manure from goats.	4B4
3A2e	Camels	Methane and nitrous oxide emissions from the decomposition of manure from camels.	4B5
3A2f	Horses	Methane and nitrous oxide emissions from the decomposition of manure from horses.	4B6
3A2g	Mules and Asses	Methane and nitrous oxide emissions from the decomposition of manure from mules and assess.	4B7
3A2h	Swine	Methane and nitrous oxide emissions from the decomposition of manure from swine.	4B8
3A2i	Poultry	Methane and nitrous oxide emissions from the decomposition of manure from poultry including chicken, broilers, turkeys, and ducks.	4B9
3A2j	Other (please specify)	Methane and nitrous oxide emissions from the decomposition of manure from other livestock (e.g. alpacas, llamas, deer, reindeer, fur-bearing animals, ostriches, etc.)	4B13
3B	Land	Emissions and removals from five land use categories (Forest land, Cropland, Grasslands, Settlements, and Other land) except for sources listed under 3C (Aggregate sources and non-CO_2 emissions sources on land) . Except for Wetlands, the greenhouse gas inventory involves estimation of changes in carbon stock from five carbon pools (i.e. aboveground biomass, belowground biomass, dead wood, litter, and soil organic matter), as appropriate.	5
3B1	Forest Land	Emissions and removals from lands with woody vegetation consistent with thresholds used to define forest land in the national GHG inventory, sub-divided into managed and unmanaged, and possibly also by climatic region, soil type and vegetation type as appropriate. It also includes systems with	5A,5B,5D

IPCC 2006 source category		Description	IPCC 1996
		vegetation that currently fall below, but are expected to later exceed, the threshold values used by a country to define the forest land category.	
3B1a	Forest land Remaining Forest Land	Emissions and removals from managed forests and plantations which have always been under forest land use or other land categories converted to forest over 20 years ago (default assumption).	5A
3B1b	Land Converted to Forest Land	Emissions and removals from lands converted to forest land. Includes conversion of cropland, grassland, wetlands, settlements, and other land to forest land. Even abandoned lands which are regenerating to forest due to human activities are also included.	5A,5C,5D
3B1bi	Cropland Converted to Forest Land	Emissions and removals from cropland converted to forest land.	
3B1bii	Grassland Converted to Forest Land	Emissions and removals from grassland converted to forest land.	
3B1biii	Wetlands Converted to Forest Land	Emissions and removals from wetlands converted to forest land.	
3B1biv	Settlements Converted to Forest Land	Emissions and removals from settlements converted to forest land.	
3B1bv	Other Land Converted to Forest Land	Emissions and removals from other land converted to forest land.	
3B2	Cropland	Emissions and removals from arable and tillage land, rice fields, and agro-forestry systems where vegetation falls below the thresholds used for the forest land category.	4C, 4D, 4F, 5A, 5B, 5D
3B2a	Cropland Remaining Cropland	Emissions and removals from cropland that has not undergone any land use change during the inventory period.	4C, 4D, 4F, 5A, 5D
3B2b	Land Converted to Cropland	Emissions and removals from lands converted to cropland. Includes conversion of forest land, grassland, wetlands, settlements, and other land to cropland.	5B, 5D
3B2bi	Forest Land Converted to Cropland	Emissions and removals from forest land converted to cropland.	
3B2bii	Grassland Converted to Cropland	Emissions and removals from grassland converted to cropland.	
3B2biii	Wetlands Converted to Cropland	Emissions and removals from wetlands converted to cropland.	
3B2biv	Settlements Converted to Cropland	Emissions and removals from settlements converted to cropland.	
3B2bv	Other Land Converted to Cropland	Emissions and removals from other land converted to cropland.	
3B3	Grassland	Emissions and removals from rangelands and pasture land that is not considered cropland. It also includes systems with woody vegetation that fall below the threshold values used in the forest land category and are not	4D, 4E, 5A,5B,5C5D

IPCC 2006 source category		Description	IPCC 1996
		expected to exceed them, without human intervention. The category also includes all grassland from wild lands to recreational areas as well as agricultural and silvi-pastural systems, subdivided into managed and unmanaged, consistent with national definitions.	
3B3a	Grassland Remaining Grassland	Emissions and removals from grassland remaining grassland.	4D, 4E, 5A,5D
3B3b	Land Converted to Grassland	Emissions and removals from land converted to grassland.	5B, 5C, 5D
3B3bi	Forest Land Converted to Grassland	Emissions and removals from forest land converted to grassland.	
3B3bii	Cropland Converted to Grassland	Emissions and removals from cropland converted to grassland.	
3B3biii	Wetlands Converted to Grassland	Emissions and removals from wetlands converted to grassland.	
3B3biv	Settlements Converted to Grassland	Emissions and removals from settlements converted to grassland.	
3B3bv	Other Land Converted to Grassland	Emissions and removals from other land converted to grassland.	
3B4	Wetlands	Emissions from land that is covered or saturated by water for all or part of the year (e.g., peatland) and that does not fall into the forest land, cropland, grassland or settlements categories. The category can be subdivided into managed and unmanaged according to national definitions. It includes reservoirs as a managed sub-division and natural rivers and lakes as unmanaged sub-divisions.	5A, 5B, 5E, 4D
3B4a	Wetlands Remaining Wetlands	Emissions from peatland undergoing peat extraction and from flooded land remaining flooded land.	5A, 5D, 5E, 4D
3B4ai	Peatlands Remaining peatlands	Includes (1) on-site emissions from peat deposits during the extraction phase and (2) off-site emissions from horticultural use of peat. The off-site emissions from the energy use of peat are reported in the Energy Sector and are therefore not included in this category.	5A, 5E, 4D
3B4aii	Flooded Land Remaining Flooded Land	Emissions from flooded land remaining flooded land. Flooded lands are defined as water bodies where human activities have caused changes in the amount of surface area covered by water, typically through water level regulation. Examples of flooded lands include reservoirs for the production of hydroelectricity, irrigation, navigation, etc. Regulated lakes and rivers that have not experienced substantial changes in water area in comparison with the pre-flooded ecosystem are not considered as flooded lands. Some rice paddies are cultivated through flooding of land, but because of the unique characteristics of rice cultivation, rice paddies are addressed in 3C7.	5A, 5E
3B4b	Land Converted to Wetlands	Emissions from land being converted for peat extraction from land converted to wetland.	5B, 5E
3B4bi	Land Converted for Peat Extraction	Emissions from land being converted for peat extraction	5B, 5E

IPCC 2006 source category		Description	IPCC 1996
3B4b ii	Land Converted to Flooded Land	Emissions from land converted to flooded land	5B, 5E
3B4biii	Land Converted to Other Wetlands	Emissions from land converted to other wetlands than flooded land and land for peat extraction.	5E
3B5	Settlements	Emissions and removals from all developed land, including transportation infrastructure and human settlements of any size, unless they are already included under other categories. This should be consistent with national definitions.	5A, 5D, 5E, 5B
3B5a	Settlements Remaining Settlements	Emissions and removals from settlements that have not undergone any land use change during the inventory period.	
3B5b	Land Converted to Settlements	Emissions and removals from lands converted to settlements. Includes conversion of forest land, cropland, grassland, wetlands, and other land to settlements.	
3B5bi	Forest Land Converted to Settlements	Emissions and removals from forest land converted to settlements.	
3B5bii	Cropland Converted to Settlements	Emissions and removals from cropland converted to settlements.	
3B5biii	Grassland Converted to Settlements	Emissions and removals from grassland converted to settlements.	
3B5biv	Wetlands Converted to Settlements	Emissions and removals from wetlands converted to settlements.	
3B5bv	Other Land Converted to Settlements	Emissions and removals from other land converted to settlements.	
3B6	Other Land	Emissions and removals from bare soil, rock, ice, and all unmanaged land areas that do not fall into any of the other five categories. It allows the total of identified land areas to match the national area, where data are available.	
3B6a	Other Land Remaining Other Land	Emissions and removals from other land that has not undergone any land use change during the inventory period.	
3B6b	Land Converted to Other Land	Emissions and removals from lands converted to other land. Includes conversion of forest land, cropland, grassland, wetlands, and settlements to other land.	
3B6bi	Forest Land Converted to Other Land	Emissions and removals from forest land converted to other land.	
3B6bii	Cropland Converted to Other Land	Emissions and removals from cropland converted to other land.	
3B6biii	Grassland Converted to Other Land	Emissions and removals from grassland converted to other land.	
3B6biv	Wetlands Converted to Other Land	Emissions and removals from wetlands converted to other land.	

IPCC 2006 source category		Description	IPCC 1996
3B6bv	Settlements Converted to Other Land	Emissions and removals from settlements converted to other land.	
3C	Aggregate Sources and Non-CO_2 Emissions Sources on Land	Includes emissions from activities that are likely to be reported at very high aggregation land level or even country level.	
3C1	Emissions from Biomass Burning	Emissions from biomass burning that include N_2O and CH4. CO_2 emissions are included here only if emissions are not included in 3B categories as carbon stock changes.	
3C1a	Biomass Burning in Forest Lands	Emissions from biomass burning that include N_2O and CH_4 in forest lands. CO_2 emissions are included here only if emissions are not included in 3B1 categories as carbon stock changes.	
3C1b	Biomass Burning in Croplands	Emissions from biomass burning that include N_2O and CH_4 in croplands. CO_2 emissions are included here only if emissions are not included in 3B2 categories as carbon stock changes.	
3C1c	Biomass Burning in Grasslands	Emissions from biomass burning that include N_2O and CH_4 in grasslands. CO_2 emissions are included here only if emissions are not included in 3B3 categories as carbon stock changes.	
3C1d	Biomass Burning in All Other Land	Emissions from biomass burning that include N_2O and CH_4 in settlements, and all other land. CO_2 emissions are included here only if emissions are not included in 3B6 categories as carbon stock changes.	
3C2	Liming	CO_2 emissions from the use of lime in agricultural soils, managed forest soils or lakes.	
3C3	Urea Application	CO_2 emissions from urea application	
3C4	Direct N_2O Emissions from Managed Soils	Direct N_2O emissions from managed soils from the synthetic N fertilizers application; organic N applied as fertilizer (e.g. animal manure, compost, sewage sludge, rendering waste); urine and dung N deposited on pasture, range and paddock by grazing animals; N in crop residues (above and below ground), including from N-fixing crops and from forages during pasture renewal; N mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils; and drainage/management of organic soils (i.e., histosols).	4D
3C5	Indirect N_2O Emissions from Managed Soils	Indirect N_2O emissions from: (1) the volatilization of N (as NH_3 and NOx) following the application of synthetic and organic N fertilizers and /or urine and dung deposition from grazing animals, and the subsequent deposition of the N as ammonium (NH_4+) and oxides of N (NOx) on soils and waters, and (2) the leaching and runoff of N from synthetic and organic N fertilizer additions, crop residues, mineralization /immobilization of N associated with loss/gain of soil C in mineral soils through land use change or management practices, and urine and dung deposition from grazing animals, into groundwater, riparian areas and wetlands, rivers and eventually the coastal ocean.	4D
3C6	Indirect N_2O Emissions from Manure Management	Indirect N_2O emissions from manure management (activity data amount of nitrogen in the manure excreted).	
3C7	Rice Cultivations	Methane (CH4) emissions from anaerobic decomposition of organic material in flooded rice fields. Any N_2O emissions from the use of nitrogen-based fertilizers in rice cultivation should be reported under N_2O emissions from managed soils.	4C
3C8	Other (please specify)	Other sources of CH_4 and N_2O emissions on land.	

IPCC 2006 source category		Description	IPCC 1996
3D	Other		
3D1	Harvested Wood Products	CO_2 net emissions or removals resulting from Harvest Wood Products.	
3D2	Other (please specify)		
4A	Solid Waste Disposal	Methane is produced from anaerobic microbial decomposition of organic matter in solid waste disposal sites. Carbon dioxide (CO_2) is also produced but CO_2 from biogenic or organic waste sources is covered by the AFOLU Sector. Emissions of halogenated gases should be accounted in IPPU. Long-term storage of carbon in SWDS is reported as an information item.	6A
4A1	Managed Waste Disposal Sites	A managed solid waste disposal site must have controlled placement of waste (i.e. waste directed to specific deposition areas, a degree of control of scavenging and fires) and will include at least one of the following: cover material; mechanical compaction; or leveling of the waste. This category can be subdivided into aerobic and anaerobic.	6A 1
4A2	Unmanaged Waste Disposal Sites	These are all other solid waste disposal sites that do not fall into the above category. This category can be subdivided into deep and shallow.	6A2
4A3	Uncategorised Waste Disposal Sites	Mixture of above 4 A1 and 4 A2. Countries that do not have data on division of managed/unmanaged may use this category.	NA
4B	Biological Treatment of Solid Waste	Solid waste composting and other biological treatment. Emissions from biogas facilities (anaerobic digestion) with energy production are reported in the Energy Sector (1A4).	6A3
4C	Incineration and Open Burning of Waste	Incineration of waste and open burning waste, not including waste-to-energy facilities. Emissions from waste burnt for energy are reported under the Energy Sector, 1A. Emissions from burning of agricultural wastes should be reported under AFOLU (3C1). All non-CO_2 greenhouse gases as well as CO_2 from fossil waste should be reported here for incineration and open burning.	6C
4C1	Waste Incineration	Combustion of solid wastes in controlled incineration facilities.	6C
4C2	Open Burning of Waste	Combustion of waste in the open-air or in an open dump.	NA
4D	Wastewater Treatment and Discharge	Methane is produced from anaerobic decomposition of organic matter by bacteria in sewage facilities and from food processing and other industrial facilities during wastewater treatment. N_2O is also produced by bacteria (denitrification and nitrification) in wastewater treatment and discharge.	6B
4D1	Domestic Wastewater Treatment and Discharge	Treatment and discharge of liquid wastes and sludge from housing and commercial sources (including human waste) through: wastewater sewage systems collection and treatment systems, open pits / latrines, anaerobic lagoons, anaerobic reactors and discharge into surface waters. Emissions from sludge disposed at SWDS are reported under category 4A.	6B2
4D2	Industrial Wastewater Treatment and Discharge	Treatment and discharge of liquid wastes and sludge from industrial processes such as: food processing, textiles, or pulp and paper production. This includes anaerobic lagoons, anaerobic reactors, and discharge into surface waters. Industrial wastewater released into domestic wastewater sewage should be included under 4D1.	6B1
4E	Other (please specify)	Release of GHGs from other waste handling activities than listed in categories 4A to 4D.	6D
5	Other		7
5A	Indirect N_2O Emissions from	Excluding indirect emissions from NOx and NH_3 in agriculture which are reported in 3C2.	NA

IPCC 2006 source category		Description	IPCC 1996
	the Atmospheric Deposition of Nitrogen in NOx and NH3		
5B	Other (please specify)	Only use this category exceptionally, for any categories than cannot be accommodated in the categories described above. Include a reference to where a detailed explanation of the category can be found.	7