IRELAND

NATIONAL INVENTORY REPORT 2010

GREENHOUSE GAS EMISSIONS 1990 - 2008 REPORTED TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

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PART II SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7.1

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EXECUTIVE SUMMARY

ES.1 Background

The reporting guidelines on annual inventories adopted by the United Nations Framework Convention on Climate Change (UNFCCC), describe the scope and reporting of greenhouse gas emission inventories by Parties included in Annex I to the Convention. The guidelines set out the methodologies and procedures to be followed for submitting consistent and comparable data on an annual basis in a timely, efficient and transparent manner to meet the needs of the Convention. The UNFCCC guidelines require that Parties prepare a National Inventory Report (NIR) as one of the key components of their annual submissions to the UNFCCC secretariat. The purpose of the NIR is to describe the input data, methodologies, emission factors, quality assurance and quality control procedures and other information underlying the inventory compilation for greenhouse gases and to give details of any recalculations of inventories previously submitted. It is needed to assess the transparency, completeness and overall quality of the inventories as part of the rigorous ongoing technical review of submissions from Annex I Parties.

The present report constitutes Irelands NIR for 2010 and refers to the inventory time-series for the years 1990-2008 under the Convention. Ireland's submission under the UNFCCC in 2010 is also its submission under the Kyoto Protocol, with 2008 being the first year of the first commitment period 2008-2012. The NIR is compiled according to the structure adopted by Decision 18/CP.8. Part I includes sections describing the national system for inventory preparation and management, emission trends, key emission categories, recalculations and ongoing improvements, in addition to the detailed documentation of methods, activity data and emission factors used for each of the six source categories as defined by the Intergovernmental Panel on Climate Change (IPCC). Part II contains the supplementary information required under Article 7.1 of the Kyoto Protocol, which includes estimates of emissions and removals for activities under Article 3.3 of the Protocol, information on the national registry and transactions of Kyoto units and information required under Article 3.14. The report contains several annexes, which include calculation sheets, activity data, emission factors and other appropriate reference material to support the descriptions of inventory calculation methods given in both Part I and Part II and to provide adequate transparency for review purposes, as required by the UNFCCC Reporting Guidelines.

The Environmental Protection Agency has overall responsibility for the national greenhouse gas inventory in Ireland's national system established in 2007 under Article 5 of the Kyoto Protocol. The EPA Office of Climate Licensing and Resource Use performs the role of inventory agency in Ireland and undertakes all aspects of inventory preparation and management and the reporting of Ireland's submissions annually in accordance with the requirements of Decision 280/2004/EC and the UNFCCC. In addition to complying with the UNFCCC reporting guidelines, the 2010 NIR is intended to inform Irish Government departments and institutions involved in the national system, as well as other relevant stakeholders in Ireland, of the level of emissions and the state-of-the-art of Irish greenhouse gas inventories as they address the challenges to comply with Ireland's commitments under the Kyoto Protocol. The in-depth analysis of key sources and the up-to-date data on emissions trends provides essential information for the implementation of the National Climate Change Strategy, the preparation of the Government's annual carbon budget and the development of emissions projections. The detailed NIR, together with activities provided for in the national system, allows data suppliers to become fully aware of the importance of their contributions to the inventory process and it serves to identify areas where improvements in input data can be achieved.

Ireland's commitment on greenhouse gases under the Kyoto Protocol, as determined by Decision 2005/166/EC, is to limit the increase in emissions in the 2008-2012 commitment period to 13 percent above base year emissions. The baseline emissions total for Ireland is calculated as the sum of CO_2, CH_4 and N_2O emissions in 1990 and the contribution from fluorinated gases in 1995. The baseline value was established at 55.607 Mt CO_2eq and results in total allowable emissions of 314.184272 Mt CO_2eq in the commitment period, which equates to the average of 62.837 Mt CO_2eq per annum. This value remains fixed for the commitment period even though methodological improvements or revised data may change the estimates of emissions in the base year. Compliance with the Kyoto Protocol limit is achieved by ensuring that Ireland's total emissions in the period 2008-2012, adjusted for any offsets from activities under Article 3.3 and the surrender of any purchased Kyoto Protocol credits, are below 314.184272 Mt CO_2eq at the end of the five-year period.

ES.2 Emissions Trends and Key Categories

In 2008, total emissions of greenhouse gases (excluding the *LULUCF* sector) in Ireland were 67,439.28 Gigagrams (Gg) CO_2 equivalent, which is 23 percent higher than emissions in 1990. The total for 2008 is 3.1 percent lower than the level of 69,600.51 Gg CO_2 equivalent in 2001 when emissions reached a maximum following a period of unprecedented economic growth. The *Energy* sector accounted for 67.8 percent of total emissions in 2008, *Agriculture* contributed 26.1 percent while a further 4.4 percent emanated from *Industrial Processes* and 1.6 percent was due to *Waste*. Emissions of CO_2 accounted for 70.3 percent of the national total in 2008, with CH_4 and N_2O contributing 18.0 percent and 10.7 percent, respectively. The combined emissions of HFC, PFC and SF_6 accounted for 1.0 percent of total emissions in 2008.

Tier 1 level assessment of emission source categories (ranking on the basis of their contribution to total emissions) taken at the level at which they could be targeted on an individual basis identified 23 key categories in 2008 (excluding the *LULUCF* sector). There were 14 key categories of CO_2, accounting for 69.1 percent of total emissions. There were five key categories of CH_4, three key categories of N_2O and 1 key category of HFC in level assessment, which accounted for 16.1 percent, 9.3 percent and 0.8 percent of total emissions, respectively. The results of the Tier 1 key category analysis clearly show the impact of CO_2 emissions from energy consumption on total emissions in Ireland. These combustion sources of CO_2 emissions accounted for 13 out of 23 key categories identified by level assessment in 2008 and for two-thirds of total emissions. The top ten key categories contributed 72 percent of total emissions in 2008 with emissions of CO_2 from the combustion of petrol and diesel by road traffic being the single largest source, accounting for 20.2 percent of the total national emissions.

The application of uncertainty analysis for Irish greenhouse gas inventories using the IPCC approach indicates an overall level uncertainty of 5.8 percent in the 2008 inventory (excluding the LULUCF sector) and a trend uncertainty of 3.5 percent for the period 1990 to 2008. These values are determined largely by the low uncertainty in the estimates of CO_2 emissions from the energy sector, which is the major source category in Ireland and for which the input data and methodologies are most reliable. The 70 percent of emissions contributed by CO_2, are estimated to have an uncertainty of 1.2 percent. The impact of

HFC, PFC and SF_6 on inventory uncertainty in the year 2008 is negligible (0.2 percent) because they account for only 1 percent of total emissions.

Ireland has reported total net greenhouse gas removals amounting to 2,652.81 Gg CO_2 eq. for 2008 under Article 3.3 of the Kyoto Protocol in respect of 265.45 ha of lands subject to afforestation since 1990 while there were net emissions of 10.98 Gg CO_2 on a deforested area of 1.38 ha. Ireland has elected not to account for any of the activities under Article 3.4 of the Kyoto Protocol in the first commitment period.

ES.3 Overview of Source Category Emissions Estimates and Trends

Chapter 2 of the NIR describes the trends in Ireland's time-series of greenhouse gas inventories for the years 1990 through 2008. The emissions time-series is available as a complete set of Common Reporting Format files, generated by the CRF Reporter tool, the electronic reporting protocol adopted for annual data submissions to the UNFCCC secretariat. The annual inventories are complete with respect to both the coverage of the six greenhouse gases for which information is required and the coverage of the six IPCC source categories. Some recalculations have again been undertaken for the purposes of the 2010 submission and the latest inventories for the years 1990-2008 indicate major revisions and improvements in some areas due to these recalculations.

Fuel combustion in the Energy sector is the principal source of emissions in Ireland and major increases in fuel use have driven the increase in emissions up to 2008. The largest increase took place in transport with an increase of 176 percent on 1990 levels, while there were increases of 29 percent and 19 percent in the emissions from electricity production and the industrial sectors, respectively. The emissions from agriculture, the other main source category, increased during the 1990s but have decreased to 9 percent below 1990 levels in 2008. As the emissions from energy increased, the contribution of agriculture to the total decreased from 35 percent in 1990 to 26 percent in 2008.

ES.4 Indirect Greenhouse Gases

The inventory reporting process requires the inclusion of a number of gases whose indirect effects are also relevant to the assessment of human-induced impacts on climate. They include sulphur dioxide (SO_2), nitrogen oxides (NO_X), carbon monoxide (CO) and volatile organic compounds (VOC). Emissions of SO_2 contribute to the formation of aerosols, which may offset the effects of greenhouse gases, while CO, NO_X and VOC are precursors of ozone, another naturally occurring greenhouse gas. This NIR does not describe the methods used to estimate emissions of SO_2, NO_X, CO and VOC but the annual emissions estimates over the period 1990-2008 are included in the submission.

The emissions of most of the indirect gases have decreased substantially in the period 1990-2008 under various forms of control legislation emanating from the European Commission and the Convention on Long Range Transboundary Air Pollution. The reductions achieved between 1990 and 2008 in Ireland are of the order of 70 percent in the case of SO_2, 60 percent for CO and 30 percent for NMVOC. However, in the case of NO_X, the emissions reductions have been more difficult to achieve, due mainly to the large increase in road traffic, with the result that emissions remain close to their 1990 levels.

PART I

ANNUAL INVENTORY SUBMISSION 2010

Chapter One

Introduction

1.1 Background and Context

1.1.1 Reporting Requirements under the UNFCCC

Under Articles 4 and 12 of the United Nations Framework Convention on Climate Change (UNFCCC), hereafter referred to as the Convention, Annex I Parties must develop, publish and make available to the Conference of the Parties (COP), the Convention's implementation body, their national inventories of emissions and removals of all greenhouse gases not controlled by the Montreal Protocol. The UNFCCC Reporting Guidelines on Annual Inventories (SBSTA, 1999 and SBSTA, 2002) hereafter referred to as the UNFCCC reporting guidelines, describe the scope and reporting of the emissions inventories. They specify the methodologies and procedures to be followed for submitting consistent and comparable data on an annual basis in a timely, efficient and transparent manner to meet the needs of the Convention. Under the UNFCCC reporting guidelines, Parties are required to compile a National Inventory Report (NIR) and up-to-date annual inventories in an electronic Common Reporting Format (CRF) as the key components of their annual submissions. The objective of the NIR is to describe the methodologies, input data, background information and the entire process of inventory compilation for greenhouse gases and to give explanations for any improvements and recalculations of the inventories reported in previous submissions. The report is needed by expert review teams to assess the transparency, completeness and overall quality of the inventories as part of the ongoing review process for the submissions from Annex I Parties.

The present report constitutes Irelands NIR for 2010 and refers to the inventory time-series for the years 1990-2008 under the Convention. Ireland's submission under the UNFCCC in 2010 is also its submission under the Kyoto Protocol, with 2008 being the first year of the first commitment period 2008-2012. The NIR is compiled according to the structure adopted by Decision 18/CP.8. Part I includes sections describing the national system for inventory preparation and management, emission trends, key emission categories, recalculations and ongoing improvements, in addition to the detailed documentation of methods, activity data and emission factors used for each of the six source categories as defined by the Intergovernmental Panel on Climate Change (IPCC). Part II contains the supplementary information required under Article 7.1 of the Kyoto Protocol, which includes estimates of emissions and removals for activities under Article 3.3 of the Protocol, information on the national registry and transactions of Kyoto units and information required under Article 3.14. The NIR addresses the full range of reporting requirements related to annual inventories set down in the UNFCCC reporting guidelines and responds to issues identified in the UNFCCC annual review process. This NIR is designed to capture the cyclical nature of the reporting process and to clarify the chronology of changes and revisions that are part of normal inventory development, including those that are implemented in response to the UNFCCC review process. In this way, the report continues to improve the basis for technical assessment and expert review of Irish greenhouse gas inventories. An attempt has been made to provide all the primary inventory information, including calculation sheets as appropriate, to facilitate replication of the emission estimates for the most recent year of the inventory time-series so that the annual submission is fully transparent.

In addition to complying with the UNFCCC reporting guidelines, the report is intended to inform Government departments, national institutions and other stakeholders of the state of the art of Irish greenhouse gas inventories as they address the challenges to comply with commitments under the Kyoto Protocol. In this context, it provides some additional background on relevant emission sources in Ireland, the standard reporting format and other issues for the benefit of those not entirely familiar with the agreed content of the NIR or the general reporting requirements under the Convention and the Kyoto Protocol. The report is also aimed at all the key data providers, with a view to making them fully aware of the importance of their contributions to the inventory process and to provide a means of identifying areas where improvements in input data may be possible. The in-depth analysis of key sources and the up-to-date data on emissions trends provides essential information for the implementation of the National Climate Change Strategy, the preparation of the Government's annual carbon budget and the development of emissions projections. The detailed NIR, together with activities provided for in the national system, allows data suppliers to become fully aware of the importance of their contributions to the inventory process and it serves to identify areas where improvements in input data can be achieved.

The NIR is updated annually in accordance with the UNFCCC guidelines and is published on the web site of the EPA [http://coe.epa.ie/ghg/nirdownloads.jsp]. Such updating is necessary to keep the UNFCCC secretariat and other interested parties informed of the status of Irish greenhouse gas inventories and to document ongoing improvements, recalculations and other developments affecting the estimates of emissions. The structure of the report is designed to facilitate year-on-year revision in a manner that allows for systematic and efficient assessment of progress towards the achievement of greenhouse gas emission inventories that meet the guiding principles of transparency, consistency, comparability, completeness and accuracy. Ireland's submission under the UNFCCC in 2010 is also its submission under the Kyoto Protocol.

The current context of inventory reporting is Ireland's commitment on greenhouse gases under the Kyoto Protocol which, as determined by Decision 2005/166/EC, is to limit the increase in emissions in the 2008-2012 commitment period to 13 percent above base year emissions. The baseline emissions total for Ireland is calculated as the sum of CO_2, CH_4 and N_2O emissions in 1990 and the contribution from fluorinated gases in 1995. The baseline value was established at 55.607 Mt CO_2eq and results in total allowable emissions of 314.184272 Mt CO_2eq in the commitment period, which equates to the average of 62.837 Mt CO_2eq per annum. This value remains fixed for the commitment period even though methodological improvements may change the estimates of emissions in the base year. Compliance with the Kyoto Protocol limit is achieved by ensuring that Ireland's total emissions in the period 2008-2012, adjusted for any offsets from activities under Article 3.3 and the surrender of any purchased Kyoto Protocol credits, are below 314.184272 Mt CO_2eq at the end of the five-year period. The annual inventory submissions for the years 2008-2012 are crucial to the determination of compliance.

1.1.2 Scope of Greenhouse Gas Inventories

1.1.2.1 Greenhouse Gases and Global Warming Potential

The full range of greenhouse gases for which emissions data are required under the Convention is given in Table A.1 of Annex A. It includes carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), the most widely known and most ubiquitous of the anthropogenic greenhouse gases, along with 13 hydrofluorocarbons (HFC), seven perfluorocarbons (PFC) and sulphur hexafluoride (SF_6). The global warming potentials (GWP) of the various greenhouse gases vary enormously, as shown on Table A.1 of Annex A. The GWP of a gas is a measure of the cumulative warming over a specified time period, e.g. 100 years, resulting from a unit mass of the gas emitted at the beginning of that time period, expressed relative to an absolute GWP of 1 for the reference gas carbon dioxide (IUCC, 1998). The mass emission of any gas multiplied by its GWP gives the equivalent emission of the gas as carbon dioxide. Therefore, while CO_2, CH_4 and N_2O are important because they are normally emitted in large amounts, HFC, PFC and SF_6 are included in the inventory process mainly because of their comparatively much larger GWP values.

The inventory reporting process allows for the inclusion of a number of additional gases whose indirect effects are also relevant to the assessment of human-induced impacts on climate. They include sulphur dioxide (SO_2), nitrogen oxides (NO_X), carbon monoxide (CO) and volatile organic compounds (VOC). Emissions of SO_2 contribute to the formation of aerosols, which may offset the effects of greenhouse gases, while CO, NO_X and VOC are precursors of ozone, another naturally occurring greenhouse gas. This NIR does not describe the methods used to estimate emissions of SO_2, NO_X, CO and VOC but up-to-date estimates of total emissions are included for information purposes. These estimates are taken from Ireland's submission to the Convention on Long Range Transboundary Air Pollution (CLRTAP), which are produced annually in a manner that is fully consistent with the inventory for greenhouse gases.

1.1.2.2 IPCC Reporting Format

The reporting of greenhouse gas emissions under the Convention is done with reference to the multi-level reporting format adopted by the Intergovernmental Panel on Climate Change (IPCC). This is a standard table format that forms the basis of the CRF and it assigns all potential sources of emission and removals making up a Party's national total to six Level 1 broad source categories. A further category is provided for the reporting of any additional sources that may be specific to individual Parties. The Level 1 source categories are each divided into as many as seven sub-categories, giving a total of 36 Level 2 source/sink categories, which in turn are further sub-divided to give the 126 standard sub-categories disaggregated at Level 3 in the CRF. Table A.2 of Annex A lists the Level 1 and Level 2 source/sink categories. The Level 3 categories are detailed in the description of category coverage and inventory methods and data in the respective sectoral chapters of this NIR. The computation of emissions is usually undertaken at Level 3 or lower, using further appropriate disaggregation (for example, by using fuel type in the case of combustion sources under *1.A Energy-Fuel Combustion*) while summary results are normally published at Level 2.

The reporting format is extended to accommodate the reporting of emissions and removals under Articles 3.3 and 3.4 of the Kyoto Protocol for the years 2008-2012. The additional tables use a hierarchial system similar to that for reporting under the Convention, with flexibility for Parties to provide as much disaggregation as is necessary to reflect the variation in the parameters underlying the estimates of emissions and removals for the Articles 3.3 and 3.4 activities applicable in their territories. The Kyoto reporting tables also include the accounting quantity for each relevant activity i.e. the quantity of units to be added or subtracted from a Party's assigned amount in accordance with the provisions of Article 7.4 of the Protocol.

The IPCC reporting format also includes a number of *Memo Item* entries. These items refer to sources of emissions whose contributions are not included in a Party's national total but which are to be reported because of their importance in relation to the overall assessment of emissions and for comparisons among Parties. Much reference is made throughout this report to the IPCC reporting format when describing source category coverage, methods, emissions and key categories. The national total of emissions that is commonly used under the Convention excludes the estimates for the Land Use Land-Use Change and Forestry (LULUCF) sector in Table A.2 of Annex A, this total being consistent with that for the categories included in Annex A of the Kyoto Protocol.

1.1.2.3 Supplementary Information

For a Party to the Kyoto Protocol, the annual inventory submission under the Convention is also its annual inventory submission under the Protocol. Supplementary information required under Article 7.1 of the Kyoto Protocol comprises the GHG emissions and removals under Articles 3.3 and 3.4 of the Kyoto Protocol, details of all Kyoto units for the year subsequent to the inventory year as generated by the national registry and compiled in the Standard Electronic Format, changes in the national system and national registry and information on the minimization of adverse impacts of climate change and response measures on developing countries in accordance with Article 3.14.

1.2 Institutional and Procedural Arrangements

1.2.1 Overview

Under Section 52 of the Environmental Protection Agency Act of 1992 (DOE, 1992), the Environmental Protection Agency is required to establish and maintain databases of information on the environment and to disseminate such information to interested parties. Section 55 of the Act states that the Agency must provide, of its own volition or upon request, information and advice to Ministers of the Government in the performance of their duties. This includes making available such data and materials as are necessary to comply with Ireland's reporting obligations and commitments within the framework of international agreements. These requirements are the regulatory basis on which the EPA prepares annual inventories of greenhouse gases and other important emissions to air in Ireland. It is in this context that in 1995 the Department of the Environment Heritage and Local Government (DEHLG) designated the EPA as the inventory agency with responsibility for the submission of emissions data to the UNFCCC Secretariat and to the Secretariat for the Convention on Long-Range Transboundary Air Pollution (CLRTAP). The Agency's Office of Climate, Licensing and Resource Use (OCLR) currently compiles the national greenhouse gas emission inventories on behalf of DEHLG for submission under the Framework Convention on Climate Change and Decision 280/2004/EC (EP and CEU, 2004a), the latter being the basis for EU Member States' reporting under the Convention and the Kyoto Protocol.

The establishment of Ireland's national inventory system was completed by Government Decision in early 2007, building on the framework that had been applied for many years. Established institutional arrangements directed towards national inventory reporting and involving the EPA, DEHLG and other stakeholders are reorganised, extended and legally consolidated across all participating institutions to strengthen inventory capacity within the EPA, ensuring that more formal and comprehensive mechanisms of data collection and processing are established and maintained for long term implementation. The system puts in place formal procedures for the planning, preparation and management of the national atmospheric inventory and identifies the roles and responsibilities of all the organisations involved in its compilation. This was achieved through extensive discussions with all key data providers leading to the adoption of Memoranda of Understanding (MOU) between the key data providers and the inventory agency stipulating the scope, timing and quality of the inputs necessary for inventory compilation in accordance with the guidelines for national systems. Secondary MOUs are in turn used by some key data providers to formalise the receipt of data from their own particular sources. Table 1.1 lists the key data providers and indicates the range of data covered by MOU in the national system. A QA/QC plan is an integral part of the national system.

Figure 1.1 provides a schematic overview of the institutions, procedures and information flows involved in the national system. In addition to the primary data received from the key data providers, the inventory team obtains considerable supplementary information from other teams in OCLR and the Office of Environmental Enforcement within the EPA. These sources include Annual Environmental Reports (AER) submitted by licensed companies and the National Waste Database. The inventory team also draws on national research related to greenhouse gas emissions and special studies undertaken from time to time to acquire the information needed to improve the estimates for particular categories and gases. The approval of the completed annual inventory involves sign-off by the QA/QC manager and the inventory manager before it is transmitted to the Board of the EPA via the Programme Manager of the Climate Change Unit in OCLR. Any issues arising from the Board's examination of the estimates are communicated to the inventory experts for resolution before final adoption of the inventory. The results for the inventory year are normally released at national level in December of the following year in advance of their official submission to the European Commission in accordance with Decision 280/2004/EC in January of the reporting year and subsequently to the UNFCCC secretariat.

The Emissions Trading Unit (ETU) forms part of OCLR and is a key component of the national system. Information submitted by participants in the European Union Emissions Trading Scheme (ETS) under Directive 2003/87/EC (EP and CEU, 2003) is managed by the ETU and is available to the inventory team in OCLR. The annual ETS compilation serves as an important source of activity-specific and company-specific data on CO_2 emissions, fuel use and emission factors for major combustion sources and industrial processes. Emissions trading covers approximately 110 installations in Ireland with combined CO_2 emissions of 20,384 Gg in 2008, accounting for 30.7 percent of total greenhouse gas emissions. Guidance provided under the associated Decision 2004/156/EC (EP and CEU, 2004) on methodologies for estimating and reporting greenhouse gas emissions to support Directive 2003/87/EC, together with monitoring and verification mechanisms administered by the ETU, consolidates and improves the information in relation to a substantial proportion of CO_2 emissions for the purposes of reporting national GHG inventories under the Convention and the Protocol.

All formal mechanisms together with the QA/QC procedures are fully operational since becoming established in the 2007 reporting cycle. The EPA Office of Climate, Licensing and Resource Use is the inventory agency and the EPA is also designated as the single national entity with overall responsibility for the annual greenhouse gas inventory. The national system is also exploited for the purpose of parallel inventory preparation and reporting under the LRTAP Convention, ensuring efficiency and consistency in the compilation of emission inventories for a wide range of substances using common datasets and inputs. As a formal management system, the national system aims for continuous improvement to increase the quality and robustness of the national atmospheric inventory over time.

Table 1.1. Key Data Providers and Information covered by MOU

Key Data Provider	Data Supplied	Deadline	Sector in which data are used
Sustainable Energy Ireland	National Energy Balance; Detailed national energy consumption disaggregated by economic sector and fuel	30 September	Energy, Waste
Department of Agriculture and Food	Use of nitrogen fertilizer, cattle populations from CMMS (Cattle Movement and Monitoring Scheme)	30 September	Agriculture
Central Statistics Office	Annual population, livestock populations, crop statistics, housing survey data	30 September	Agriculture, Industrial Processes, Waste
COFORD (National Forest Research Institute)	Estimates of CO_2 emissions and removals and other GHG emissions for forest land; Statistical data on afforestation, reforestation and harvesting; Estimates of CO_2 emissions and removals and other GHG emissions for Article 3.3 activities	30 September	LULUCF
Bord Gais	Analysis results for indigenous and imported natural gas	30 September	Energy
Marine Institute	Annual Report on Discharges, Spills and Emissions from Offshore Gas Production Installations	30 October	Energy
Emissions Trading Unit	Verified CO_2 estimates and related fuel and production data for installations covered by the EU ETS[1]	30 April	Energy, Industrial Processes
*Department of Communications, Energy and Natural Resources	National Oil Balance (as a component of the energy balance)	30 September	Energy
*Road Safety Authority	Road transport statistics from the National Car Test (NCT)	30 April	Energy
**Forest Service	(i) GIS data base on premiums and grants afforestation areas (iFORIS) with associated attributes (II) NFI database	30 September 2007, 2012	LULUCF and Article 3.3 activities
**Coillte	GIS data base of intersected of NFI permanent sample plot points (Coillte-NFI plots) with sub-compartment and management unit data.	30 September	LULUCF and Article 3.3 activities

[1]ETS – Emissions Trading Scheme
*These bodies have MOUs with SEI rather than with OCLR
**These bodies have MOUs with COFORD rather than with OCLR

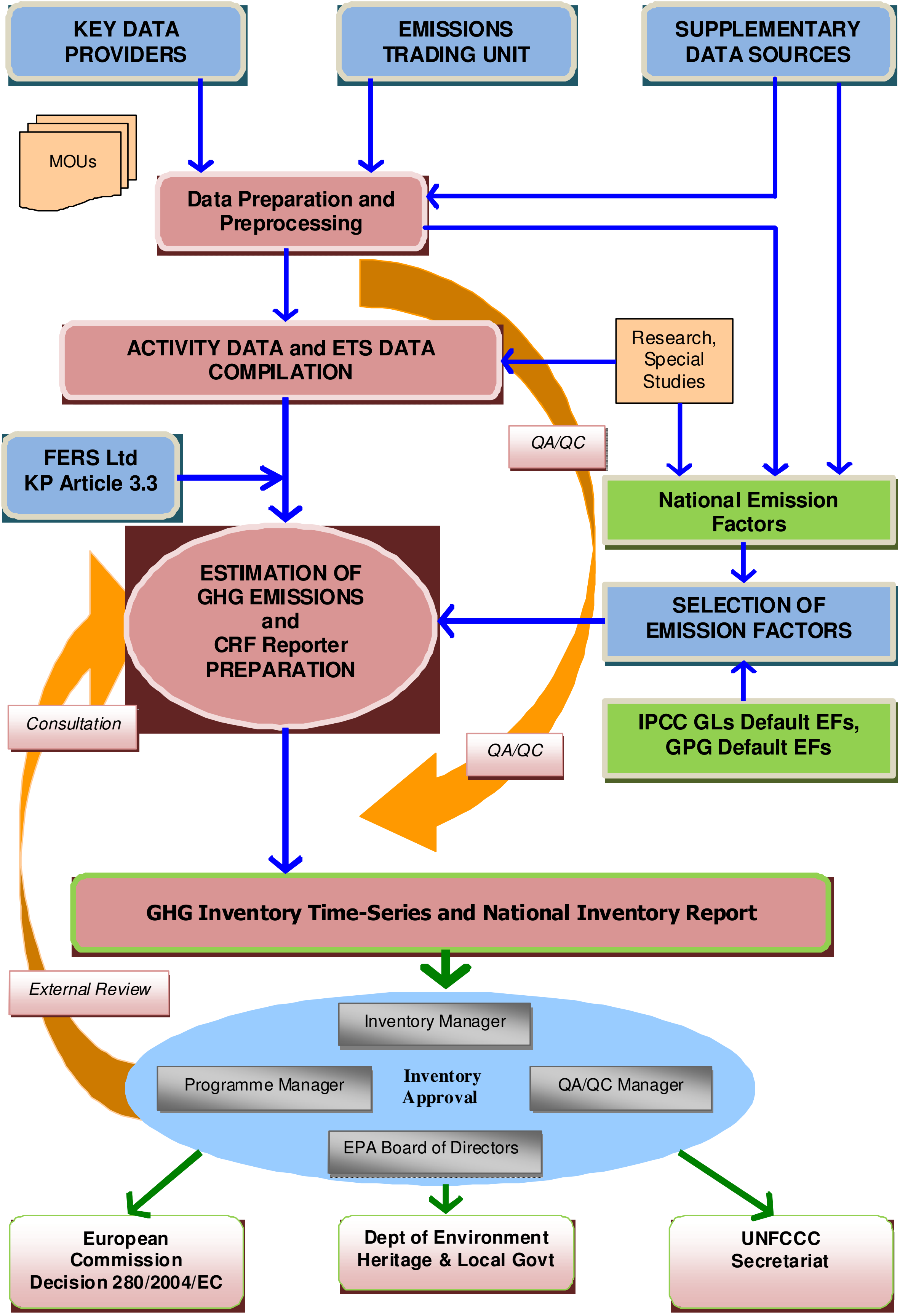

Figure 1.1. National Inventory System Overview

1.2.2 Inventory Planning

The inventory agency plans for preparation of the annual inventory as soon as possible after completion of the annual reporting cycle through the April submission to the UNFCCC secretariat. Planning largely involves the internal identification of improvements to be undertaken by way of revised methodologies and updated activity data or emission factors and addressing the issues and recommendations in the review of the previous inventory submission. Planning also considers the further development of inventory reporting for the LULUCF sector and for activities under Article 3.3, which are not handled by the OCLR inventory team and for which new information is becoming available on a continuous basis through national research and development of the National Forest Inventory. In addition, any changes required by the outcome of review activities conducted among the Member States of the European Union, or by the need to report in a manner consistent with other Member States for the purposes of Decision 280/2004/EC, are taken into account in inventory planning. The target date for the first release of the latest annual inventory at national level, which has become established as that given by the Government's economic and carbon budget presentation in December of the following year, is adopted as part of inventory planning.

1.2.3 Overview of Inventory Preparation and Management

The OCLR of the EPA performs the role of inventory agency and prepares the GHG inventory for all IPCC sectors except LULUCF through the system described above and using the data sources listed in Table 1. The estimates of emissions and removals for forest lands under the Convention, as well as those in respect of Article 3.3 activities under the Kyoto Protocol, are prepared by consultants contracted to COFORD, the Council for Forest Research and Development, and are delivered to the inventory agency under a Memorandum of Understanding between COFORD and OCLR. Research fellows contracted directly to OCLR are responsible for completion of the annual inventory for all other land categories in LULUCF for the annual inventory under the Convention. The deliverables received by OCLR from COFORD and the research fellows include the completed CRF tables and draft NIR sections for their respective areas of responsibility.

This first version of the latest annual inventory produced in December of the following year is then used to comply with the subsequent 15 January deadline prescribed by Decision 280/2004/EC, which governs the reporting of greenhouse gases and implementation of the Kyoto Protocol by the European Union and its EU Member States. The inventory preparation and management process thereafter involves making any revisions consequent on the receipt of updated or outstanding information nationally, accounting for any observations or amendments following initial assessment at EU level of the 15 January submission by Member States to the European Commission and the completion of the National Inventory Report in order to comply with the 15 March deadline for the delivery of the complete and final inventory submission under Decision 280/2004/EC. This version of the latest inventory is fixed and retained for submission to the UNFCCC secretariat by 15 April to complete the reporting cycle. Ireland's national system is operating very successfully and the timeliness of inventory preparation has benefited from the implementation of more formal arrangements and enhanced engagement among the various institutions and contributors.

1.3 Inventory Preparation

1.3.1 GHG Inventory and KP-LULUCF Inventory

An emissions inventory database normally contains information on measured emission quantities, activity statistics (populations, fuel consumption, vehicle/kilometres of travel, industrial production, land areas), emission factors and the associated emission estimates for a specified list of source categories. In practice, very few measured data are available for greenhouse gases and, consequently, the emissions from most activities are estimated by applying emission factors for each source/gas combination to appropriate activity data for the activity concerned. Virtually all emissions and removals estimates may be ultimately derived on the basis of such simple product of activity data and emission factor. However, a certain amount of data analysis and preparatory calculations are generally needed in order to make available suitable combinations of activity data and emission factors at the level of disaggregation that gives the best estimates of emissions and removals. In the case of some source/gas combinations, such as methane emissions from solid waste landfills and CO_2 sequestration by forest biomass, it may be necessary to apply sophisticated models to generate the activity data, the emission factors or the emissions. The methods recommended by the Revised 1996 IPCC Guidelines (IPCC, 1997), IPCC Good Practice Guidance (IPCC, 2000) and IPCC Good Practice Guidance on LULUCF (IPCC, 2000) use a tier system to take account of these issues and other factors, such as data availability, technical expertise, inventory capacity and other circumstances, which may vary considerably across countries.

1.3.2 Data Collection Processing and Storage

Preparation for the annual GHG inventory takes place in an EXCEL spreadsheet system where activity data stored in *Source Data* files are linked to calculation sheets in *Data Processing* files that produce the emissions estimates at the lowest possible level of disaggregation. These estimates are combined and allocated according to IPCC requirements for direct transmission into the CRF Reporter utility for the generation of the CRF tables. These results are stored in *Outputs* files while supporting QA/QC sheets extracted from *Data Processing* files are held in summary *QA/QC* record files. The *Data Processing* files hold the emission factors and they are structured on a time-series basis, which facilitates efficient recalculation and output to the CRF Reporter. This procedure applies to all IPCC sectors of the GHG inventory for which the calculations are made by the inventory team and the full set of files applicable to each year under the four headings is stored using appropriate version control on the OCLR servers. A national model is used to derive the estimates of emissions and removals for forest lands, which are incorporated in the overall scheme for LULUCF reporting under the Convention following the procedure outlined above.

Table 1.1 lists the principal data suppliers and the information that they are required to deliver to the inventory agency annually under MOU for the preparation of the GHG inventory. In some cases, e.g. the national energy balance, the input file received from the data supplier may be linked directly to the *Data Processing* files, but generally some degree of preparation and pre-processing is needed before the activity data are used in inventory preparation. The inventory team draws on various other data streams available within the EPA, such as the National Waste Database, reports on wastewater treatment, Annual Environmental Reports from companies subject to Integrated Pollution Prevention and Control licences and submissions prepared under the European Pollutant Release and Transfer Register and also obtains information from other diverse sources to prepare the inventories for fluorinated gases and solvent use. A variety of databases related to land cover, soil type and forest areas are applied for the LULUCF inventory under the

Convention. These include the National Forest Inventory (NFI), the Forest Inventory and Planning System (FIPS), the Land Parcels Information System (LPIS), CORINE Land Cover Maps, the General Soil Map of Ireland, which are supported by statistical information from the Central Statistics Office (C.S.O.), Bord na Mona and the National Roads Authority.

The static national model used for many years to estimate emissions and removals for forest lands for Convention reporting has been extensively developed to a dynamic version to provide the necessary estimates for Article 3.3 activities under the Kyoto Protocol. This work has been undertaken by Forest Environmental Research and Services (FERs), the consultants working to COFORD, which supplies the Article 3.3 results to OCLR under an agreed MOU (Table 1.1). Secondary MOUs between COFORD and its data suppliers formalise annual data collection for this area of the inventory. The model contains a multitude of component modules needed to produce estimates of the carbon stock changes for the various carbon pools under afforestation and deforestation areas and for reporting any relevant emissions of CH_4 and N_2O. The model processes detailed spatially explicit data on forest species and soil type obtained from the NFI and FIPS and soils maps, supported by the Grants and Premiums Administration System (GPAS) and felling license records, using complex pre-processing functions, growth models, allometric equations and pool allocation and transfers to produce the results required for Article 3.3 activities.

1.3.3 Quality Assurance and Quality Control

In early 2005, the inventory agency in Ireland commissioned a project with UK consultants NETCEN to establish formal QA/QC procedures in emission inventories that would meet the needs of the UNFCCC reporting requirements. The project developed a QA/QC system including a documented QA/QC plan and procedures along with a QA/QC manual. The manual provides a general overview to the QA/QC system and guidance on the application of the plan and procedures. The QA/QC plan identifies the specific data quality objectives related to the principles of transparency, consistency, completeness, comparability and accuracy required for Ireland's national inventory and provides specific guidance and documentation forms and templates for the practical implementation of QA/QC procedures. The QA/QC procedures cover such elements as data selection and acquisition, data processing and reporting so that the international requirements under the Kyoto Protocol and Decision 280/2004/EC are met. The manual provides guidance and templates for appropriate quality checking, documentation and traceability, the selection of source data and calculation methodologies and peer and expert review of inventory data and outlines the annual requirements for continuous improvement for the inventory.

1.4 Methodologies and Emission Factors

Table 1.2 and Table 1.3 present summaries of the methodologies and emission factors used by Ireland to estimate GHG emissions reported for the years 1990-2008. Tier 2 or Tier 3 methods are used for the majority of CO_2 combustion source categories and country-specific emission factors are used for all fuels. Even for those combustion categories where data limitations dictate the use of Tier 1 methods, such as 1.A.2 and 1.A.4, the CO_2 emissions obtained using the energy balance fuel data and country-specific emission factors are reliable. Tier 2 methods also apply to important process sources of CO_2 emissions, such as cement and lime production, where country-specific circumstances are again taken fully into account. Ireland's national circumstances are well captured in the Tier 2 methods applied for the major sources of CH_4 in the inventory, which are enteric fermentation and manure management associated with cattle and the CH_4 emissions from solid waste disposal sites. Tier 2 and Tier 3 methods are used for CH_4 emissions from 1.A.1 Energy Industries and 1.A.3(b) Road Transport, respectively, while Tier 1 methods and IPCC default emission factors are used for other CH_4 emissions.

Table 1.2. Summary of Methods

IPCC SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	HFC	PFC	SF_6
1. Energy						
A. Fuel Combustion (Sectoral Approach)						
1. Energy Industries	Tier 2& 3	Tier 2& 3	Tier 2& 3	NA	NA	NA
2. Manufacturing Industries and Construction	Tier 1	Tier 1	Tier 1	NA	NA	NA
3. Transport	Tier 1& 2	Tier 1& 3	Tier 1& 3	NA	NA	NA
4. Other Sectors	Tier 1	Tier 1	Tier 1	NA	NA	NA
5. Other	NA	NA	NA	NA	NA	NA
B. Fugitive Emissions from Fuels						
1. Solid Fuels	NA	NA	NA	NA	NA	NA
2. Oil and Natural Gas	CS	CS	NA	NA	NA	NA
2. Industrial Processes						
A. Mineral Products	Tier 1& 2	NA	NA	NA	NA	NA
B. Chemical Industry	Tier 1	NA	Tier 1	NA	NA	NA
C. Metal Production	NA	NA	NA	NA	NA	NA
D. Other Production	NA	NA	NA	NA	NA	NA
E. Production of Halocarbons and SF_6	NA	NA	NA	NA	NA	NA
F. Consumption of Halocarbons and SF_6	NA	NA	NA	Tier 1,2& 3	Tier 2	Tier 1& 2
G. Other	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	CS, C	NA	NA	NA	NA	NA
4. Agriculture						
A. Enteric Fermentation	NA	Tier 1& 2	NA	NA	NA	NA
B. Manure Management	NA	Tier 1& 2	Tier 1	NA	NA	NA
C. Rice Cultivation	NA	NA	NA	NA	NA	NA
D. Agricultural Soils	NA	NA	Tier 1a,1b	NA	NA	NA
E. Prescribed Burning of Savannas	NA	NA	NA	NA	NA	NA
F. Field Burning of Agricultural Residues	NA	NA	NA	NA	NA	NA
G. Other	NA	NA	NA	NA	NA	NA
5. Land-Use Land-Use Change Change and Forestry						
A. Forest Land	Tier 1& 3	Tier 1	Tier 1	NA	NA	NA
B. Cropland	Tier 1	NA	Tier 1	NA	NA	NA
C. Grassland	Tier 1	NA	NA	NA	NA	NA
D. Wetlands	Tier 1	NA	Tier 1	NA	NA	NA
E. Settlements	Tier 1	NA	NA	NA	NA	NA
F. Other Land	Tier 1	NA	NA	NA	NA	NA
G. Other	NA	NA	NA	NA	NA	NA
6. Waste						
A. Solid Waste Disposal on Land	NA	Tier 2	NA	NA	NA	NA
B. Wastewater Handling	NA	Tier 1	Tier 1	NA	NA	NA
C. Waste Incineration	NA	NA	NA	NA	NA	NA
D. Other	NA	NA	NA	NA	NA	NA
7. Other	NA	NA	NA	NA	NA	NA
Article 3.3 Afforestation and Deforestation	Tier 3	Tier 1	Tier 1	NA	NA	NA
International Bunkers						
Aviation	Tier 1	D	D	NA	NA	NA
Marine	D	D	D	NA	NA	NA
Multilateral Operations	NA	NA	NA	NA	NA	NA
CO_2 Emissions from Biomass	Tier 1	Tier 1	Tier 1	NA	NA	NA

Tier 1 : IPCC Tier 1 or equivalent
Tier 2 : IPCC Tier 2 or equivalent
Tier 3 : IPCC Tier 3 or equivalent

CS : Country specific
C : CORINAIR
D : IPCC Default

Table 1.3. Summary of Emission Factors

IPCC SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	HFC	PFC	SF_6
1. Energy						
A. Fuel Combustion (Sectoral Approach)						
1. Energy Industries	PS, CS	D	D	NA	NA	NA
2. Manufacturing Industries and Construction	C	D	D	NA	NA	NA
3. Transport	CS	M, C	M, C	NA	NA	NA
4. Other Sectors	CS	D	D	NA	NA	NA
5. Other	NA	NA	NA	NA	NA	NA
B. Fugitive Emissions from Fuels						
1. Solid Fuels	NA	NA	NA	NA	NA	NA
2. Oil and Natural Gas	CS	CS	NA	NA	NA	NA
2. Industrial Processes						
A. Mineral Products	CS, PS, D	NA	NA	NA	NA	NA
B. Chemical Industry	CS	NA	CS	NA	NA	NA
C. Metal Production	NA	NA	NA	NA	NA	NA
D. Other Production	NA	NA	NA	NA	NA	NA
E. Production of Halocarbons and SF_6	NA	NA	NA	NA	NA	NA
F. Consumption of Halocarbons and SF_6	NA	NA	NA	CS	CS	CS
G. Other	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	C	NA	NA	NA	NA	NA
4. Agriculture						
A. Enteric Fermentation	NA	CS, D	NA	NA	NA	NA
B. Manure Management	NA	CS, D	D	NA	NA	NA
C. Rice Cultivation	NA	NA	NA	NA	NA	NA
D. Agricultural Soils	NA	NA	CS, D	NA	NA	NA
E. Prescribed Burning of Savannas	NA	NA	NA	NA	NA	NA
F. Field Burning of Agricultural Residues	NA	NA	NA	NA	NA	NA
G. Other	NA	NA	NA	NA	NA	NA
5. Land-Use Land-Use Change and Forestry						
A. Forest Land	CS, D	D	D	NA	NA	NA
B. Cropland	D	NA	D	NA	NA	NA
C. Grassland	D	NA	NA	NA	NA	NA
D. Wetlands	D	NA	D	NA	NA	NA
E. Settlements	D	NA	NA	NA	NA	NA
F. Other Land	D	NA	NA	NA	NA	NA
G. Other	NA	NA	NA	NA	NA	NA
6. Waste						
A. Solid Waste Disposal on Land	NA	CS, M	NA	NA	NA	NA
B. Wastewater Handling	NA	D	D	NA	NA	NA
C. Waste Incineration	NA	NA	NA	NA	NA	NA
D. Other	NA	NA	NA	NA	NA	NA
7. Other	NA	NA	NA	NA	NA	NA
Article 3.3 Afforestation and Deforestation	CS	D	D	NA	NA	NA
International Bunkers						
Aviation	CS	C	C	NA	NA	NA
Marine	CS	C	C	NA	NA	NA
Multilateral Operations	NA	NA	NA	NA	NA	NA
CO_2 Emissions from Biomass	C	C	C	NA	NA	NA

PS : Plant specific D : Default
CS : Country specific M : Model
C : CORINAIR

Ireland relies on the simplified IPCC Tier 1 methodologies and default emission factors available to estimate all N_2O emissions in agriculture, which is the main source of N_2O in the inventory. Tier 2 and Tier 3 methods are used for N_2O emissions from 1.A.1 Energy Industries and 1.A.3(b) Road Transport, respectively, while Tier 1 methods and IPCC default emission factors are used for other N_2O emissions. The national model used to estimate carbon stock change in the various carbon pools for forest lands in respect of both Convention reporting and Article 3.3 activities is a Tier 3 methodology. The methods for CO_2 in other LULUCF categories and for relevant CH_4 and N_2O emissions in this sector are invariably Tier 1. More than 80 percent of the total emissions (excluding LULUCF) are covered by Tier 2 methods in Ireland's GHG inventory under the Convention and a Tier 3 model is applied for carbon stock changes for Article 3.3 activities under the Kyoto Protocol.

1.5 Overview of Key Categories

The IPCC good practice guidance defines a key category as one that is prioritised within the national inventory system because its emission estimate has a significant influence on the Party's total inventory in terms of the absolute level of emissions, the trend in emissions or both. Information about key categories is considered to be crucial to the choice of methodology for individual sources and to the management and reduction of overall inventory uncertainty. The identification of such categories is recommended in order that inventory agencies can give them priority in the preparation of annual inventories, especially in cases where resources may be limited. Information on key categories is clearly also vital for the development of policies and measures for emissions reduction. The IPCC good practice guidance provides several methods for undertaking the analysis of key categories that can be applied at any appropriate level of source aggregation, depending on the information available. The simplest Tier 1 approach is again used for 2008 to further highlight which sources of emissions are the most important in Ireland.

1.5.1 Key Categories at IPCC Level 2

As inventories of CO_2, CH_4 and N_2O were being developed in Ireland during the 1990s, it was quickly established that CO_2 emissions from fuel combustion made by far the largest contribution to the combined national total for these three primary greenhouse gases. It was also evident that CH_4 emissions produced by large cattle herds and the N_2O emissions from agricultural soils, associated with intensive farming practices and large inputs of nitrogen to agricultural soils, were also major sources, even if the estimates were more uncertain than those for CO_2. A good first estimate of key categories is therefore provided by considering the emissions aggregated at the IPCC Level 2 source category classification, which clearly indicates the importance of CO_2 emissions from fuel combustion and CH_4 and N_2O emissions from agriculture.

The results at the IPCC Level 2 source category classification may be readily drawn from the CRF Summary 2 and those for 1990 and 2008 are shown in Table 1.4 and Table 1.5, respectively. It can be seen that there are six highly significant key categories of emissions in Ireland. They are the CO_2 combustion sources *in 1.A.1 Energy Industries, 1.A.4 Other Sectors, 1.A.2 Manufacturing Industries and Construction* and *1.A.3 Transport,* along with the CH_4 emissions from category *4.A Enteric Fermentation* and N_2O emissions from *4.D Agricultural Soils*. These categories accounted for 85.2 percent and 89.0 percent of total emissions in 1990 and 2008, respectively. In the case of 2008 emissions, only two additional Level 2 source categories are needed to reach the cumulative 95 percent threshold that defines a key category. The increase in the contribution of CO_2 emissions from category *1.A.3 Transport* from 9.2 percent in 1990 to 20.8 percent in 2008 is notable, along with the corresponding reductions in the contributions from the two categories in

Agriculture. This simple analysis of key categories continues to prove useful to the formulation of abatement strategies and for prioritising work on inventories in Ireland. When LULUCF is accounted for in the Level 2 analysis, the CO_2 removals in 5.A Forest Land become a key category in 2008.

Table 1.4. Key Categories at IPCC Level 2 in 1990

IPCC Level 2 Source Category		GHG	Emissions in 1990 Gg CO_2 eq	1990 Level Assessment %	Cumulative Total of Level %
1.A.1	Energy Industries	CO_2	11,158.61	20.36	20.36
1.A.4	Other Sectors(Comm/Resid/Agric)	CO_2	10,052.73	18.34	38.70
4.A	Enteric Fermentation	CH_4	9,493.47	17.32	56.02
4.D	Agricultural Soils	N_2O	7,008.17	12.79	68.81
1.A.3	Transport	CO_2	5,039.39	9.19	78.00
1.A.2	Manufacturing Industries and Construction	CO_2	3,940.06	7.19	85.19
4.B	Manure Management	CH_4	2,324.53	4.24	89.43
6.A	Solid Waste Disposal on land	CH_4	1,173.05	2.14	91.57
2.B.2	Nitric Acid Production*	N_2O	1,035.40	1.89	93.46
2.B.1	Ammonia Production*	CO_2	990.23	1.89	95.26

* nitric acid and ammonia plants ceased operation in 2002 and 2001, respectively

Table 1.5. Key Categories at IPCC Level 2 in 2008

IPCC Level 2 Source Category		GHG	Emissions in 2008 Gg CO_2 eq	2008 Level Assessment %	Cumulative Total of Level %
1.A.1	Energy Industries	CO_2	14,495.44	21.49	21.49
1.A.3	Transport	CO_2	14,061.80	20.85	42.34
1.A.4	Other Sectors(Comm/Resid/Agric)	CO_2	10,923.78	16.20	58.54
4.A	Enteric Fermentation	CH_4	8,804.09	13.05	71.59
4.D	Agricultural Soils	N_2O	6,245.40	9.26	80.85
1.A.2	Manufacturing Industries and Construction	CO_2	5,522.95	8.19	89.04
4.B	Manure Management	CO_2	2,152.42	3.19	92.23
2.A.1	Cement Production	CH_4	2,106.73	3.12	95.35

1.5.2 Disaggregated Key Categories

Ireland uses the Tier 1 methods provided in the IPCC good practice guidance to extend the analysis above to identify key categories that may be treated separately at a more disaggregated level, which gives more information about the individual sources or combination of sources and gases that are of most importance within a Level 2 category. The disaggregation corresponds generally to that at which the emissions are calculated and to that used for estimating uncertainty. The results of the analysis for the Tier 1 level assessment in relation to emissions in both 1990 and 2008 are presented in Table 1.6 and Table 1.7, respectively. Ranking in this way identifies those categories that should be prioritised in the inventory process itself and also the individual components of emissions that could be targeted by specific abatement measures. There is insufficient information available on uncertainties to allow for analysis using the Tier 2 methods. Results for Tier 1 trend assessment for 2008 are shown in Table 1.8. The results of the assessment for 2008 excluding LULUCF categories may be summarised as follows

(i) level assessment identifies 23 key categories;

(ii) there are 14 key categories of CO_2 in level assessment, accounting for 69.0 percent of total emissions;

(iii) there are five key categories of CH_4 and three key categories of N_2O in level assessment, which account for 16.0 percent and 9.3 percent, respectively, of total emissions;

(iv) *Energy* accounts for 13 key categories, *Agriculture* for seven while *Industrial Processes* contributes two and *Waste* contributes one;

(v) trend assessment identifies 21 key categories, all of which are key categories for level assessment;

(vi) there are 12 key categories of CO_2 in trend assessment, accounting for 76.5 percent of the total trend;

(vii) there are five key categories of CH_4 and three key categories of N_2O in trend assessment, which account for 10.5 percent and 6.6 percent, respectively, of the total trend.

The list of key categories given by level assessment in 2008 is very similar to that for 1990 but the higher ranking of the main CO_2 sources in *Energy,* at the expense of CH_4 and N_2O sources in *Agriculture*, is notable in 2008. The top ten key categories contributed 70.2 and 72.2 percent, of total emissions in 1990 and 2008, respectively. The emissions of CO_2 from fuel combustion in *1.A.1 Energy Industries* and from the use of petrol and diesel by road traffic were the largest source categories of greenhouse gas emissions in Ireland in 2008, accounting for approximately 21 percent each of the total. The CO_2 removals in category *5.A.1 Forest Land Remaining Forest Land* and the CO_2 emissions in *5.C.1 Grassland Remaining Grassland* are key categories in level assessment when the LULUCF sector is included in the detailed analysis. Similarly, CO_2 removals in category *A.1 Afforestation and Deforestation (*which are determined largely by *5.A.1 Forest Land Remaining Forest Land* under LULUCF) is a key category in 2008 when Article 3.3 activities are included instead of the LULUCF sector. Under trend assessment including LULUCF, two additional categories (*5.A.2 Land Converted to Forest Land* and *5.B.2 Land Converted to Cropland*) become key categories in 2008.

1.5.3 Use of Key Category Analysis

The Tier 1 approach to the determination of key categories is based on the principle that the cumulative uncertainty in their emissions represents 90 percent of the total inventory uncertainty and that 95 percent of total emissions account for this cumulative fraction of uncertainty. This quantitative approach may therefore result in a much larger number of key categories than might be expected using simpler qualitative criteria. In effect, an inventory with only a small number of major emission sources will require the inclusion of many source categories in order to reach the 95 percent emissions threshold.

This is well shown by the results of key source determination for Ireland, based on Tier 1 level assessment. The results excluding LULUCF indicate that 12 of the 23 key categories in 2008 each accounted for less than 3 percent of the total emissions and that only five key categories contributed more than 5 percent each to the total. The Tier 1 analysis adequately identifies the specific sources of emissions that are significant in terms of the overall uncertainty of the inventory but it provides little direction on where to focus priority when the number is large. In these circumstances, information on the uncertainty in the individual source categories and other factors must be taken into account in making decisions regarding the most cost-effective use of inventory capacity related to key source categories.

The results of the Tier 1 key category analysis in Table 1.6 clearly show that the impact of CO_2 emissions from energy consumption on total emissions in Ireland continues to increase. These emissions account for 14 of the key categories listed in Table 1.6 and for 69 percent of total emissions in 2008. While key categories determined by CO_2 emissions from energy consumption have a major bearing on total emissions in Ireland, the remaining potential for significant reduction in the uncertainties associated with these sources is rather limited. The activity data and CO_2 emission factors for *Energy* source categories in general are among the most reliable items of input data in the inventory and there is consequently little scope for improving the accuracy of the emission estimates. The application of a robust Tier 2 methodology for emissions of CH_4 from enteric fermentation in cattle (dairy and non-dairy) and the use of verified estimates for CO_2 emissions from cement production means that the contributions from three additional key categories (ranked 4, 8 and 11 in Table 1.6), making up a further 15.1 percent of the total, are also known with probably the highest certainty now achievable. The N_2O emissions from *4.D Agricultural Soils* and *4.B Manure Management* and the CH_4 emissions from *6.A Solid Waste Disposal on Land* account for most of the remaining important key categories in Table 1.6. The uncertainties in the estimates for these complex sources (Section 1.7) will remain high due to the large number of factors that influence their emissions and the relatively simple methods that continue to be used.

1.6 Quality Assurance and Quality Control

The inventory agency used the 2006 reporting cycle to begin implementation of the new approach to QA/QC developed for the national system and its application was completed and consolidated in delivering the submissions up to 2009. This involved the allocation of responsibilities linked to the national system mentioned in section 1.3.2 and the use of a template spreadsheet system to record the establishment and maintenance of general inventory checking and management activities covering the overall compilation process, as well as the undertaking of specific annual activities and any necessary periodic activities in response to specific events or outcomes in inventory reporting and review. The system facilitates record keeping related to the chain of activities from data capture, through emissions calculations and checking, to archiving and the identification of improvements. The system has been carried forward for use in completing the 2010 submission.

Ireland's calculation spreadsheets in all sectors are structured and organised to facilitate the QA/QC process and more efficient time-series analysis and also to ensure ease of transfer of the outputs to the CRF Reporter Tool. This facilitates rapid year-on-year extension of the time-series and allows regular inter-annual comparisons and efficient updating and recalculation, where appropriate, in the annual reporting cycle. Internal aggregation to various levels corresponding to the CRF tables provides immediate and complete checks on the results.

External reviews of the agriculture sector and of the entire ETS results for 2005 were conducted as important new components of quality assurance at the beginning of 2007. The review for Agriculture was performed by a technical inspector in the Department of Agriculture and Food using the new calculation files with a view to assessing the consistency of the time series which had been subject to considerable improvement and recalculation in the 2006 reporting cycle to account for higher tier methods for enteric fermentation in cattle and advice from the Department on various aspects of input data and calculation parameters. As there have been no further changes to the methodologies in agriculture the detailed external review has not been repeated. However, the inventory agency continues to work closely with the Department and seeks advice and guidance from experts in Teagasc, who developed the improved methods, in relation to technical inventory matters that may arise. The ETS returns to the Agency's Office of Climate, Licensing and Resource Use (OCLR) provide for the complete coverage of CO_2 estimates for in a number of sub-categories under 1.A.1 Energy Industries and 2.A. Mineral Products. When the allocation to these categories from the ETS raw data is completed, the output is returned to the ETS administrator in OCLR for final checking against the source data. This ensures the efficient and consistent transfer of the verified ETS emissions estimates into the national inventory. Inventory development continues to benefit from the internal review procedures that are ongoing with regard to the EU and its Member States. The most recent work in this forum focused on harmonising the reporting relating to sub-categories under 2.A Mineral Products across the EU Member States.

1.7 Uncertainty Assessment

The Tier 1 method provided by the IPCC good practice guidance has been used to make an assessment of uncertainty in the emissions inventory for 2008 in the same way as for previous years. This method estimates uncertainties for the entire inventory in a particular year and the uncertainty in the trend over time by combining the uncertainties in activity data and emission factors for each source category. The analysis for 2008 is presented in Table 1.8, using emissions on a GWP basis and a level of source category disaggregation that corresponds closely to the level used for emissions calculation and for key category analysis. This disaggregation level limits the likely dependency and correlation between source categories.

The input values of uncertainty for activity data and emission factors in the GHG inventory have been assigned largely on the basis of general information related to the methodological descriptions in the IPCC good practice guidance, supported by opinions elicited from the principal data suppliers, such as statistical offices, energy agencies, Government departments and individual experts who contributed to certain parts of the inventory. Where high tier methods are used for combustion sources, such as those covered by ETS and road transport, the activity data uncertainty estimates are those indicated for the tier concerned. Accordingly, low estimates of uncertainty apply to the activity data for categories such as 1.A.1 and 1.A.3, as shown on Table 1.8. Slightly higher uncertainty levels are used for energy activity data in sub-categories under 1.A.2 and 1.A.4, where the end use of fuels is not as well quantified in the top-down methods used. Low activity data uncertainties are justified in respect of CO_2 emissions sources in Industrial Processes, for which bottom-up data are applied in most cases and the major sources of emissions are covered by ETS. Country-specific CO_2 emission factors are used for all combustion sources, which gives a basis for assigning the uncertainties for emission factors while again taking into account the applicable tiers. Uncertainties in the emission factors for CH_4 and N_2O released from combustion sources are high and not well established quantitatively. For the 2010 submission, Ireland has updated the CH_4 and N_2O emission factors for combustion categories in general to those given by the most up-to-date IPCC publications and has used an indicative uncertainty of 50 percent for both gases.

The *Agriculture* sector is the second most important sector in Ireland's GHG inventory and has a major influence on overall uncertainty due to its large contribution in terms of CH_4 and N_2O emissions. Ireland has long-established and robust statistical data collection procedures in place for agriculture in general, which guides the selection of 1 percent as the activity data uncertainty for all agriculture sub-categories. The IPCC good practice guidance indicates that the emission factor estimates for the Tier 2 approach to determine CH_4 emissions from enteric fermentation in cattle are likely to have an uncertainty of 20 percent. Following the opinion of national agriculture experts, a value of 15 percent has been adopted for these emissions considering that Ireland's Tier 2 method is very detailed and uses reliable data. In some of the other important emissions sources in *Agriculture* (such as manure management and agricultural soils) the activity data or emission factors ultimately used are determined by several specific component inputs, which are individually subject to varying degrees of uncertainty. The uncertainty estimates used for emission factors for these sources have been derived by assigning uncertainties to the key component parameters and combining them at the level of activity data or emission factors, as appropriate, using equation 6.4 in section 6.3 of the IPCC good practice guidance to obtain the input to the Tier 1 uncertainty assessment. The footnotes to Table 1.8 show how some of these uncertainty inputs are obtained.

Category 6.A Solid Waste is the principal source of CH_4 emissions outside *Agriculture*. Under the revised methodology used for category 6.A in this submission, the component uncertainties for both activity data and emission factor for CH_4 generation are derived using equation 6.4 of the IPCC good practice guidance and as shown in the footnotes to Table 1.8. These are combined with uncertainties of 30 percent and 10 percent for flaring and utilisation respectively to obtain the overall uncertainty using equation 6.3 of the IPCC good practice guidance. A full analysis of uncertainty remains to be completed for LULUCF under the Convention and only a top-level estimate is provided. Equations 6.3 and 6.4 are both applied as appropriate in a hierarchial approach to derive uncertainty for LULUCF Article 3.3 activities. This is achieved by developing uncertainties for carbon pools, which are combined to give the values for the individual land-use categories, which are then combined with uncertainties for other reported activities to give the totals for Article 3.3. The uncertainty estimates for F-gases are those developed by the consultants who produced the F-gas inventories for Ireland in 2005 as the data sources and methodologies remain unchanged.

The Tier 1 uncertainty analysis for Ireland's 2008 inventory under the Convention (Table 1.9) gives an overall uncertainty of 6.4 percent in total emissions and a trend uncertainty of 4.7 percent for the period 1990 to 2008. These relatively low estimates are determined largely by the low uncertainties in the estimate of CO_2 emissions, which accounts for 70 percent of total Irish emissions in 2008 and which are estimated to have a level uncertainty of 2.9 percent. When CH_4 is included, bringing the proportion of total emissions up to 88 percent, the total uncertainty estimate is 3.3 percent, even though there are large uncertainties assigned to the CH_4 emission factors in some source categories. However, it is the influence of N_2O that leads to a substantial uncertainty in total emissions. This influence is not as large in the case of the trend, due to the modest change in emissions of N_2O from 1990 to 2007 and the relatively small share of this gas in total emissions. The impact of HFC, PFC and SF_6 on inventory uncertainty remains negligible because these gases account for only 1 percent of total emissions in Ireland. The overall uncertainty estimate for Article 3.3 activities in 2008 is 27 percent, which is determined largely by an uncertainty of 26 percent calculated for CO_2 removals in the category 5(KP-I)A.1.1

1.8 Completeness and Time-Series Consistency

Table 1.10 gives an overview of the level of completeness of the 2008 GHG inventories with respect to the six greenhouse gases covered by the UNFCCC reporting guidelines, the IPCC Level 2 source-category split in operation since 2005 for reporting under the Convention and Article 3.3 activities under the Kyoto Protocol. Further detail on source/gas coverage at IPCC Level 3 is provided in the individual chapters describing the inventory methods and data for each Level 1 source-category. The work done for the current reporting cycle serves to maintain a complete and consistent emissions time-series by improving the inventories for the years 1990-2007 to bring them fully into line with that for 2008, which features important methodological changes in the *Energy* and *Waste* sectors. The opportunity has also been taken in this current cycle to improve, wherever possible, the estimates of emissions and removals for all years for LULUCF reported under the Convention in accordance with the requirements of Decision 13/CP.9 in order to achieve consistency with the reporting on Article 3.3 activities under the Kyoto Protocol.

Table 1.6. Key Category Level Assessment 1990

1990 Rank	IPCC Sub-Category	Emission Source/Activity	Gas	1990 Emission exc LULUCF Gg CO_2 eq	1990 Emission LULUCF Gg CO_2 eq	1990 Absolute Values Gg CO_2 eq	1990 Level Assessment inc LULUCF %	Cumulative Level inc LULUCF %	1990 Level Assessment exc LULUCF %	Cumulative Level exc LULUCF %
1	1.A.1.	Energy Industries - Solid Fuels	CO2	8009.44		8009.44	13.97	13.97	14.61	14.61
2	1.A.4.b	Residential- Solid Fuels	CO2	5606.94		5606.94	9.78	23.76	10.23	24.84
3	4.A.1.	Enteric Fermentation - Non-Dairy Cattle	CH4	5546.63		5546.63	9.68	33.43	10.12	34.96
4	1.A.3.b.	Road Transportation - Liquid Fuels	CO2	4700.93		4700.93	8.20	41.64	8.58	43.54
5	4.A.1.	Enteric Fermentation - Dairy Cattle	CH4	2875.51		2875.51	5.02	46.65	5.25	48.78
6	4.D.1.	Agricultural Soils - Direct Soil Emissions	N2O	2861.74		2861.74	4.99	51.65	5.22	54.01
7	4.D.2.	Agricultural Soils - Pasture, Range and Paddock	N2O	2802.31		2802.31	4.89	56.53	5.11	59.12
8	1.A.2.	Manufacturing Ind & Const - Liquid Fuels	CO2	2195.69		2195.69	3.83	60.37	4.01	63.12
9	1.A.4.a.	Commercial/Institutional - Liquid Fuels	CO2	1976.61		1976.61	3.45	63.81	3.61	66.73
10	1.A.1.	Energy Industries - Gaseous Fuels	CO2	1880.66		1880.66	3.28	67.10	3.43	70.16
11	4.D.3.	Agricultural Soils - Indirect Emissions	N2O	1344.11		1344.11	2.35	69.44	2.45	72.61
12	1.A.1.	Energy Industries - Liquid Fuels	CO2	1268.51		1268.51	2.21	71.65	2.31	74.93
13	4.B.1.	Manure Management - Non-Dairy cattle	CH4	1255.57		1255.57	2.19	73.84	2.29	77.22
14	1.A.4.b	Residential - Liquid Fuels	CO2	1177.50		1177.50	2.05	75.90	2.15	79.37
15	6.A.	Waste - Solid Waste Disposal on land	CH4	1173.05		1173.05	2.05	77.94	2.14	81.51
16	2.B.	Chemical Industry	N2O	1035.40		1035.40	1.81	79.75	1.89	83.40
17	4.A.3.	Enteric Fermentation - Sheep	CH4	1032.48		1032.48	1.80	81.55	1.88	85.28
18	5.A.1	LULUCF - Forest Land Remaining Forest Land	CO2		-999.06	999.06	1.74	83.30		
19	2.B.	Chemical Industry	CO2	990.23		990.23	1.73	85.02	1.81	87.09
20	2.A.1.	Cement Production	CO2	884.00		884.00	1.54	86.57	1.61	88.70
21	1.A.2.	Manufacturing Ind & Const - Gaseous Fuels	CO2	873.14		873.14	1.52	88.09	1.59	90.29
22	1.A.2.	Manufacturing Ind & Const - Solid Fuels	CO2	871.24		871.24	1.52	89.61	1.59	91.88
23	1.A.4.c.	Agriculture/Forestry/Fisheries - Liquid Fuels	CO2	660.30		660.30	1.15	90.76	1.20	93.09
24	5.A.2.	LULUCF - Land Converted to Forest Land	CO2		659.24	659.24	1.15	91.91		
25	5.C.1	LULUCF - Grassland Remaining Grassland	CO2		621.96	621.96	1.09	93.00		
26	4.B.1.	Manure Management - Dairy Cattle	CH4	611.80		611.80	1.07	94.06	1.12	94.20
27	1.A.4.b	Residential - Solid Fuels	CH4	356.29		356.29	0.62	94.69	0.65	94.85
28	4.B.13.	Manure Management - Solid Storage	N2O	341.48		341.48	0.60	95.28	0.62	95.48

Table 1.7. Key Category Level Assessment 2008

2008 Rank	IPCC Sub-Category	Emission Source/Activity	Gas	2008 Emission exc LULUCF Gg CO_2 eq	2008 Emission LULUCF Gg CO_2 eq	2008 Absolute Values Gg CO_2 eq	2008 Level Assessment inc LULUCF %	Cumulative Level inc LULUCF %	2008 Level Assessment exc LULUCF %	Cumulative Level exc LULUCF %
1	1.A.3.b.	Road Transport - Liquid Fuels	CO2	13649.83		13649.83	19.15	19.15	20.24	20.24
2	1.A.1.	Energy Industries - Solid Fuels	CO2	6754.54		6754.54	9.47	28.62	10.01	30.25
3	1.A.1.	Energy Industries - Gaseous Fuels	CO2	6230.57		6230.57	8.74	37.36	9.24	39.49
4	4.A.1.	Enteric Fermentation - Non-Dairy Cattle	CH4	5593.34		5593.34	7.85	45.20	8.29	47.78
5	1.A.4.b	Residential - Liquid Fuels	CO2	3689.48		3689.48	5.17	50.38	5.47	53.25
6	1.A.2.	Manuf Ind and Const - Liquid Fuels	CO2	3085.03		3085.03	4.33	54.71	4.57	57.83
7	4.D.2.	Agricultural Soils - Pasture, Range & Paddock	N2O	2664.25		2664.25	3.74	58.44	3.95	61.78
8	4.A.1.	Enteric Fermentation - Dairy Cattle	CH4	2524.28		2524.28	3.54	61.98	3.74	65.52
9	4.D.1.	Agricultural Soils - Direct Soil Emissions	N2O	2375.10		2375.10	3.33	65.31	3.52	69.04
10	5.A.1	LULUCF - Forest Land Remaining Forest Land	CO2		-2368.95	2368.95	3.32	68.64		
11	1.A.4.b	Residential - Solid Fuels	CO2	2110.61		2110.61	2.96	71.60	3.13	72.17
12	2.A.1.	Cement Production	CO2	2106.73		2106.73	2.95	74.55	3.12	75.29
13	1.A.2.	Manuf Ind and Const - Gaseous Fuels	CO2	1941.45		1941.45	2.72	77.28	2.88	78.17
14	1.A.4.a.	Commercial/Institutional - Liquid Fuels	CO2	1684.62		1684.62	2.36	79.64	2.50	80.67
15	1.A.4.b	Residential - Gaseous Fuels	CO2	1592.58		1592.58	2.23	81.87	2.36	83.03
16	1.A.1.	Energy Industries - Liquid Fuels	CO2	1510.33		1510.33	2.12	83.99	2.24	85.27
17	4.D.3.	Agricultural Soils - Indirect Emissions	N2O	1206.05		1206.05	1.69	85.68	1.79	87.06
18	4.B.1.	Manure Management - Non-Dairy Cattle	CH4	1148.46		1148.46	1.61	87.29	1.70	88.76
19	1.A.4.a.	Commercial/Institutional - Gaseous Fuels	CO2	971.72		971.72	1.36	88.66	1.44	90.20
20	6.A.	Solid Waste Disposal on land	CH4	947.19		947.19	1.33	89.98	1.40	91.61
21	1.A.4.c.	Agriculture/Forestry/Fisheries - Liquid Fuels	CO2	771.19		771.19	1.08	91.07	1.14	92.75
22	4.A.3.	Enteric Fermentation - Sheep	CH4	633.11		633.11	0.89	91.95	0.94	93.69
23	5.C.1	LULUCF - Grassland Remaining Grassland	CO2		595.75	595.75	0.84	92.79		
24	2.F.	Consumption of F Gas and SF6	HFC	517.36		517.36	0.73	93.51	0.77	94.46
25	1.A.2.	Manuf Ind and Const - Solid Fuels	CO2	496.47		496.47	0.70	94.21	0.74	95.19
26	4.B.1.	Manure Management - Dairy Cattle	CH4	473.89		473.89	0.66	94.88	0.70	95.90
27	4.B.8.	Manure Management - Pigs	CH4	402.59		402.59	0.56	95.44	0.60	96.49

Table 1.8. Key Category Trend Assessment 2008 (excluding LULUCF)

Rank	Category	Emission Source	Gas	Emissions in 1990 Gg CO_2 eq	Emissions in 2008 Gg CO_2 eq	Level Assessment %	Trend Assessment	Contribution to Trend %	Cumulative Contribution to Trend %
1	1.A.3.b.	Road Transport - Liquid Fuels	CO2	4700.93	13649.83	20.24	9.48	21.91	21.91
2	1.A.4.b	Residential - Solid Fuels	CO2	5606.94	2110.61	3.13	5.77	13.34	35.24
3	1.A.1.	Energy Industries - Gaseous Fuels	CO2	1880.66	6230.57	9.24	4.72	10.91	46.15
4	1.A.1.	Energy Industries - Solid Fuels	CO2	8009.44	6754.54	10.01	3.74	8.64	54.79
5	1.A.4.b	Residential - Liquid Fuels	CO2	1177.50	3689.48	5.47	2.70	6.24	61.03
6	1.A.4.b	Residential - Gaseous Fuels	CO2	269.73	1592.58	2.36	1.52	3.51	64.54
7	4.A.1.	Enteric Fermentation - Non-Dairy Cattle	CH4	5546.63	5593.34	8.29	1.48	3.43	67.97
8	4.D.1.	Agricultural Soils - Direct Soil Emissions	N2O	2861.74	2375.10	3.52	1.38	3.19	71.16
9	2.A.1.	Cement Production	CO2	884.00	2106.73	3.12	1.23	2.84	74.00
10	4.A.1.	Enteric Fermentation - Dairy Cattle	CH4	2875.51	2524.28	3.74	1.22	2.82	76.83
11	1.A.2.	Manuf Ind and Const - Gaseous Fuels	CO2	873.14	1941.45	2.88	1.04	2.41	79.24
12	4.D.2.	Agricultural Soils - Pasture, Range & Paddock	N2O	2802.31	2664.25	3.95	0.94	2.18	81.42
13	1.A.4.a.	Commercial/Institutional - Liquid Fuels	CO2	1976.61	1684.62	2.50	0.90	2.08	83.51
14	1.A.4.a.	Commercial/Institutional - Gaseous Fuels	CO2	223.37	971.72	1.44	0.84	1.94	85.45
15	4.A.3.	Enteric Fermentation - Sheep	CH4	1032.48	633.11	0.94	0.77	1.78	87.22
16	1.A.2.	Manuf Ind and Const - Solid Fuels	CO2	871.24	496.47	0.74	0.69	1.60	88.83
17	2.F.	Consumption of F Gas and SF6	HFC	0.69	517.36	0.77	0.62	1.44	90.26
18	6.A.	Solid Waste Disposal on land	CH4	1173.05	947.19	1.40	0.60	1.38	91.65
19	4.D.3.	Agricultural Soils - Indirect Emissions	N2O	1344.11	1206.05	1.79	0.54	1.25	92.89
20	4.B.1.	Manure Management - Non-Dairy Cattle	CH4	1255.57	1148.46	1.70	0.48	1.10	94.00
21	1.A.2.	Manuf Ind and Const - Liquid Fuels	CO2	2195.69	3085.03	4.57	0.46	1.07	95.07

Table 1.9 Tier 1 Uncertainty Estimates 2008 (continued on following pages)

IPCC Source Category		Gas	Emissions in 1990	Emissions in 2008	Activity Data (AD) Uncertainty	Emission Factor (EF) Uncertainty	Combined Uncertainty	Combined Uncertainty as % of Emissions in 2008	Combined Emissions Uncertainty Squared	Type A Sensitivity	Type B Sensitivity	Uncertainty in Trend in Total Emissions due to AD	Uncertainty in Trend in Total Emissions due to EF	Combined Uncertainty in Trend in Total Emissions	Combined Trend Uncertainty Squared
			Gg CO_2eq	**Gg CO_2eq**	**%**	**%**	**%**	**%**		**%**	**%**	**%**	**%**	**%**	
1A1	Energy-Liquid	CO2	1268.51	1510.33	1.0	2.5	2.69	0.06	0.00	0.00	0.03	0.04	0.00	0.04	0.00
1A1	Energy-Solid	CO2	8009.44	6754.54	1.0	5.0	5.10	0.51	0.26	-0.06	0.12	0.17	-0.28	0.33	0.11
1A1	Energy-Gas	CO2	1880.66	6230.57	1.0	2.5	2.69	0.25	0.06	0.07	0.11	0.16	0.18	0.24	0.06
1A2	Industry-Liquid exc Pet Coke	CO2	2010.97	2233.39	10.0	2.5	10.31	0.34	0.12	0.00	0.04	0.58	-0.01	0.58	0.33
1A2	Industry-Coal	CO2	871.24	496.47	2.0	5.0	5.39	0.04	0.00	-0.01	0.01	0.03	-0.05	0.06	0.00
1A2	Industry-Pet Coke	CO2	184.72	851.64	5.0	5.0	7.07	0.09	0.01	0.01	0.02	0.11	0.06	0.12	0.02
1A2	Industry-Gas	CO2	873.14	1941.45	2.5	2.5	3.54	0.10	0.01	0.02	0.04	0.13	0.04	0.13	0.02
1A3	Transport-Oil	CO2	4977.35	13916.18	1.0	2.5	2.69	0.56	0.31	0.14	0.25	0.36	0.35	0.50	0.25
1A3	Transport-Gas	CO2	62.04	145.61	1.0	2.5	2.69	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1A4	Comm-Liquid	CO2	1976.61	1684.62	10.0	5.0	11.18	0.28	0.08	-0.01	0.03	0.43	-0.07	0.44	0.19
1A4	Comm-Coal	CO2	2.56	103.59	5.0	10.0	11.18	0.02	0.00	0.00	0.00	0.01	0.02	0.02	0.00
1A4	Comm-Peat	CO2	135.73	0.00	10.0	20.0	22.36	0.00	0.00	0.00	0.00	0.00	-0.06	0.06	0.00
1A4	Comm-Gas	CO2	223.37	971.72	2.5	2.5	3.54	0.05	0.00	0.01	0.02	0.06	0.03	0.07	0.00
1A4	Res-Liquid	CO2	1101.79	3598.50	10.0	5.0	11.18	0.60	0.36	0.04	0.07	0.93	0.20	0.95	0.90
1A4	Res-Coal	CO2	2483.57	915.52	5.0	10.0	11.18	0.15	0.02	-0.04	0.02	0.12	-0.39	0.41	0.17
1A4	Res-Petcoke	CO2	75.70	90.98	5.0	5.0	7.07	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.00
1A4	Res-Peat	CO2	3123.37	1195.09	10.0	20.0	22.36	0.40	0.16	-0.05	0.02	0.31	-0.97	1.01	1.03
1A4	Res-Gas	CO2	269.73	1592.58	2.5	2.5	3.54	0.08	0.01	0.02	0.03	0.10	0.06	0.12	0.01
1A4	Agric Liquid	CO2	660.30	771.19	10.0	5.0	11.18	0.13	0.02	0.00	0.01	0.20	0.00	0.20	0.04
2.A.1	Cement Production	CO2	884.00	2106.73	1.5	1.5	2.12	0.07	0.00	0.02	0.04	0.08	0.03	0.09	0.01
2.A.2	Lime Production	CO2	214.08	186.63	5.0	5.0	7.07	0.02	0.00	0.00	0.00	0.02	-0.01	0.03	0.00
2.A.3	Limestone and Dolomite Use	CO2	0.15	2.71	5.0	2.5	5.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.A.4	Soda Ash Production and Use	CO2	0.10	0.04	5.0	2.5	5.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.A.7	Glass Production	CO2	13.33	0.31	5.0	5.0	7.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.A.7.	Other Mineral Products	CO2	5.07	4.66	5.0	5.0	7.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.B.1	Ammonia Production	CO2	990.23	0.00	1.0	5.0	5.10	0.00	0.00	-0.02	0.00	0.00	-0.11	0.11	0.01
3	Solvent and Other Product Use	CO2	79.43	85.97	30.0	5.0	30.41	0.04	0.00	0.00	0.00	0.07	0.00	0.07	0.00
	LULUCF exc Liming	CO2	-122.76	-1732.46	30.0	100.0	104.40	-2.68	7.18	-0.03	-0.03	-1.34	-2.88	3.18	10.12
	Liming	CO2	355.04	376.77	5.0	5.0	7.07	0.04	0.00	0.00	0.01	0.05	-0.01	0.05	0.00
	Total CO_2		**32377.19**	**47391.02**				**2.93**	**8.60**					**3.65**	**13.29**

Energy-Liquid	CH_4	0.33	0.42	1.0	50.0	50.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Energy-Solid	CH_4	2.36	2.17	1.0	50.0	50.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Energy-Gas	CH_4	2.88	4.66	1.0	50.0	50.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industry-Liquid exc Pet Coke	CH_4	1.60	1.78	10.0	50.0	50.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industry-Coal	CH_4	1.93	1.10	2.0	50.0	50.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industry-Pet Coke	CH_4	0.12	0.58	5.0	50.0	50.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industry-Gas	CH_4	0.33	0.72	2.5	50.0	50.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transport-Oil	CH_4	47.57	26.63	1.0	50.0	50.01	0.02	0.00	0.00	0.00	0.00	-0.03	0.03	0.00
Transport-Gas	CH_4	0.12	0.27	1.0	50.0	50.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Comm-Liquid	CH_4	5.59	4.78	10.0	50.0	50.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Comm-Coal	CH_4	0.01	0.23	5.0	50.0	50.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Comm-Peat	CH_4	0.28	0.00	10.0	50.0	50.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Comm-Gas	CH_4	0.43	1.79	2.5	50.0	50.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Res-Liquid	CH_4	2.95	10.22	10.0	50.0	50.99	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.00
Res-Coal	CH_4	165.07	60.23	5.0	50.0	50.25	0.04	0.00	0.00	0.00	0.01	-0.13	0.13	0.02
Res-Petcoke	CH_4	0.17	0.21	5.0	50.0	50.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Res-Peat	CH_4	191.22	73.77	10.0	50.0	50.99	0.06	0.00	0.00	0.00	0.02	-0.15	0.15	0.02
Res-Gas	CH_4	0.52	2.94	2.5	50.0	50.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agric Liquid	CH_4	0.90	1.05	10.0	50.0	50.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Biomass	CH_4	13.39	12.48	10.0	50.0	50.99	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fugitive Emissions	CH_4	131.08	51.25	2.5	10.0	10.31	0.01	0.00	0.00	0.00	0.00	-0.02	0.02	0.00
Ent Ferm Dairy Cattle	CH_4	2875.51	2524.28	1.0	15.0	15.03	0.56	0.32	-0.02	0.05	0.07	-0.28	0.29	0.08
Ent Ferm Other Cattle	CH_4	5546.63	5593.34	1.0	15.0	15.03	1.25	1.55	-0.02	0.10	0.14	-0.34	0.37	0.13
Ent Ferm Other Livestock	CH_4	1071.34	686.47	1.0	30.0	30.02	0.31	0.09	-0.01	0.01	0.02	-0.35	0.35	0.12
Manure Mgt Dairy Cattle	CH_4	611.80	473.89	1.0	15.0	15.03	0.11	0.01	-0.01	0.01	0.01	-0.08	0.08	0.01
Manure Mgt Other Cattle	CH_4	1255.57	1148.46	1.0	15.0	15.03	0.26	0.07	-0.01	0.02	0.03	-0.11	0.11	0.01
Manure Mgt Other Livestock	CH_4	457.16	530.07	1.0	30.0	30.02	0.24	0.06	0.00	0.01	0.01	-0.02	0.02	0.00
LULUCF	CH_4	1.12	0.77	30.0	70.0	76.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solid Waste[abc]	CH_4	1173.05	935.83	34.6	34.6	31.13	0.43	0.19	-0.01	0.02	0.84	-0.32	0.89	0.80
Wastewater Handling	CH_4	14.73	15.43	10.0	30.0	31.62	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total CH_4		**13575.75**	**12165.81**				**1.51**	**2.29**					**1.09**	**1.20**
Cumulative CO_2 and CH_4		**45952.94**	**59557.33**	**0.88**			**3.30**	**10.89**					**3.81**	**14.49**

1A1	Energy-Liquid	N_2O	1.52	1.73	1.0	50.0	50.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1A1	Energy-Solid	N_2O	62.22	58.10	1.0	50.0	50.01	0.04	0.00	0.00	0.00	0.00	-0.02	0.02	0.00
1A1	Energy-Gas	N_2O	10.62	76.81	1.0	50.0	50.01	0.06	0.00	0.00	0.00	0.00	0.06	0.06	0.00
1A2	Industry-Liquid exc Pet Coke	N_2O	4.65	5.15	10.0	50.0	50.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1A2	Industry-Coal	N_2O	4.28	2.44	2.0	50.0	50.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1A2	Industry-Pet Coke	N_2O	0.37	1.70	5.0	50.0	50.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1A2	Industry-Gas	N_2O	0.49	1.06	2.5	50.0	50.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1A3	Transport-Oil	N_2O	72.55	164.69	1.0	25.0	25.02	0.06	0.00	0.00	0.00	0.00	0.03	0.03	0.00
1A3	Transport-Gas	N_2O	0.70	1.59	1.0	50.0	50.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1A4	Comm-Liquid	N_2O	4.92	4.20	10.0	50.0	50.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1A4	Comm-Coal	N_2O	0.01	0.51	5.0	50.0	50.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1A4	Comm-Peat	N_2O	0.58	0.00	10.0	50.0	50.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1A4	Comm-Gas	N_2O	0.13	0.53	2.5	50.0	50.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1A4	Res-Liquid	N_2O	2.43	8.81	10.0	50.0	50.99	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.00
1A4	Res-Coal	N_2O	12.18	4.45	5.0	50.0	50.25	0.00	0.00	0.00	0.00	0.00	-0.01	0.01	0.00
1A4	Res-Petcoke	N_2O	0.15	0.18	5.0	50.0	50.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1A4	Res-Peat	N_2O	13.17	5.08	10.0	50.0	50.99	0.00	0.00	0.00	0.00	0.00	-0.01	0.01	0.00
1A4	Res-Gas	N_2O	0.15	0.87	2.5	50.0	50.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1A4	Agric Liquid	N_2O	72.05	84.15	10.0	50.0	50.99	0.06	0.00	0.00	0.00	0.02	0.00	0.02	0.00
	Biomass	N_2O	5.48	10.19	10.0	50.0	50.99	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2B	Nitric Acid	N_2O	1035.40	0.00	1.0	10.0	10.05	0.00	0.00	-0.02	0.00	0.00	-0.23	0.23	0.05
4B	Liquid System[d]	N_2O	55.48	52.96	11.2	100.0	100.63	0.08	0.01	0.00	0.00	0.02	-0.03	0.03	0.00
4B	Solid Storage and Dry Lot[d]	N_2O	341.48	320.59	11.2	100.0	100.63	0.48	0.23	0.00	0.01	0.09	-0.18	0.20	0.04
4D	Direct Soil Emissions[d]	N_2O	2861.74	2375.10	11.2	100.0	100.63	3.54	12.54	-0.02	0.04	0.69	-2.09	2.20	4.84
4D	Pasture Range and Paddock[d]	N_2O	2802.31	2664.25	11.2	100.0	100.63	3.97	15.78	-0.01	0.05	0.77	-1.43	1.62	2.64
4D	Indirect Emissions[d]	N_2O	1344.11	1206.05	11.2	50.0	51.24	0.92	0.84	-0.01	0.02	0.35	-0.41	0.54	0.29
5	LULUCF	N_2O	14.16	42.49	30.0	100.0	104.40	0.07	0.00	0.00	0.00	0.03	0.05	0.06	0.00
6B	Wastewater Handling	N_2O	114.00	143.67	10.0	10.0	14.14	0.03	0.00	0.00	0.00	0.04	0.00	0.04	0.00
	Total N_2O		**8837.35**	**7237.35**				**5.42**	**29.42**					**2.81**	**7.88**
	Cumulative CO_2, CH_4, N_2O		**54790.29**	**66794.69**				**6.35**	**40.31**					**4.73**	**22.37**
2F	Halocarbons & SF6	HFC	0.69	520.83	20.0	10.0	22.36	0.17	0.03	0.01	0.01	0.22	0.09	0.24	0.06
2F	Halocarbons & SF6	PFC	0.09	106.20	10.0	2.5	10.31	0.02	0.00	0.00	0.00	0.02	0.00	0.02	0.00
2F	Halocarbons & SF6	SF_6	35.40	60.83	15.0	5.0	15.81	0.01	0.00	0.00	0.00	0.02	0.00	0.02	0.00
	Total HFC, PFC & SF_6		**36.19**	**687.85**				**0.17**	**0.03**					**0.24**	**0.06**
	Total all gases		**54826.48**	**67482.54**					**40.34**						**22.42**
					Overall Uncertainty in Emissions			**6.35**				**Trend Uncertainty**		**4.74**	

a AD uncertainty for CH4 generation based on equation 6.4 of GPG with uncertainties of 20%, 20% and 20% for MSW quantity, MSW composition and DOC, respectively 0.3464
b EF uncertainty for CH4 generation based on equation 6.4 of GPG with uncertainties of 20%, 20% and 20% for fraction of DOC dissimilated, MCF and decay rate constant, respectively 0.3464
c Combined uncertainty based on equation 6.3 of GPG using a and b above and assuming 30% and 10% uncertainties for CH4 flaring and utilisation, respectively 0.3113
d AD uncertainty based on Equation 6.4 of IPCC GPG with uncertainties of 5%, 1% and 10% for AWMS proportion, livestock/fertiliser numbers and nitrogen excretion

Table 1.10. Summary of Completeness

IPCC SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	HFC	PFC	SF_6
1. Energy						
A. Fuel Combustion (Sectoral Approach)	All	All	All	NA	NA	NA
1. Energy Industries	All	All	All	NA	NA	NA
2. Manufacturing Industries and Construction	All	All	All	NA	NA	NA
3. Transport	All	All	All	NA	NA	NA
4. Other Sectors	All	All	All	NA	NA	NA
5. Other	NO	NO	NO	NA	NA	NA
B. Fugitive Emissions from Fuels						
1. Solid Fuels	NO	NO	NO	NA	NA	NA
2. Oil and Natural Gas	All	All	Part	NA	NA	NA
2. Industrial Processes						
A. Mineral Products	All	Part	Part	NA	NA	NA
B. Chemical Industry	NO	NO	NO	NO	NO	NO
C. Metal Production	NO	NO	NO	NO	NO	NO
D. Other Production	NE	NA	NA	NA	NA	NA
E. Production of Halocarbons and SF_6	NA	NA	NA	NO	NO	NO
F. Consumption of Halocarbons and SF_6	NA	NA	NA	All	All	All
G. Other	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	All	NA	NE	NA	NA	NA
4. Agriculture						
A. Enteric Fermentation	NA	All	NA	NA	NA	NA
B. Manure Management	NA	All	All	NA	NA	NA
C. Rice Cultivation	NA	NO	NA	NA	NA	NA
D. Agricultural Soils	NA	NE	All	NA	NA	NA
E. Prescribed Burning of Savannas	NO	NO	NO	NA	NA	NA
F. Field Burning of Agricultural Residues	NO	NO	NO	NA	NA	NA
G. Other	NO	NO	NO	NA	NA	NA
5. Land-Use Land-Use Change and Forestry						
A. Forest Land	All	Part	Part	NA	NA	NA
B. Cropland	All	NO	All	NA	NA	NA
C. Grassland	All	NO	IE	NA	NA	NA
D. Wetlands	All	NE	All	NA	NA	NA
E. Settlements	Part	NO	NO	NA	NA	NA
F. Other Land	All	NE	NE	NA	NA	NA
G. Other	NO	NO	NO	NA	NA	NA
6. Waste						
A. Solid Waste Disposal on Land	NO	All	NA	NA	NA	NA
B. Wastewater Handling	NA	All	All	NA	NA	NA
C. Waste Incineration	NE	NE	NE	NA	NA	NA
D. Other	NO	NO	NO	NA	NA	NA
7. Other	NO	NO	NO	NA	NA	NA
Article 3.3 Afforestation and Deforestation	All	All	All	NA	NA	NA
Memo Items:						
International Bunkers						
Aviation	All	All	All	NA	NA	NA
Marine	All	All	All	NA	NA	NA
Multilateral Operations	NO	NO	NO	NA	NA	NA
CO_2 Emissions from Biomass	All	NA	NA	NA	NA	NA

All : Emissions of the gas are covered for all sources under the source category/memo item
NA : Emissions of the gas not applicable to the source category/memo item
NO : Emissions of the gas does not occur in Ireland for the source category/memo item
NE : Emissions on the gas not estimated for the source category/memo item
Part : Emissions of the gas estimated for some activities in the source category

Chapter Two

Emission Trends

2.1 Trends in Total Emissions

Table 2.1 shows the trends in emissions of the six greenhouse gases in Ireland over the period 1990-2008. The estimates reported here show some changes on those reported in the 2009 submission, which reflect recalculations that are fully described in subsequent chapters. The trends in the principal emission components as CO_2 equivalents within the six IPCC sectors are shown on Figure 2.2 through Figure 2.10. Total emissions of the six greenhouse gases in Ireland (excluding net emissions from *Land Use Land Use Change and Forestry*) increased steadily from 54,811.19 Gg CO_2 equivalent in 1990 to 69,600.51 Gg CO_2 equivalent in 2001 and then decreased slightly to 67,300.90 Gg CO_2 equivalent in 2004. Total emissions increased again in 2005 to 68,821.39 Gg CO_2 equivalent and then decreased for three consecutive years to the current level of 67,439.28 Gg CO_2 equivalent. Total emissions in 2008 were 23.0 percent higher than in 1990 and 3.1 percent lower than the peak level in 2001. The estimated total for 2008 is 209 kilotonnes CO_2 equivalent lower than that for 2007.

In 2008, the *Energy* sector accounted for 67.8 percent of total emissions, *Agriculture* contributed 26.1 percent while a further 4.4 percent emanated from *Industrial Processes* and 1.6 percent was due to *Waste*. The *Energy* and *Industrial Processes* sectors account for the bulk of the CO_2 emissions, CH_4 emissions are produced mainly in the *Agriculture* and *Waste* sectors and most of the N_2O emissions are generated in *Agriculture*.

The large increase in emissions during the period 1990-2001 was clearly driven by the growth in CO_2 emissions from energy use. The increase in CO_2 from energy use amounted to 43.9 percent over these 12 years. The bulk of this increase occurred in the years between 1994 and 2001, during which Ireland experienced a period of unprecedented economic growth, and energy emissions grew by an average of 4.3 percent annually. The rate of economic growth slowed down from 2000 to 2004, which together with the closure of ammonia and nitric acid production plants and continued decline in cattle populations and fertilizer use, resulted in some reduction in the emission levels in 2002 -2004. The increase in 2005 was due largely to increased emissions from road transport and from electricity generation where two new peat-fired stations entered service. The recent declining trend between 2005 and 2008 can be largely attributed to decreases in the agriculture and waste sectors and in 2008 to reduced emissions from mineral products in the industrial processes sector. In addition, the sustained increase in transport emissions, the major contributor to the trend, came to an end in 2008.

Table 2.1. Greenhouse Gas Emissions 1990-2008 (Gg CO_2 equivalent)

(a) Emissions by Gas

GAS	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
CO_2 (inc net CO_2 from LULUCF)	32,609.46	33,511.74	33,467.67	33,396.28	34,522.01	35,486.98	37,285.02	38,689.66	40,390.92	42,037.48	44,769.27	47,094.98	45,500.21	44,605.75	45,568.19	47,011.21	46,578.91	46,292.19	45,878.16
CO_2 (exc net CO_2 from LULUCF)	32,377.19	33,184.05	33,083.59	33,214.83	34,441.59	35,220.20	36,912.28	38,357.92	40,470.12	42,156.16	44,650.87	47,057.98	45,648.54	44,897.65	45,762.58	47,519.62	47,110.21	47,305.20	47,391.52
CH_4 emissions (inc CH_4 from LULUCF)	13,575.75	13,751.62	13,838.10	13,921.48	13,866.33	13,869.34	14,052.46	14,046.12	14,296.23	13,898.05	13,336.56	13,335.54	13,328.36	13,812.63	12,994.45	12,786.16	12,821.27	12,302.83	12,165.81
CH_4 emissions (exc CH_4 from LULUCF)	13,574.62	13,750.91	13,837.63	13,920.55	13,865.27	13,867.91	14,050.88	14,045.26	14,295.77	13,897.68	13,335.63	13,333.70	13,327.94	13,810.03	12,992.94	12,785.61	12,820.72	12,302.21	12,165.04
N_2O emissions (inc N_2O from LULUCF)	8,837.35	8,634.56	8,619.84	8,773.59	8,994.94	9,206.80	9,242.75	9,107.66	9,645.77	9,660.36	9,200.71	8,616.88	8,231.11	8,138.26	7,941.30	7,848.16	7,682.49	7,373.28	7,237.35
N_2O emissions (exc N_2O from LULUCF)	8,823.19	8,619.88	8,604.59	8,755.14	8,976.24	9,187.34	9,221.02	9,086.04	9,624.02	9,638.49	9,178.45	8,590.49	8,202.50	8,106.12	7,909.00	7,815.64	7,649.82	7,340.59	7,194.86
HFCs	0.69	5.27	6.17	9.44	19.97	44.85	76.11	133.35	191.95	198.25	231.23	253.05	278.14	351.44	387.31	436.72	509.17	500.49	520.83
PFCs	0.09	7.62	15.15	30.21	45.27	75.38	103.09	130.82	61.87	195.93	305.41	295.98	212.40	228.79	182.43	168.34	148.32	130.58	106.20
SF_6	35.40	40.64	45.87	55.35	64.83	82.83	102.06	132.10	94.19	68.87	55.81	69.30	69.95	118.18	66.64	95.46	67.46	68.75	60.83
Total including LULUCF	**55,058.75**	**55,951.46**	**55,992.79**	**56,186.35**	**57,513.35**	**58,766.17**	**60,861.48**	**62,239.71**	**64,680.92**	**66,058.95**	**67,898.98**	**69,665.73**	**67,620.18**	**67,255.06**	**67,140.33**	**68,346.05**	**67,807.63**	**66,668.13**	**65,969.17**
Total excluding LULUCF	**54,811.19**	**55,608.37**	**55,593.00**	**55,985.52**	**57,413.18**	**58,478.51**	**60,465.43**	**61,885.49**	**64,737.91**	**66,155.38**	**67,757.40**	**69,600.51**	**67,739.48**	**67,512.22**	**67,300.90**	**68,821.39**	**68,305.70**	**67,647.82**	**67,439.28**

Table 2.1 contd. Greenhouse Gas Emissions 1990- 2008 (Gg CO_2 equivalent)

(b) Emissions by IPCC Source Category

SOURCE AND SINK CATEGORIES	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1. Energy	31,028.31	31,913.00	31,842.14	32,012.77	32,981.77	33,831.92	35,465.07	36,561.54	38,816.08	40,507.68	42,523.67	44,637.96	43,435.36	43,767.69	43,882.01	45,609.32	45,193.07	45,350.17	45,693.47
2. Industrial Processes	3,178.55	2,888.68	2,816.16	2,804.76	3,080.85	3,073.12	3,214.94	3,666.77	3,507.14	3,571.78	4,195.80	4,304.40	3,726.33	3,041.03	3,143.45	3,253.32	3,263.69	3,280.25	2,989.44
3. Solvent and Other Product Use	79.43	81.13	81.62	81.91	82.92	84.58	84.55	85.11	85.76	82.97	78.96	78.61	76.97	76.54	76.82	78.70	81.57	83.97	85.97
4. Agriculture	19,223.13	19,343.45	19,405.52	19,591.52	19,727.84	19,913.30	20,240.08	20,352.46	21,049.44	20,707.69	19,629.88	19,139.88	18,965.33	19,033.94	18,844.83	18,662.09	18,430.81	17,743.93	17,575.46
5. LULUCF	247.56	343.09	399.80	200.83	100.18	287.67	396.05	354.22	-56.99	-96.43	141.58	65.22	-119.29	-257.17	-160.58	-475.34	-498.07	-979.69	-1,470.10
6. Waste	1,301.78	1,382.10	1,447.56	1,494.55	1,539.80	1,575.59	1,460.79	1,219.61	1,279.49	1,285.27	1,329.08	1,439.67	1,535.48	1,593.02	1,353.80	1,217.95	1,336.56	1,189.50	1,094.93
7. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total including LULUCF	**55,058.75**	**55,951.46**	**55,992.79**	**56,186.35**	**57,513.35**	**58,766.17**	**60,861.48**	**62,239.71**	**64,680.92**	**66,058.95**	**67,898.98**	**69,665.73**	**67,620.18**	**67,255.06**	**67,140.33**	**68,346.05**	**67,807.63**	**66,668.13**	**65,969.17**

2.2 Trends by Gas

Emissions of CO_2 accounted for 70.3 percent of the total (excluding LULUCF) of 67,439.28 Gg CO_2 equivalent in 2008, with CH_4 and N_2O contributing 18.0 percent and 10.7 percent, respectively. The combined emissions of HFC, PFC and SF_6 accounted for approximately 1 percent of total emissions in 2008. In 1990 emissions of CO_2, CH_4, N_2O and the combined emissions of HFCs, PFCs and SF_6 accounted for 59.1, 24.8, 16.1 and less than 0.1 percent, respectively of total emissions of 54,811.19 Gg CO_2 equivalents.

Emissions of CO_2 increased from 32,377.19 Gg in 1990 to 47,391.52 Gg in 2008, which equates to an increase of 46.4 percent. The main driver behind this increase in emissions is fuel combustion in *1.A.3 Transport* and *1.A.1 Energy Industries*. Over this period emissions of CO_2 from transport sources, which in Ireland are largely accounted for by road traffic, increased by 179.0 percent. This trend is exaggerated somewhat in later years by so-called fuel-tourism whereby approximately 11 percent of automotive fuel (10.0 percent of petrol and 12.0 percent of diesel) sold in Ireland is used in vehicles in the UK and other countries. Over the time-series, emissions of CO_2 from energy industries increased by 29.9 percent, further adding to the trend. In addition, even though Ireland has only a small number of energy intensive industries and CO_2 emissions from combustion in the industrial sector *1.A.2 Manufacturing Industries and Construction* accounted for only 8.2 percent of total emissions in 2008, these emissions increased by 40.2 percent between 1990 and 2008.

Methane is the second most significant contributor to greenhouse gas emissions in Ireland after CO_2, due mainly to large populations of cattle. In 2008 emissions of CH_4 were 12,165.04 Gg CO_2 equivalent, indicating a decrease of 10.4 percent on the 1990 level of 13,574.62 Gg CO_2 equivalent. Emissions of CH_4 increased progressively from 1990, reaching a peak in 1998 of 14,295.77 Gg CO_2 equivalent, which reflects an increase in livestock numbers and therefore increased emissions from source categories *4.A Enteric Fermentation and 4.B Manure Management*. Between 1998 and 2008 CH_4 emissions decreased as a result of falling livestock numbers due to reform of the Common Agricultural Policy (CAP). However, total CH_4 emissions in the period 2001-2008 fluctuated to some extent on a yearly basis. This trend is a direct result of fluctuating CH_4 emissions from *1.A.4 Other Sectors* and *1.B.Fugitive Emissions from Fuels.* Another significant source of methane emissions is from landfill gas in category *6.A Solid Waste Disposal on Land*. Emissions from this category decreased by 20.2 percent from 1990 to 2008 as a result of improved management of landfill facilities and increased recovery of landfill gas.

Emissions of N_2O decreased by 18.5 percent from their 1990 level of 8,823.19 Gg CO_2 equivalent in 1990 to 7,194.86 Gg CO_2 equivalent in 2008. Similar to CH_4, emissions of N_2O increased during the 1990s to reach peak levels in 1999 reflecting increased use of synthetic fertilisers and increased amounts of animal manures associated with increasing animal numbers over that period. Emissions of N_2O subsequently show a clear downward trend following the closure of Irelands only nitric acid plant in 2002 and reductions in synthetic fertilizer use and organic nitrogen applications on land as a result of the effect of CAP reform on animal numbers.

Emissions of the F-gases (HFCs, PFCs and SF_6) were 687.85 Gg CO_2 equivalent in 2008 compared to 36.19 Gg CO_2 equivalent in 1990, a 20-fold increase over the time series. However F-gas emissions only account for approximately one percent of the national total. F-gases include a wide range of substances that are used in a diverse range of products and manufacturing processes. Therefore it can be difficult to identify the factors contributing to actual trends in emissions over time. However it is possible to establish the main contributory sub-categories underlying these trends.

The main causative factor of this increase has been the growth in HFC emissions in *2.F.1 Refrigeration and Air Conditioning* through their use as replacement refrigerants across virtually all refrigeration sub-categories since 1991. Increased use of HFCs in *2.F.2 Foam Blowing* is also an important component of the trend.

Emissions of PFCs show an increasing trend up to 130.82 Gg CO_2 equivalent in 1997 through their use in the semiconductor manufacturing process in *2.F.7 Semiconductor Manufacture.* Emissions subsequently decreased, only to significantly increase to reach 305.41 Gg CO_2 equivalent in 2000. Semiconductor manufacturers continue to investigate various reduction initiatives through gas substitution and new process technologies. As a result, the downward trend in PFC emissions between 2000 and 2008 may continue into the future.

SF_6 is used in a diverse number or products and processes and is therefore included in a number of IPCC source sub-categories including *2.F.7 Semiconductor Manufacture, 2.F.8 Electrical Equipment* and *2.F.9 Other*. Emissions of SF_6 were 35.40 Gg CO_2 equivalent and 60.83 Gg CO_2 equivalent in 1990 and 2008, respectively. However, emissions of SF_6 peaked in 1997 following a steady increase in emissions from 1990 onwards. This was largely due to increased use of the gas in *2.F.7 Semiconductor Manufacture* and *2.F.8 Electrical Equipment*. Similar to PFCs, semiconductor manufacturers have undertaken to reduce the use of SF_6 through gas substitution and new process technologies. In *2.F.8 Electrical Equipment* where SF_6 is used for electrical insulation, arc quenching and current interruption, a leak reduction programme has been in place since 1997.

2.3 Trends by IPCC Sector

Greenhouse gas emissions broken down by IPCC sector are presented in Table 2.1 (b). It can be clearly seen that the largest contribution is from the *Energy* sector, which in 2008 contributes 67.8 percent of total greenhouse gas emissions (excluding *LULUCF*). The second largest sector is *Agriculture*, which accounted for 26.1 percent of total emissions in 2008. Emissions from *Industrial Processes, Solvent and Other Product Use* and *Waste* accounted for 4.4 percent, 0.1 percent and 1.6 percent, respectively of total emissions in 2008. The following sub-sections discuss the main contributors to trends within each IPCC source sector including LULUCF. Emissions of indirect gases are discussed in section 2.4.

2.3.1 Trends in Energy (IPCC Sector 1)

Emissions from the *Energy* sector increased by 47.3 percent from 31,028.31 Gg CO_2 equivalent in 1990 to 45,693.47 Gg CO_2 equivalent in 2008. The increase occurred during the 1990s, driven by major increases in emissions from *1.A.1 Energy Industries* and *1.A.3 Transport*, and emissions are comparatively stable between 2001 and 2008. Total greenhouse gas emissions from *1.A.1 Energy Industries* increased by 54.5 percent from 11,238.54 Gg in 1990 to 17,364.19 Gg in 2001. Some reductions were achieved in 2002, 2003 and 2004 from improvements in energy efficiency and fuel switching as some new electricity producers entered the market with the result that emissions decreased to 15,383.33 Gg CO_2 equivalent in 2004. Emissions subsequently increased in 2005 to 15,771.30 Gg CO_2 equivalent as levels of peat use returned to former levels with the entry into service of two new power plants. Emissions in 2006 decreased to 15,027.01 Gg CO_2 equivalent due to a reduction in the use of Moneypoint coal-fired station during the installation of pollutant control measures, while further reductions in 2007 are largely as a result of the displacement of oil by natural gas. In 2008, emissions increased by 0.7 percent or 107 kilotonnes to 14,640.70 Gg CO_2 equivalent. Overall drivers and trends in emissions from the *Energy* sector are presented in Figure 2.1 and Figure 2.2.

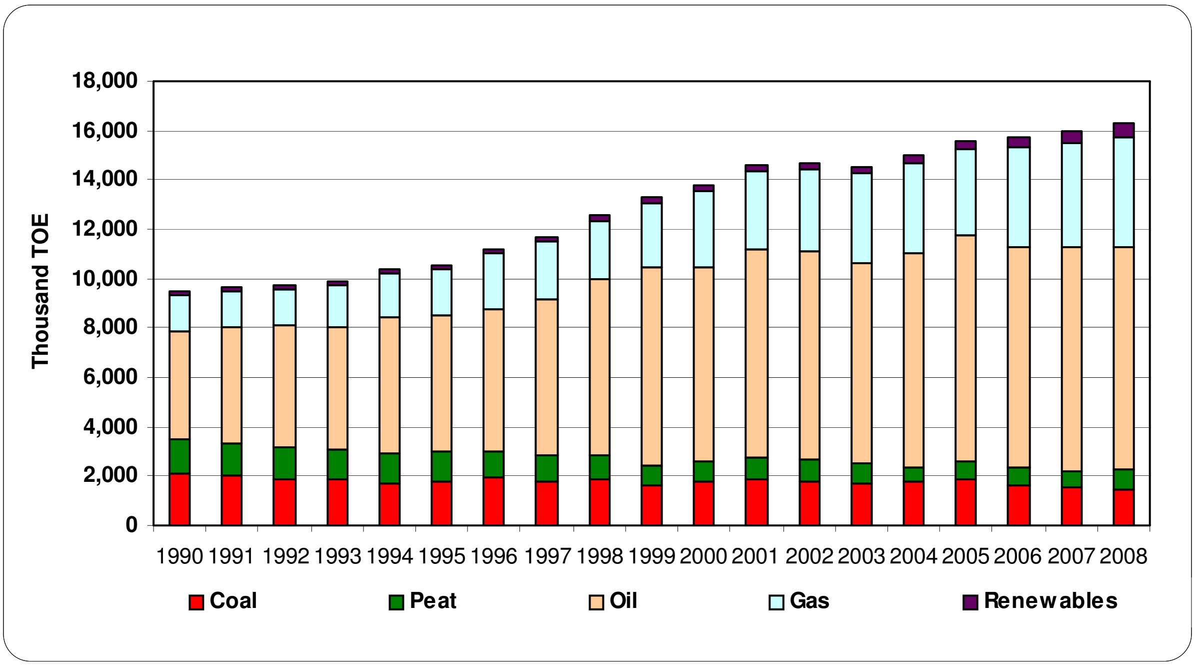

Figure 2.1 Total Primary Energy Requirement (TPER) 1990-2008

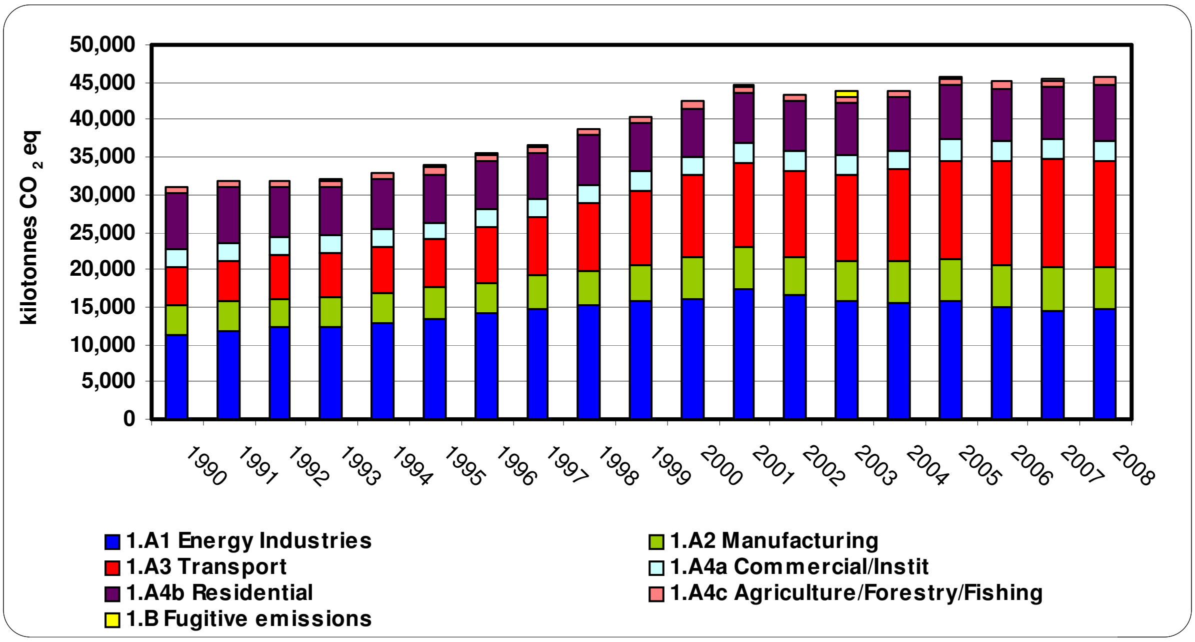

Figure 2.2 Trend in Emissions from Energy 1990-2008

There are only a small number of energy intensive industries in Ireland under sub-category *1.A.2 Manufacturing Industries and Construction*. This sub-category accounted for 7.2 percent and 8.2 percent of total national greenhouse gas emissions in 1990 and 2008, respectively. However, the trend shows an increase of 40.2 percent over the same period as a result of large increases in use of petroleum coke and natural gas in *1.A.2.F Other Industries*.

Fuel combustion emissions in *1.A.3 Transport* increased by 176.2 percent from 5,160.32 Gg CO_2 equivalent in 1990 to 14,254.98 Gg CO_2 equivalent in 2008. This is largely accounted for by a 187.8 percent increase in road transport associated emissions over the same period, due to sustained growth in the use of passenger cars and goods vehicles. The trend is however, somewhat exaggerated by so-called fuel tourism whereby a proportion of the automotive fuel sold in the Republic of Ireland is used in vehicles in the UK and other countries. Fuel tourism is estimated to account for 11.0 percent of automotive fuels (10.0 percent of petrol and 12.0 percent of diesel) in 2008. It is worth noting that in the years 1990-1995 inclusive there was cross border movement of automotive fuels into the Republic of Ireland. The principal drivers in road transport emission trends are shown in Figures 2.3 and 2.4. Even though emissions from civil aviation have more than doubled from 1990 to 2008, their overall effect on emission trends is negligible.

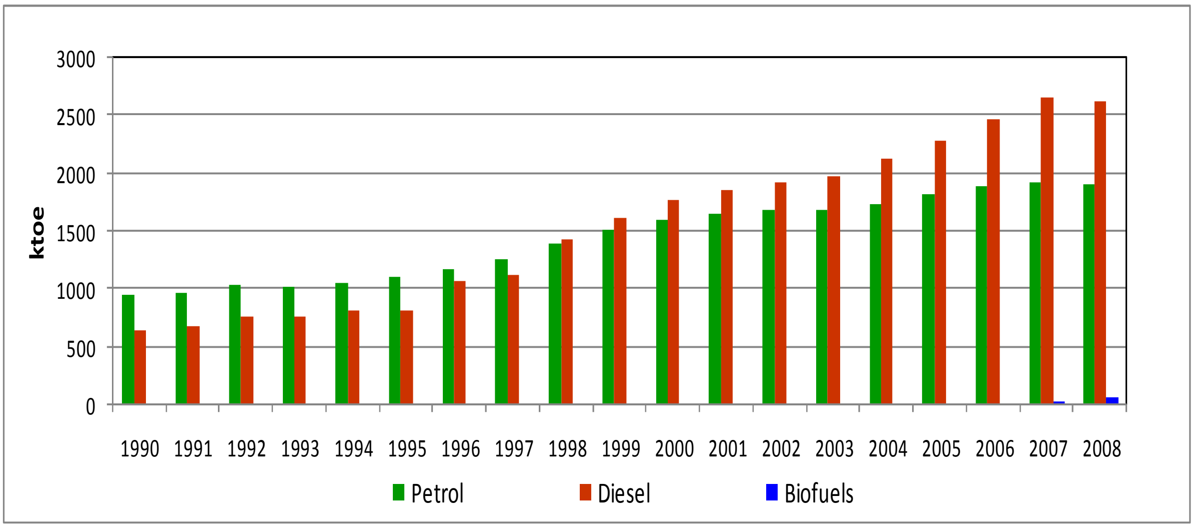

Figure 2.3 Fuel Use in Road Transport 1990-2008

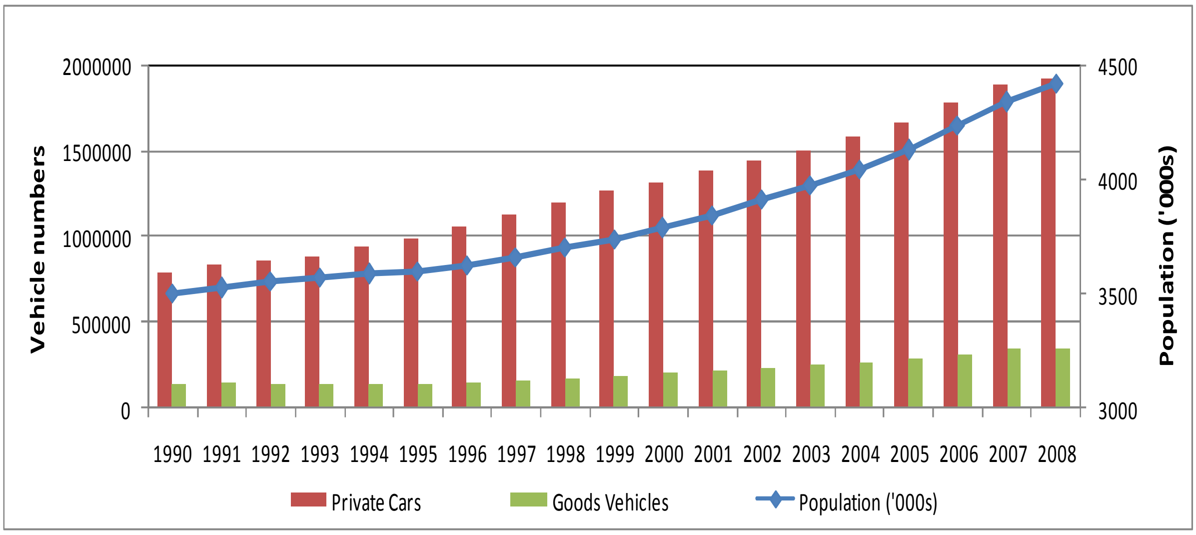

Figure 2.4 Vehicle Numbers and Population 1990-2008

Emissions from category *1.A.4 Other Sectors* increased by 6.2 percent from 10,539.74 Gg CO_2 equivalent in 1990 to 11,198.31 Gg CO_2 equivalent in 2008. Emissions from the Commercial (1.A.4 a), Residential (1.A.4 b) and Agriculture (1.A.4 c) sub-categories increased by 18.1, 1.5 and 16.8 percent respectively. Although residential fossil fuel consumption increased by 29.6 percent from 1990 to 2008 there has been a decline in the use of carbon-intensive fuels, such as peat and coal, and greater use of oil and natural gas. The emissions of CO_2 from coal and peat use in the residential sector decreased by 62.4 percent between 1990 and 2008 while those from oil and natural gas more than tripled over this period.

2.3.2 Trends in Industrial Processes (IPCC Sector 2)

The contribution from *Industrial Processes* is relatively small, accounting for 5.8 percent of total greenhouse gases in 1990 and 4.4 percent in 2008. Total emissions from the sector were 3,178.55 Gg CO_2 equivalent in 1990 and 2,989.44 Gg CO_2 equivalent in 2008. This is a decrease of 5.9 percent in emissions over the time series. Overall trends in emissions from *Industrial Processes* are presented in Figure 2.5.

In the early 1990's the contribution of *2.B Chemical Industry* to overall sectoral emissions was on average 64.0 percent. By the late 1990's this proportion had fallen to approximately 50 percent of total emissions from the sector. In 1990 emissions from *2.B. Chemical Industry* were 2,025.63 Gg CO_2 equivalent, however by 2000 they had reduced by 16.3 percent to 1,694.75 Gg CO_2 equivalent. Over the same period Ireland was experiencing increased levels of economic growth, the knock-on effect of which was an increase in construction and therefore an increased need for building products such as cement. In the period 1990-2000 emissions from cement production, which are reported under *2.A Mineral Products,* increased by 92.4 percent. Economic growth was sustained into the early years of the new millennium with associated increases in emissions from the sector, during which two new cement production plants were commissioned, with one opening in 2000 and the other in 2003.

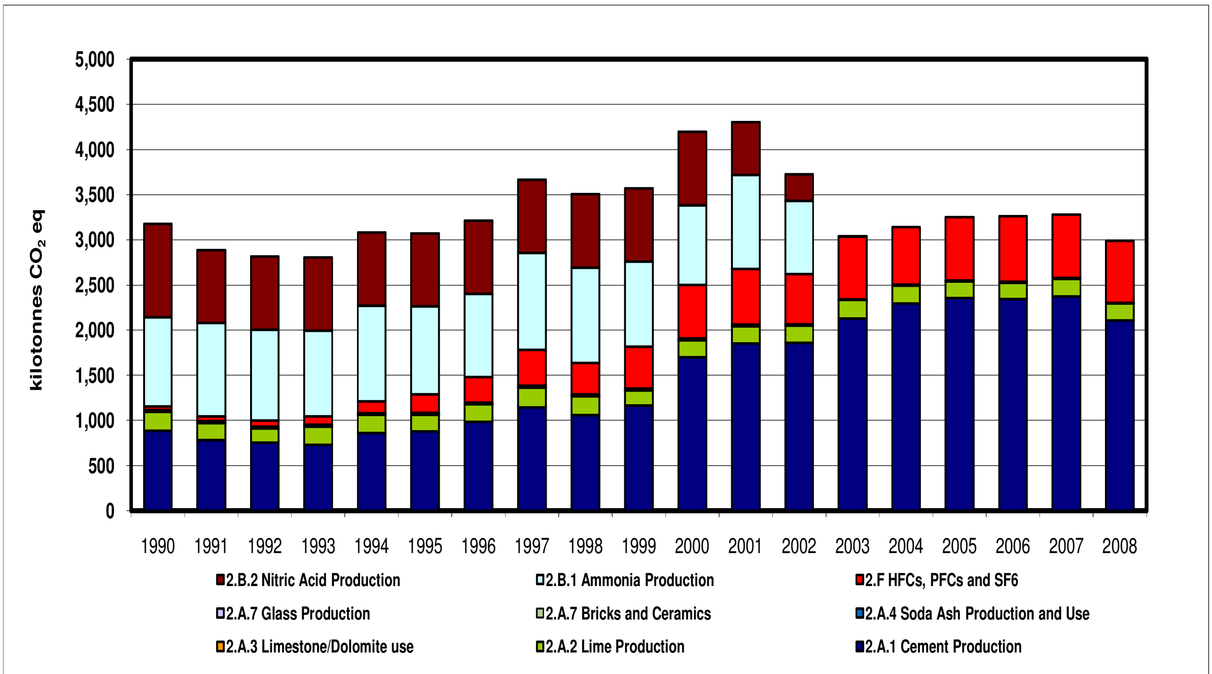

Figure 2.5 Trend in Emissions from Industrial Processes 1990-2008

The closure of Ireland's ammonia and nitric acid plants in 2003 and 2002, respectively significantly changed the level of process emissions in Ireland. As a result CO_2 emissions from cement manufacture (2.A.1) became the major component and these emissions increased steadily during the period of economic growth up to 2006. Emissions from cement manufacture decreased in line with the economic downturn in 2008, accounting for 70.5

percent of total emissions from *Industrial Processes* in 2008. Other sources of emissions within *2.A Mineral Products* in Ireland are *2.A.2 Lime Production, 2.A.3 Limestone and Dolomite Use, 2.A.4 Soda Ash Production and Use* and *2.A.7 Other Mineral Products,* which collectively accounted for 6.5 percent of total sectoral emissions in 2008. The emissions from these sub-categories are small and their effect on overall trends is negligible.

Emissions from *2.F Consumption of Halocarbons and SF_6* were estimated to be 687.85 Gg CO_2 equivalent in 2008, compared to 36.19 Gg CO_2 equivalent in 1990. This represents a 19-fold increase over the time series with the result that the contribution of this category to the sectoral total for Industrial Processes increased to 23 percent in 2008 as that from cement production decreased.

2.3.3 Trends in Solvent and Other Product Use (IPCC Sector 3)

Greenhouse gas emissions from *Solvents and Other Product Use* do not affect the overall trend in greenhouse gases in Ireland. The CO_2 emissions from this source were estimated to be 79.43 Gg CO_2 in 1990 and 85.97 Gg CO_2 in 2008. The largest contributor to overall emissions in this sector is *3.D Other,* largely represented by domestic use of solvents, which accounts for approximately 50 percent of total sectoral emissions in any one year. The contribution of sub-category *3.A Paint Application* to overall emissions from the sector has grown from 25.6 percent in 1990 to 38.3 percent in 2008 as a result of increasing paint sales. However, the market share of water-based paints, which have a lower VOC content, is increasing in response to market forces and Directive 2004/42/EC. Sub-categories *3.B Degreasing and Dry Cleaning* and *3.C Chemical Products, Manufacture and Processing* accounted for 4.5 percent and 8.2 percent, respectively of total over all emissions in the sector in 2008. Emissions from both sub-categories show downward trends over the time-series 1990-2008. A graphical representation of the trends in emissions from *Solvent and Other Product Use* is presented in Figure 2.6.

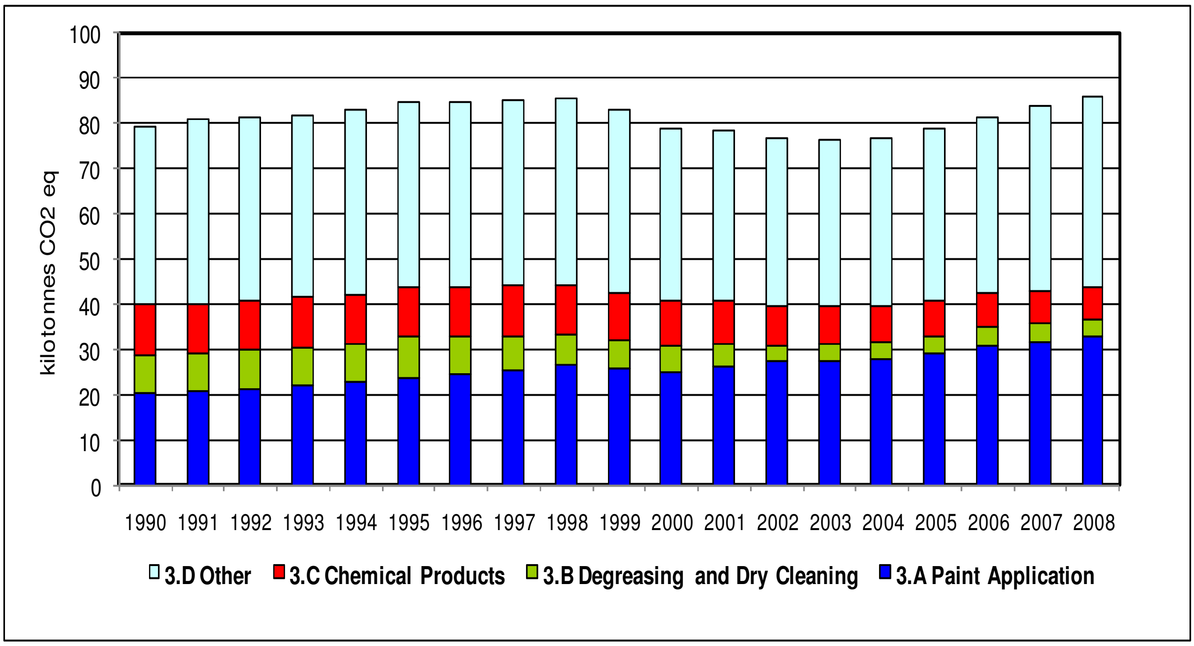

Figure 2.6 Trend in Emissions from Solvents and Other Product Use 1990-2008

2.3.4 Trends in Agriculture (IPCC Sector 4)

The trend in emissions from the *Agriculture* sector is presented in Figure 2.7 with the main drivers of the emissions presented in Figure 2.8. Emissions of greenhouse gases from the *Agriculture* sector amounted to 19,223.13 Gg CO_2 equivalent in 1990 and 17,575.46 Gg CO_2 equivalent in 2008, a reduction of 8.6 percent. Total emissions from the *Agriculture* sector increased by 9.5 percent in the period 1990-1998, reflecting an increase in animal numbers and increased synthetic nitrogen use on farms. Following this peak in emission levels in 1998, the annual emissions from the sector decreased by 16.5 percent to those in 2008 as a result of reductions in animal numbers and synthetic nitrogen fertilizer use due to reforms of the Common Agricultural Policy.

Methane emissions from *4.A Enteric Fermentation* and *4.B Manure Management* are dependent on the type and number of livestock present on farms and in Ireland's case, the amounts are largely determined by a large cattle population. The combined total of emissions of CH_4 from enteric fermentation and manure management expressed in CO_2 equivalents was 11,818.00 Gg CO_2 equivalent in 1990. This increased by 7.9 percent to reach 12,748.93 Gg CO_2 equivalent in 1998 and subsequently decreased by 14.1 percent to 10,956.51 Gg CO_2 equivalent in 2008. Cattle accounted for almost 89 percent of annual CH_4 emissions in Irish agriculture in 2008.

The emissions of N_2O from the Agriculture sector follow similar trends to those of CH_4 because cattle also largely determine the amount of nitrogen inputs to agricultural soils from synthetic fertilizer and animal manures, which produces the bulk of N_2O emissions. Nitrous oxide emissions in the sector increased by 12.1 percent in the period 1990-1999 with emissions in 1999 totalling 8,303.64 Gg CO_2 equivalent. Nitrous oxide emissions totalling 6,618.95 Gg CO_2 equivalent in 2008 represent a reduction of 20.3 percent on the 1999 level. Crops contribute very little to N_2O emissions in Ireland and the amount fluctuates annually in response to varying production of the relevant crops grown in Ireland.

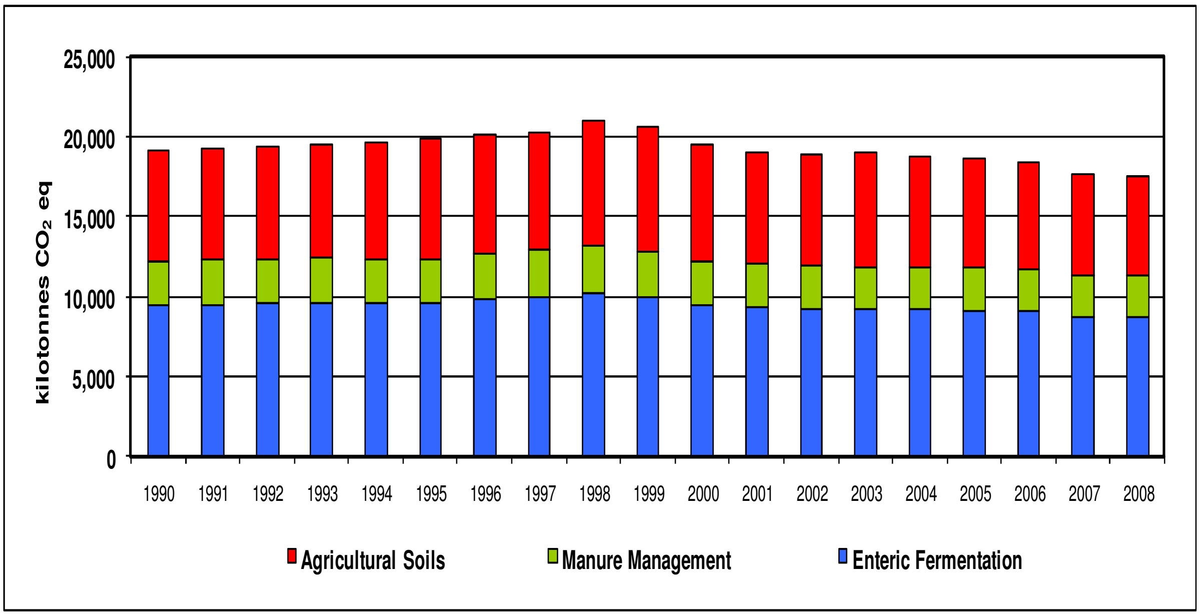

Figure 2.7 Trend in Emissions from Agriculture 1990-2008

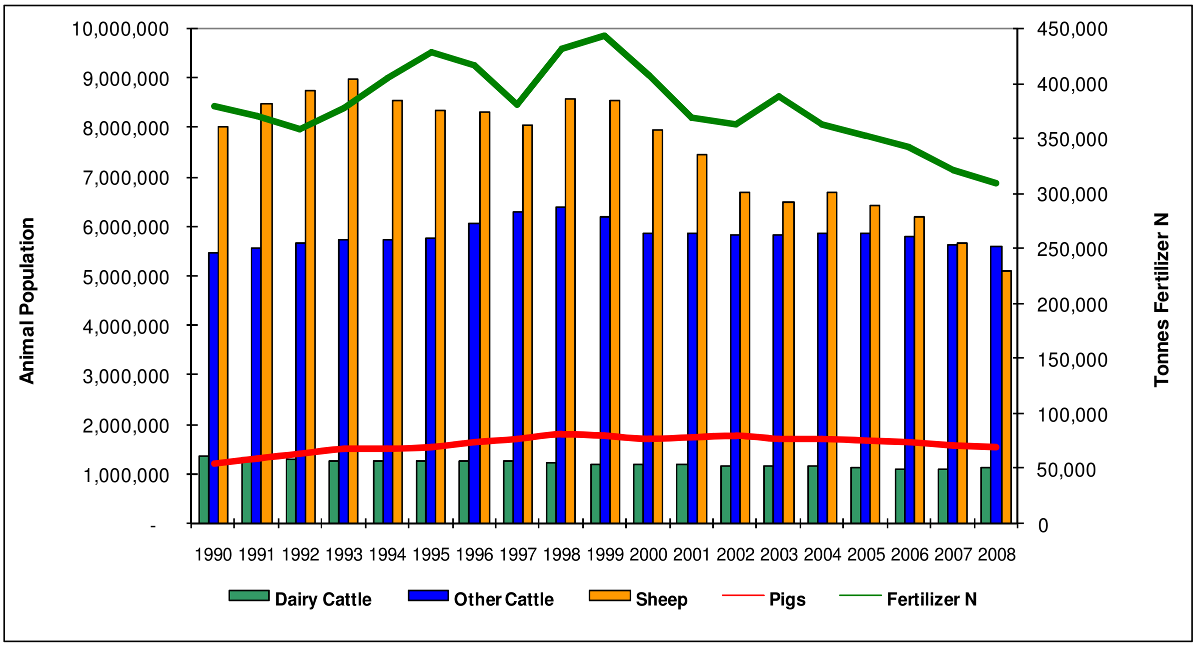

Figure 2.8 Principal Drivers of Emissions from Agriculture 1990-2008

2.3.5 Trends in Land Use, Land Use Change and Forestry (IPCC Sector 5)

The full assessment of emissions and removals in the LULUCF sector according to the reporting requirements of Decision 13/CP.9 has given a new understanding of the relative contributions of sub-categories in this sector and it has identified a number of land-use categories that are important in terms of either emissions or removals of CO_2. This sector is a net source of emissions in some years and a net sink of carbon in other years (Table 2.1 and Figure 2.9). This result is determined largely by the balance between *5.A Forest Land*, which is a major carbon sink, and *5.C Grassland*, where soil disturbance and liming of agricultural lands generate relatively large emissions of CO_2. The complex dynamics of land-use changes between categories and the relative contributions from biomass and soils lead to highly fluctuating estimates of sectoral emissions and removals over the period 1990-2008.

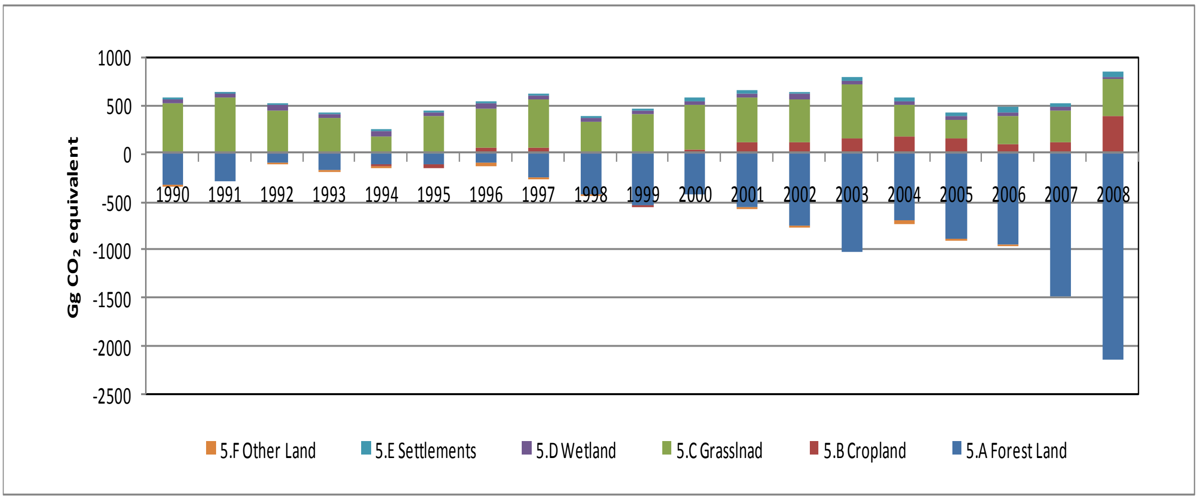

Figure 2.9 Trend in Emissions and Removals from LULUCF 1990-2008

The most important individual emission categories over the time-series are the carbon releases from soils in *5.A.2 Land Converted to Forest Land* and the CO_2 emissions from agricultural lime application on *Grassland* and *Cropland*. The increase in carbon stocks in living biomass in the category *5.A.1 Forest Land remaining Forest Land* is the dominant removal that offsets CO_2 emissions. The *Wetland, Settlements* and *Other Land* categories are comparatively unimportant in terms of emissions or removals but *Cropland* constitutes a significant net source of carbon to the atmosphere towards the end of the time series.

2.3.6 Trends in Waste (IPCC Sector 6)

The *Waste* sector remains an important source of CH_4 emissions (Figure 2.10) due to the continued dominance of landfills as a means of solid waste disposal in Ireland. Emissions from the waste sector decreased by 15.9 percent from 1,301.77 Gg CO_2 equivalent in 1990 to 1,094.93 Gg CO_2 equivalent in 2008. The main contributor to trends in the *Waste* sector is the CH_4 emissions from municipal solid wastes (MSW) disposed of in solid waste disposal sites (*6.A Solid Waste Disposal on Land*). The decrease in emission levels reflects increasing recovery of landfill gas for energy production and particularly through flaring at landfill sites, without which emissions in this sector would be considerably larger.

Since 1990 the population of Ireland increased by 26.1 percent giving an associated increase in the quantity of MSW produced and sustaining the amount of MSW disposed to landfills at close to 2 million tonnes per annum. The proportion of organic materials in MSW increased from 34 percent in 1990 to 42 percent in 2008. The proportions of paper and textiles changed from 29 percent and 3 percent, respectively in 1990 to 19 percent and 12 percent, respectively in 2008, reflecting a significant diversion of paper products from landfills. This reduces CH_4 potential, as paper products are the main source of degradable organic carbon in landfills. A major increase in the use of flares as a means of odour control in landfills in recent years offsets a large proportion of the CH_4 generated. This offset from flares and utilisation was 63 percent in 2008. Emissions of CH_4 and N_2O from *6.B Wastewater Handling* accounted for 128.73 Gg CO_2 equivalent in 1990 and 159.10 Gg CO_2 equivalent in 2008, which equates to approximately 10 and 15 percent of total emissions from the waste sector, respectively. The contribution of this sub-category to overall sectoral trends is negligible.

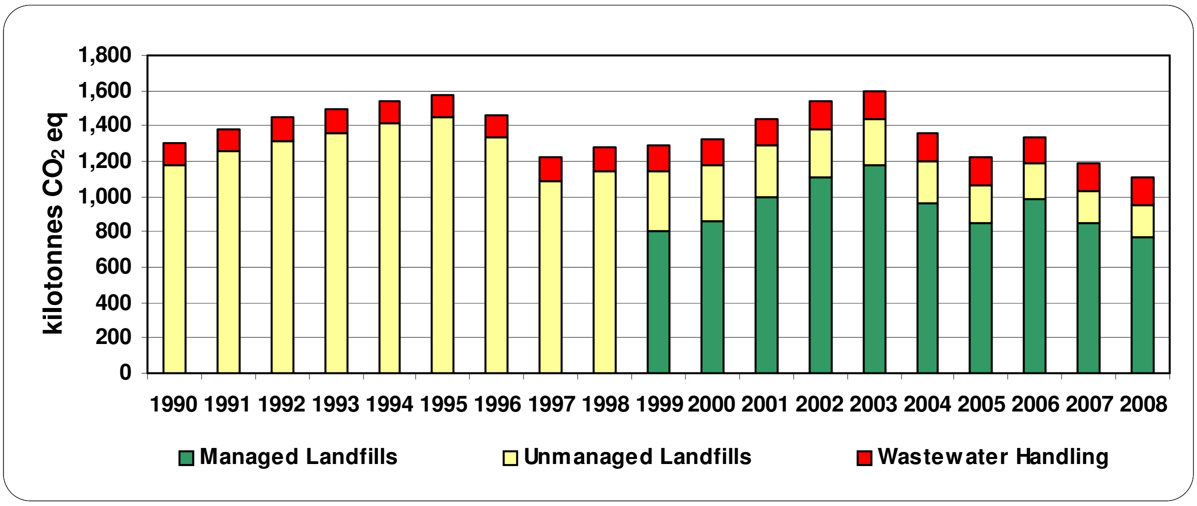

Figure 2.10 Trend in Emissions from Waste 1990-2008

2.4 Emissions of Indirect Greenhouse Gases

The total emissions of SO_2, NO_X, NMVOC and CO for the years 1990 to 2008 are summarised in Table 2.2. As in the case of CO_2, the emissions of SO_2, NO_X and CO in Ireland are dominated by those emanating from fuel combustion activities, while the bulk of NMVOC emissions are generated by road traffic and solvent use. Substantial decreases have occurred in the emissions of SO_2 and CO. Some reductions have also taken place in NMVOC emissions (30.2 percent) and emissions of NO_X in 2008 were 12.0 percent lower than those in 1990.

Table 2.2. Emissions of SO_2, NO_X, NMVOC and CO 1990-2008 (Tonnes)

	SO_2	NO_X	NMVOC	CO
1990	182,300	123,154	81,727	418,021
1991	180,684	124,997	82,822	415,479
1992	169,229	134,089	82,699	403,246
1993	160,223	124,095	79,006	369,384
1994	175,073	122,831	78,443	345,704
1995	160,935	124,848	75,025	317,478
1996	148,822	128,947	79,909	324,755
1997	166,274	129,084	79,675	308,280
1998	177,609	133,929	81,324	318,166
1999	158,723	133,965	74,341	283,041
2000	139,486	135,228	69,436	255,276
2001	134,174	137,135	68,495	244,494
2002	101,240	127,745	64,120	225,434
2003	78,445	122,824	62,263	213,543
2004	71,062	122,131	59,518	200,532
2005	70,429	123,079	58,575	190,486
2006	60,000	118,112	58,142	180,998
2007	54,071	116,707	57,589	170,864
2008	44,536	108,376	57,068	162,284

Total SO_2 emissions decreased by approximately 75.6 percent, from 182,300 tonnes in 1990 to 44,536 tonnes in 2008, reflecting reductions in the sulphur content of fuels, fuel switching and use of abatement technologies. Power stations remain the principal source of SO_2 emissions, contributing approximately 56.6 percent of the total in 2008. Combustion sources in the industrial and residential/commercial sectors largely account for the remainder of emissions, with contributions of 16.2 percent and 23.0 percent, respectively in 2008. In 1990, coal combustion accounted for 51.6 percent of SO_2 emissions and fuel oil contributed 30.1 percent. By 2008, the share of SO_2 emissions from coal had increased to 69.7 percent and that from fuel oil had decreased to 22.2 percent.

Road transport is the principal source of NO_X emissions, contributing approximately 43.6 percent of the total in 2008. The power generation sector is the other main source of NO_X emissions, accounting for 20.3 percent of emissions in 2008. The reductions in NO_X emissions given by catalytic converters in cars and heavy-duty vehicles have only become apparent in recent years, as the technology has been offset by large increases in vehicle numbers in the past 10 years. This effect is exaggerated in latter years by so-called fuel-tourism, whereby a significant proportion of the automotive fuel sold in Ireland is used by vehicles in the UK and possibly to some extent in other countries.

The emissions of NMVOC are determined mainly by road traffic and solvent use. These sources typically produce between 70 to 80 per cent of the annual total of NMVOC emissions in Ireland. Coal burning in the residential sector is another important source. Technological controls for NMVOCs in motor vehicles have been more successful than in the case of NO_X, and have given a significant reduction in emissions from road transport over recent years. However, NMVOC emissions from paint application and the domestic use of various solvent-based products are still increasing with the result that overall NMVOC emissions reductions are not large for the period 1990-2008.

Emissions of CO continue to decline, driven by major reductions due to catalysts in petrol cars, which is the principal source of CO, and a large decrease in the use of solid fuels for space heating in the residential sector. Further reductions in the emissions of SO_2, NO_X and NMVOC will occur in the coming years as Ireland continues to implement programmes to comply with various EU legislation aimed at air quality and emissions control.

Chapter Three

Energy

3.1 Overview of Energy Sector

The *Energy* source category covers all combustion sources of CO_2, CH_4 and N_2O emissions and the fugitive emissions of these gases associated with the production, transport and distribution of fossil fuels. Table 3.1 presents the CRF Level 3 classification of sources concerned and indicates their degree of coverage in Ireland. Estimates are included for all emission sources that occur in the country and the required level of disaggregation is achieved for detailed completion of the CRF tables. The overall approach and methodologies used to estimate emissions in the *Energy* sector for 2008 remain largely as described in the 2009 and 2008 NIRs. As for 2006 and 2007, CO_2 estimates reported under the ETS for 2008 are used to achieve complete bottom-up results in respect of some important sub-categories in this sector for the 2008 inventory. This is a significant advance in terms of accuracy as the ETS estimates are verified and they represent a large proportion of the total emissions from the *Energy* sector.

The Energy sector accounted for 67.8 percent of GHG emissions in Ireland in 2008, with CO_2 emissions making up 98.5 percent of the total for the sector. The categories 1.A.1 Energy Industries and 1.A.3 Transport were the principal sources, contributing 32.0 percent and 31.2 percent, respectively to the sector total. Category 1.A.4 is also a significant source of emissions, contributing 24.5 percent in 2008 while 1.A.2 Manufacturing Industries and Construction accounted for 12.1 percent of the total. Fugitive GHG emissions are insignificant in this sector.

Table B.1 of Annex B shows the national energy balance sheets for 2008, published by Sustainable Energy Ireland (SEI), which form the key activity data for the *Energy* sector. The energy statistics are compiled using a combination of top-down and bottom-up methods and the 2008 example indicates the same form of expanded balance sheet as previously used for all years from 1990 to 2007. The improved balance sheets reflect revisions made by SEI over recent years following a programme to harmonise national energy balances in compliance with the needs of the International Energy Agency (IEA) and EUROSTAT and to facilitate their wider use nationally. The energy balances incorporate additional sectoral disaggregation specific to the needs of the greenhouse gas inventory, following close collaboration between SEI and the inventory agency. The annual submission of up-to-date energy balances from SEI to the inventory agency is one of the primary data inputs covered by MOU in Ireland's national system. A fully consistent set of energy balance sheets for the years 1990-2008 underlies the estimates of emissions for *Energy* in this submission.

Following the methods decision tree of the IPCC good practice guidance for combustion sources, the information in Table B.1 of Annex B allows for the full application of the two available IPCC methods for emission sources in *Energy*, i.e. the Sectoral Approach and the Reference Approach. The Sectoral Approach uses the detailed sectoral breakdown of fuel consumption by all end users as the basis of the calculations for CO_2, CH_4 and N_2O. The relevant activity data are represented by the disaggregated entries below TPER (Total Primary Energy Requirement) in Table B.1 of Annex B. A combination of top-down and bottom-up methods is used in the sectoral application of the national statistics on fuel consumption to derive the emission estimates in the various sub-categories. The Reference Approach provides an estimate of aggregate CO_2 emissions only, based on the apparent consumption of fuels in the country. This estimate is not used in the compilation of total national emissions but rather for comparison purposes only. The apparent fuel consumption is determined from the energy balance items relating to primary and secondary fuels represented by those above TPER in Table B.1 of Annex B. The application of the Sectoral Approach and the Reference Approach is now described with reference to 2008 data and their results are then compared for CO_2, as required by the UNFCCC reporting guidelines. The Sectoral Approach is described according to the individual sub-categories listed in Table 3.1.

Table 3.1. Level 3 Source Category Coverage for Energy

1 Energy	**CO_2**	**CH_4**	**N_2O**
A. Fuel Combustion			
1. Energy Industries			
a. Public Electricity and Heat Production	All	All	All
b. Petroleum Refining	All	All	All
c. Manufacture of Solid Fuels and Other Energy Industries	All	All	All
2. Manufacturing Industries and Construction			
a. Iron and Steel	All	All	All
b. Non-Ferrous Metals	All	All	All
c. Chemicals	All	All	All
d. Pulp, Paper and Print	All	All	All
e. Food Processing, Beverages and Tobacco	All	All	All
f. Other	All	All	All
3. Transport			
a. Civil Aviation	All	All	All
b. Road Transportation	All	All	All
c. Railways	All	All	All
d. Navigation	All	All	All
e. Other Transportation	All	All	All
4. Other Sectors			
a. Commercial/Institutional	All	All	All
b. Residential	All	All	All
c. Agriculture/Forestry/Fisheries	All	All	All
5. Other	NO	NO	NO
B. Fugitive Emissions from Fuels			
1. Solid Fuels			
a. Coal Mining	NO	NO	NO
b. Solid Fuel Transformation	NO	NO	NO
c. Other	NO	NO	NO
2. Oil and Natural Gas			
a. Oil	NO	NO	NA
b. Natural gas	All	All	NA
c. Venting and Flaring	All	All	NA
d. Other	NO	NO	NO

All : all emission sources covered; NE : emissions not estimated; NO : activity not occurring; NA : not applicable (emissions of the gas do not occur in the source category); IE : emissions included elsewhere

3.2 Sectoral Approach for Emissions from Energy Use

3.2.1 Combustion Sources

The combustion of fossil fuels accounts for the bulk of CO_2 emissions in most countries. In Ireland, emissions of CO_2 from fuel combustion contributed two-thirds of total emissions in

2008. The CO_2 emissions are relatively easy to quantify with reasonable accuracy as the fuel amounts are detailed in the energy balance sheets and information on their carbon contents is well established. The total amount of CO_2 released on combustion can therefore be readily ascertained. Only small amounts of CH_4 and N_2O are associated with fuel combustion activities. The emissions of these gases are generally not quantified with the same reliability as the emissions of CO_2 because the rates of CH_4 and N_2O production depend on several factors, in addition to fuel type, and consequently there is considerable uncertainty in the available emission factors for these gases.

Ireland's energy data in the expanded energy balance sheets (Table B.1 of Annex B) are disaggregated according to fuel and sector for the purposes of calculating emissions in the IPCC Level 3 source categories in a top-down approach. Supplementary sources of information facilitate the use of bottom-up methods in some important sub-categories and they provide greater detail in the overall fuel-sector matrix, making it more compatible with the inventory reporting format required for the Sectoral Approach. The simple calculation spreadsheet given in Table D.1 of Annex D shows how the emissions from combustion sources are computed for the year 2008 using the activity data and emission factors described below. The complete allocation to IPCC Level 1 source categories is readily achieved from this compilation, as shown in Table D.2. of Annex D. The correspondence between the national disaggregation of sources and IPCC combustion source categories is given in Table D.3 of Annex D.

All CO_2 emission factors for fuel combustion in the present submission, except in the case of biomass, are country-specific values, regardless of methodological tier used, which are determined directly from information on the carbon contents and net calorific values of the fuels used in stationary and mobile sources. The CO_2 emission factor for natural gas takes into account the increasing contribution of imported gas in the national total given by the energy balance. The importation of natural gas from the UK began around 1993 and imported gas accounted for more than 90 percent of the total in 2008. The CO_2 emission factor appropriate to the split between domestic and imported natural gas, which is more carbon intensive, is now used for all years from 1993 to 2008.

The annual returns to the EPA's Climate Change Unit (CCU) by participants in the EU Emissions Trading Scheme under Directive 2003/87/EC (EP and CEU, 2003) comprise an important source of information on CO_2 emissions and emission factors that is now fully utilised for the national inventory compilation. The fuel combustion CO_2 emission factors for solid fuels used by participants under ETS take account of the fact that a very small fraction (typically less than 1 percent) of fuel carbon may remain unoxidised and IPCC oxidation factors appropriate to these fuels are applied when computing the emissions under the scheme. Complete oxidation of carbon is assumed in the case of liquid and gaseous fuels. For other stationary combustion sources, where activity data are in general top-down fuel use quantities taken from the energy balance, the inventory agency adopts the approach that no specific allowance is needed for unoxidised carbon in the calculation of CO_2 emissions. Default CO_2 emission factors from IPCC are used only for biomass, which almost invariably refers to wood and wood wastes. For stationary sources and all mobile sources except road traffic, Ireland relied largely on the default emission factors for CH_4 and N_2O available from the CORINAIR/EMEP Emission Factor Guidebook (McInnes, 1996 and Richardson, 1999) in preparing the submissions up to and including 2009. A comprehensive internal review of CH_4 and N_2O emission factors was undertaken in 2009, which led to substantial revision of these emission factors across stationary combustion sources in general so that they now conform to the latest available IPCC values. Annex C describes this review and tabulates the revised CH_4 and N_2O emission factors that have been applied for 2008 and in the recalculated inventories for the years 1990-2007.

3.2.1.1 Energy Industries (1.A.1)

The Annual Installation Emissions Reports (AIER) submitted by ETS participants in respect of their CO_2 emissions and fuel combustion in 2008 under Directive 2003/87/EC were used to report the complete inventory for category 1.A.1. The emissions data from a total of 19 individual installations – 16 electricity generating stations in 1.A.1(a), one oil refinery in 1.A.1(b) and two peat briquetting plants under 1.A.1(c) – are the basis for compiling the results in this important category. In each of the three sub-categories, the verified CO_2 estimates reported by the ETS participants were used directly and the corresponding fuel use as given in the national energy balance was used to estimate CH_4 and N_2O emissions using the revised emission factors mentioned in the previous section.

The CO_2 emissions for sub-category 1.A.1(a) obtained from AEIRs are estimated by ETS operators using tier 3 methodologies in accordance with the monitoring and verification guidelines for combustion activities set down in Decision 2004/156/EC (EP and CEU, 2004), which were developed for the implementation of Directive 2003/87/EC. These methods involve a rigorous accounting of fuel consumption and detailed information on fuel properties based on fuel sampling protocols agreed in the greenhouse gas emission permits for each installation and the application of specific emission factors for each fuel determined by accredited laboratories. The summarised CO_2 emissions compiled in the ETS database according to fuel type for all installations that constituted sub-category 1.A.1(a) in 2008 are aggregated to report the CO_2 emissions for this category.

The implementation of the ETS incorporates two layers of verification. The operator's report for the installation is verified independently in accordance with requirements specified in Directive 2003/87/EC before being submitted to the competent authority. This verification assesses whether the report contains omissions, misrepresentations or errors that lead to material misstatement of the reported information. Verification undertaken by the competent authority involves resolution of issues identified in the verified reports through consultation and installation site visits. The CO_2 emissions estimates compiled through ETS for sub-category 1.A.1(a) are cross-checked with a separate long-standing data flow to the inventory agency covering plant-specific emissions for electricity generating stations that are used to report on the Large Combustion Plant Directive and the Convention on Long-Range Transboundary Air Pollution. The aggregated CO_2 emissions reported in the latter data-flow correspond to the compilation available under the ETS for all years since the latter became available.

The rigour of the monitoring and verification process for CO_2 emissions under the ETS results in estimates for sub-category 1.A.1(a) that are clearly more accurate and more reliable than previously reported plant-specific estimates for the same source activities. The ETS estimates are available only for recent years and the detailed information that underlies these data cannot reasonably be acquired by the inventory agency for historical years of the relevant UNFCCC time-series. As such, the application of the improved methodology introduces a degree of inconsistency in the time-series that is unavoidable in this instance. However, given that the ETS results fully cover sub-category 1.A.1(a) and that these estimates match those reported separately under parallel arrangements that have been in place for many years for the same plants, it may be assumed that time-series consistency is not seriously affected and that there is no impact on the emission trend from using the ETS data.

The bottom-up CO_2 emission estimates received from the ETS participants, along with the emissions of CH_4 and N_2O estimated by the inventory agency, are aggregated on the basis of four main fuel types (peat, coal, oil and natural gas) in the calculation sheets shown in Annex D and also by solid, liquid and gaseous fuels for reporting in the CRF. However, the corresponding energy use as reported in the CRF is taken from the national energy balance, rather than from the ETS returns, following Ireland's established practice to always reflect the published official national energy data in emission inventories. The resulting implied emission factors (IEFs) appearing in the CRF may have large inter-annual fluctuations, which are often identified in the UNFCCC review process. These IEF fluctuations are a consequence of the difference between energy data reported to the inventory agency through the ETS and that reported by SEI in the national energy balance. The inventory agency is working closely with SEI to minimise these differences so that the IEF will better represent the reported emissions and activity data in future years. Additional information on fluctuating IEFs for CO_2 in category 1.A.1 can be found for liquid and solid fuels in Tables D.6 and D.7 of Annex D, respectively. The application of the most up-to-date IPCC CH_4 and N_2O emission factors in this category now also improves the robustness and comparability of the emissions estimates.

Figure 3.1 shows the trend in emissions from 1.A.1 (a) Public Electricity and Heat Production over the period 1990-2008, which account for more than 95 percent of the total for category 1.A.1. The emissions from the category in 2008 were similar to those in 2007 but there was a small shift in the balance of contributions between peat and coal.

One small oil refinery accounts for the emissions reported under 1.A.1 (b) Petroleum Refining. The reported CO_2 emissions are those available from the ETS database. These emissions are estimated using tier 2 methodologies in accordance with the monitoring and verification guidelines for combustion activities set down in Decision 2004/156/EC. The emissions are estimated from the use of high-pressure gas, low-pressure gas, LPG and small amounts of other gases as well as gasoil and residual fuel oil using country-specific emission factors. The CH_4 and N_2O emissions are estimated by the inventory agency using the IPCC default emission factors (Annex C). Because high-pressure gas, low-pressure gas and residual fuel oil account for the bulk of the emissions in 1.A.1 (b) in all years and the emission factors for these fuels do not fluctuate significantly, the emissions reported using ETS data are consistent with the annual estimates for historical years.

Emissions for 1.A.1(c) Manufacture of Solid Fuels and Other Energy Industries were reported for the first time in the 2006 submission and refer to the production of peat briquettes from milled peat in two plants. The 2008 values for CO_2 are also taken from ETS returns which are based on tier 2 methodologies in accordance with the monitoring and verification guidelines for combustion activities set down in Decision 2004/156/EC. The CH_4 and N_2O estimates are computed by the inventory agency using IPCC default emission factors (Annex C). Milled peat is the principal fuel concerned in 1.A.1(c), and while the annual emission factor may fluctuate in response to peat quality and moisture content, both the emission factor and activity data are sufficiently well established to ensure that the emissions time-series for this sub-category is consistent in the 2008 submission.

The inventory experts continue to collaborate with colleagues managing annual ETS returns from all participants to fully consolidate and formalise data gathering in respect of categories 1.A.1(a), 1.A.1(b) and 1.A.1(c) using the prescribed monitoring and verification mechanisms to ensure full consistency with reporting of CO_2 estimates under ETS and under the Convention and Decision 280/2004/EC.

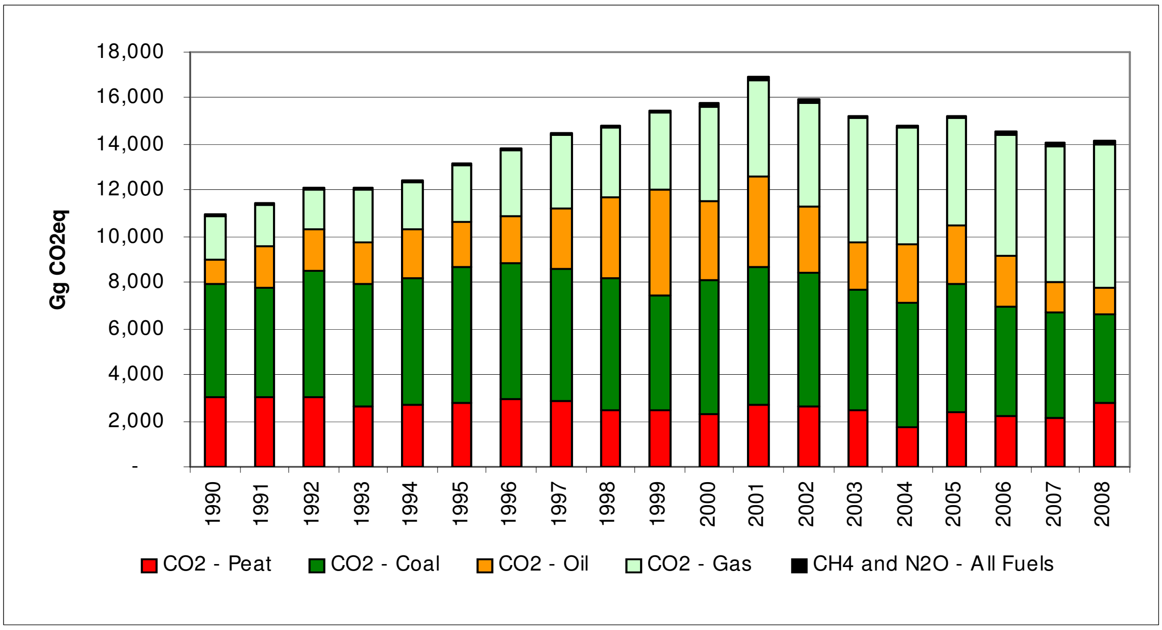

Figure 3.1 Trend in Emissions from 1.A.1(a) Public Electricity and Heat 1990-2008

3.2.1.2 Manufacturing Industries and Construction (1.A.2)

The revised and expanded annual energy balance sheets published by SEI incorporate a mapping of industrial fuel use in combustion into the CRF sub-categories (a) through (f) under 1*.A.2 Manufacturing Industries and Construction*. This facilitates the complete disaggregation of emissions in this source category for completion of the CRF Table 1.A (a)s2. In the past, allocation to the lower level was often based on poor information, which resulted in outlier implied emission factors for some of the fuels in sub-categories 1.A.2(a) through 1.A.2(f). The combustion CO_2 emissions in a variety of installations across the CRF sub-categories 1.A.2(a) through 1.A.2(f) are covered by the ETS Directive 2003/87/EC but the total CO_2 emissions in any sub-category cannot be reported for Ireland using ETS data alone, as in the case of the sub-categories under 1.A.1. The ETS data are instead used to compare fuel quantities reported under ETS with corresponding amounts given in the preliminary national energy balance and to determine improved country-specific emission factors that can be applied for particular fuels and sub-categories. The emissions of CO_2 are estimated by the inventory agency on a top-down basis using the agreed final energy balance activity data and country-specific emission factors as shown in Table D.1 of Annex D. The emissions of CH_4 and N_2O are estimated using the IPCC default emission factors adopted following the review of emission factors referred to in section 3.2.1.

For the present submission, ETS fuel data have been used to develop a new annual country-specific CO_2 emission factor for petroleum coke in sub-category 1.A.2(f), for which the IPCC default value of 100.8 t CO_2/TJ was used in the 2007 inventory. Approximately 80 percent of petroleum coke is used in the production of cement and lime. The verified reports from the ETS installations concerned indicate emission factors of 95.13, 93.43, 93.21 and 92.93 t CO_2/TJ in 2005, 2006, 2007 and 2008 respectively and these have been applied to the full amount of petroleum coke in each year. To achieve consistency for other years, the average of the above values for the years 2005-2008 has been applied for the years 1990-2004. When the country-specific emission factor for petroleum coke is taken into account, the implied emission factor for liquid fuels fluctuates significantly depending on the proportion of petroleum coke in liquid fuels. This implied emission factor increases from 76.2 t CO_2/TJ in 1990 to 83.0 t CO_2/TJ in 2007 and decreased slightly to 81.6 t CO_2/TJ in 2008.

3.2.1.3 Transport (1.A.3)

The fuel consumption within Ireland associated with sub-category 1.A.3 (a) Civil Aviation is calculated from the number of annual landing and take-off (LTO) cycles for domestic air travel provided by airport authorities, the fuel consumption rates given by the IPCC good practice guidance appropriate to the type of aircraft concerned (Table 2.10, GPG Appendix 2.5A.1) and the length of the flights within Ireland. This approach is used for consistency with other years even though the expanded and updated energy balance sheets record the amount of fuel used in domestic air transport.

Emissions of CO_2 reported under 1.A.3 (b) Road Transportation are computed from the amounts of petrol and diesel given under road transport in the national energy balance and country-specific emission factors for these fuels as shown in Table D.1 of Annex D. Following the IPCC good practice guidance, the activity data are based on fuel sales within Ireland, even though a significant proportion of automotive fuels purchased in Ireland is used in the UK. The CH_4 and N_2O emissions from road traffic are estimated in the COPERT 4v.6.1 model (Gkatzoflias et al., 2007), developed within the CORINAIR programme for estimating a range of emissions from this important source. This version of the COPERT model was first applied for the 2010 submission and resulted in minor recalculations to CH_4 and N_2O emissions for all years in the period 1990-2007. Road traffic is an important source of N_2O from fuel combustion and the emissions have increased in line with the increasing share of catalyst-controlled vehicles in the national fleet. The COPERT 4v.6.1 model estimates these emissions on the basis of distance travelled using a detailed bottom-up approach (Tier 3) that accounts for such factors as fuel type, fuel consumption, engine capacity, driving speed and a range of applicable technological emission controls that may be applied on the basis of the age of the vehicle. The model is applied annually in Ireland to derive CH_4 and N_2O emissions estimates. The resultant 2008 emission factors have been converted to national average values per fuel type for the purpose of Table D.1 in Annex D.

The CO_2 emissions under 1.A.3 (c) Railways and 1.A.3 (d) Navigation are calculated from the amounts of oil used by these activities, as recorded in the energy balance, and the country specific emission factors for oil. The emissions of CH_4 and N_2O are estimated using the IPCC default emission factors adopted following the review of emission factors referred to in section 3.2.1. The emissions reported in sub-category 1.A.3 (e) Other Transportation are those due to the use of natural gas at off-shore production platforms and in pipeline compressor stations. The fuel use is estimated as the difference between the value given for natural gas under own use/losses in the national energy balance (Table B.1 of Annex B) and the amount of gas estimated to be lost from the distribution network, as reported under fugitive emissions in sub-category 1.B.2 (b) Natural Gas. The country-specific emission factor for CO_2 and the default values for CH_4 and N_2O referred to in section 3.2.1 are used.

3.2.1.4 Other Sectors (1.A.4)

The CRF sub-category 1.A.4 Other Sectors covers combustion sources in the residential, commercial, agriculture and forestry sectors. The residential sub-category 1.A.4(b) remains the most important source of emissions in this sub-category in Ireland. This is evident from Figure 3.2, which shows the trend in the principal components of emissions in 1.A.4 Other Sectors over the period 1990-2008. While the shift from carbon-intensive fuels, such as coal and peat, to oil and natural gas in 1.A.4(b) has been sufficient to maintain emissions relatively constant up to 2007, the benefits from fuel switching have been fully realised and the emissions from oil and gas are increasing in line with higher overall fuel consumption resulting from greater housing stock and population. The emissions in the residential sub-category increased by almost 9 percent in 2008, which is attributed to colder than normal winter months.

Table D.2 of Annex D shows the calculation of emissions for sub-category 1.A.4 Other Sectors, using the fuel quantities as given by the energy balance (Table B.1 of Annex B). The inventory agency uses country-specific emission factors for CO_2, including that for petroleum coke referred to in section 3.2.1.2, and IPCC default values for CH_4 and N_2O. The energy balance provides no indication on the specific end-use of gasoil in the agricultural sector. Consequently, a split based on information from agricultural experts (10 percent stationary sources and 90 percent mobile sources) is used by the inventory agency to distinguish between the use of this fuel in stationary and mobile combustion sources. This split has little bearing on emissions of CO_2, but it is important in relation to CH_4 or N_2O and the indirect greenhouse gases.

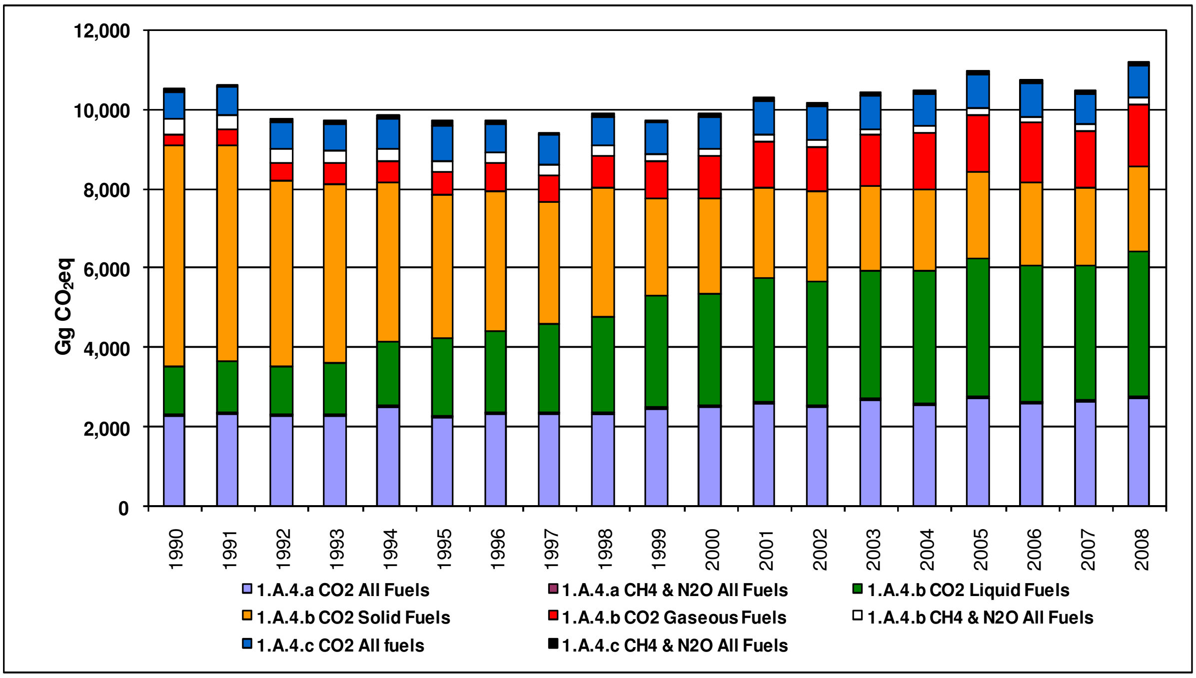

Figure 3.2 Trend in Emissions from 1.A.4 Other Sectors 1990-2008

3.2.2 Fugitive Emissions (1.B)

Ireland has no coal or oil industries and therefore fugitive emissions of greenhouse gases are limited to those associated with natural gas production and distribution. Natural gas has been produced from gas fields off the south coast of Ireland since the 1970s but this source is rapidly being depleted. Recently, substantial reserves of natural gas have been discovered off the west coast and they will soon come into production.

Bord Gais Eireann (BGE), Ireland's gas company has assessed gas losses in the pipeline network in the context of the needs of annual inventory reporting and a long-term programme to replace cast-iron mains with polyethylene pipe in all urban areas served by natural gas. The change to polyethylene pipe is considered to result in negligible losses. The gas company indicated that gas loss in 1995, determined as the difference between system input and metered sales, was 1.92 million therms, which equates to 4,085 tonnes of methane, when the amounts of indigenous and imported gas and their respective properties are taken into account. This value implied a loss of the order of 0.2 percent of total sales. Projections made by BGE for five-year intervals from 2000 show losses decreasing to zero by 2020 on completion of the pipe replacement programme.

The BGE data continue to be used as the best available for this particular fugitive emission source. The rate of loss implied by the 1995 value and the projections is applied to give an emission for all years of the inventory time-series referred to in this report. The gas consumption recorded in the energy balance for the industrial, commercial and residential sectors is used as activity data rather than total sales and the appropriate split between indigenous and imported gas is applied for all years. The inventory agency was informed by BGE in 2004 that natural gas losses from the distribution network were so small that they could not be measured.

Only one company is involved in natural gas production in Ireland. Emissions to the atmosphere from this company's offshore gas production platforms are reported to the Department of Communications Energy and Natural Resources (DCENR) under the OSPAR Convention. Such reports have been obtained for several years in the 1990-2008 time series and are currently covered by MOU with the inventory agency. The available data, which relate largely to gas extraction but which also account for a small amount of flaring in some years, indicate a close relationship between emissions and the amount of gas produced. This relationship has been applied in terms of the indicative emission rates of CO_2 and CH_4 per unit of gas extracted to estimate the emissions for those years for which no reports were received. A report on emissions was supplied to the inventory agency for 2008.

3.3 IPCC Reference Approach for CO_2 Emissions from Energy Use

The IPCC Reference Approach is a top-down methodology for CO_2 that estimates emissions by accounting for the overall production of primary fuels, the external trade in primary and secondary fuels, stock changes and for the carbon that may enter long-term storage in non-energy products and feedstocks. It can be used to report national emissions in cases where the detailed activity data required for the Sectoral Approach are not available but it is more usually applied for verification of the results of the latter for those countries that have the information to apply both methods. The Reference Approach is used in Ireland as a verification procedure for CO_2 emissions from fuel combustion activities. The calculation sheet for the Reference Approach (Table 1.A (b) of the 2008 CRF) is reproduced as Table D.4 of Annex D of this report. The apparent consumption of fuels, the basic activity data in this case, is determined as:

Apparent Consumption = Production + Imports – Exports – International Bunkers – Stock Changes

where production applies only to primary fuels. Naphtha was previously the only petroleum product to be considered in relation to non-energy fuel-use, where the carbon is not fully released as in combustion. The IPCC default value of 0.50, 0.75 and 1.0 are used for the proportion of carbon stored in lubricants, naphtha and bitumen respectively. Ireland's only oil refinery is a small hydroskimming refinery where there is no production of other petroleum products normally used for non-energy purposes, such as bitumen, lubricants, plastics and asphalt. The expanded SEI energy balance sheets now record the import of some of these products, thereby allowing improved completeness in the Reference Approach estimation of CO_2 emissions and carbon storage. A significant amount of natural gas feedstock was traditionally used in ammonia production in Ireland but the company closed in 2003 and there is consequently no feedstock use of natural gas since then.

3.4 Comparison between Sectoral Approach and Reference Approach

The national energy consumption and CO_2 emissions estimates obtained using the Sectoral Approach usually differ to some extent from the corresponding values resulting from the Reference Approach (Table D.5 of Annex D). According to the UNFCCC guidelines, differences greater than 2 percent should be explained and investigated to see whether they indicate systematic underestimation or overestimation of energy consumption by one or other of the methods. The differences in 2008 are very minor, indicating that in the Reference Approach energy use and CO_2 emissions were 0.44 percent and 0.23 percent lower than in the Sectoral Approach. The emissions from solid fuels are marginally higher in the Reference Approach while the emissions from liquid and gaseous fuels are marginally higher in the Sectoral Approach.

3.5 Memo Items

The memo items of the IPCC reporting format refer to activities for which the emissions are excluded from national totals. The use of fuels in international aviation and marine bunkers is the most important of these activities. Some of the associated emissions, particularly CO_2 emissions from international aviation, are increasing very rapidly and it is therefore important that they are closely monitored for comparison with other sources and for the benefit of the international organisations that will have to develop control strategies for them in the future. The emissions of CO_2 from biomass combustion are not included in national totals of greenhouse gases because it is assumed that an equivalent amount of CO_2 is removed from the atmosphere by the growth of the next biomass crop. The estimation of emissions for memo items is described here because they are calculated as part of the general estimation procedures for the Energy sector.

The activity data for biomass appear as a specific item in the Irish energy balance sheets (Table B.1 of Annex B). For the industrial and residential sectors, this is known to refer to wood and wood wastes. Default emission factors for CO_2, CH_4 and N_2O for wood burning are used to estimate the emissions from biomass in these sectors using the simple Tier 1 approach. The estimates for all gases appear in the CRF tables covering these sectors, but in the case of CO_2, they do not contribute to the total for Energy or to the national total in the CRF summary tables.

The national energy balance sheets include marine bunkers and international aviation as specific items and the emissions may be calculated directly. The allocation of fuels to marine bunkers and international aviation in the national energy balance is achieved on the basis of particular tax and excise rates applicable to the sale of such fuels. The approach used to estimate fuel consumption in domestic civil aviation by the inventory agency is described in section 3.2.1.3 above and gives a result for 2008 close to that in the energy balance. This fuel amount is deducted from the value given in the energy balance sheet for kerosene use in air transport to obtain an estimate of international aviation bunker fuel consumption. In 2008, the amount of fuel allocated to domestic aviation was four percent of the total recorded under air transport in the energy balance.

3.6 Quality Assurance and Quality Control

Extensive QA/QC procedures have again been followed for the Energy sector during the present reporting cycle by fully implementing the plan that underpins Ireland's formal national system. The inventory agency continues to apply a system of quality control checks and documentation spreadsheets to the front of all calculation workbooks. These workbooks correspond directly to the disaggregation given by the CRF sectoral background data tables and are designed so that calculations may be made on a time-series basis, rather than by individual year. This increases efficiency in the use of the time-series energy data provided by SEI and allows for rapid recalculation and checking across the time-series and facilitates the transfer of the output emission estimates and energy quantities to the CRF Reporter Tool. Additional summary sheets are used for aggregation to various levels to provide full cross-checking with completed CRF tables for any year.

The quality checks at inventory level build on the extensive upgrading and quality control of energy balances completed by SEI in recent years. This work, together with further collaboration with inventory experts and thorough evaluation of the SEI role in relation to the national system and QA/QC procedures, has resulted in substantial improvements that are now taken into account in the emissions for Energy for the years 1990 through 2008 included in the present submission. In recognition of its role as a key data provider, SEI is continuing to develop its own procedures to ensure that energy balances fully harmonised with Eurostat and IEA requirements are made available in a timely manner to facilitate the annual reporting of greenhouse gas emissions estimates. Arrangements have been established whereby the bottom-up energy data reported to the EPA for individual enterprises in all relevant energy-use sectors covered by the EU emissions trading scheme may be reconciled at an early stage with the corresponding top-down information collected by SEI (section 3.2.1.2). This procedure aims to progressively minimise differences that still persist between the energy amounts reported by SEI and that supplied for particular sub-categories and fuels.

The formal application of the ETS data in the *Energy* sector for the 2008 submission is again considered an important step towards improved reliability and accuracy of the estimates for categories 1.A.1 and 1.A.2. Thorough checking of this input is achieved in collaboration with colleagues in the Climate Change Unit (CCU) of the EPA, which acts as the competent authority for the ETS in Ireland. Following receipt of the raw ETS data from CCU, the inventory experts allocate the CO_2 estimates and corresponding energy amounts to the appropriate sub-categories for CRF reporting and then return the compilation to the CCU contact person for final checking and accounting of any amendments following the ETS verification process. This ensures that where ETS emissions estimates cover a category completely, such as in 1.A.1, the verified CO_2 values are transferred directly to the national inventory and consistency of results is guaranteed. In the case where the CO_2 estimates from ETS do not completely cover the category, as for 1.A.2, the benefit is realised as better information on fuels and more representative emission factors, which improves the top-down estimates of emissions obtained using the energy balance.

3.7 Recalculations in Energy

Recalculations have been undertaken in the *Energy* sector for the years 1990-2008 to account for the following improvements

- Major revision of CH_4 and N_2O emission factors for all stationary combustion categories to the best available IPCC values (Annex C), which has been undertaken to address issues in the UNFCCC review outcomes relating to Ireland's submissions over several recent years;
- Use of a country-specific CO_2 emission factor for petroleum coke in all categories where this fuel is used, which improves the accuracy and reliability of the emissions estimates.

Detailed information on recalculations is available in chapter ten. The results of the recalculations are given by category and gas in Tables 3.2, 3.3, 3.4 and 3.5. The effect of using the latest available IPCC emission factors for CH_4 and N_2O is to increase emissions of CH_4 and decrease emissions of N_2O and the impact for N_2O is more significant due to its higher GWP. The country-specific CO_2 emission factor for petroleum coke gives a very minor decrease in CO_2 for categories 1.A.2 and 1.A.4. Total emissions for the sector are reduced by approximately 1.5 percent in the early years of the time-series and by the order of 2 percent towards the end of the time-series.

3.8 Planned Improvements in Energy

The changes referred to above for 2008 conclude a series of improvements affecting activity data, emission factors and methodologies that have been applied to inventories for the *Energy* sector over recent years. The inventory agency believes that CO_2 emissions from this sector, which account for 98.5 percent of total emissions from the sector, are accurately quantified and there is therefore very little scope for further improvement in the inventories as delivered in the 2010 submission. No important changes are foreseen for inventory submissions relating to the remaining years of the Kyoto Protocol commitment period 2008-2012.

Table 3.2. Percentage Change in total GHG Emissions from Energy due to Recalculations

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
		Estimates in 2009 Submission (Gg CO2eq)																	
1.A.1.	Energy Industries	11,576.40	12,072.50	12,769.06	12,776.66	13,137.67	13,835.56	14,559.97	15,247.30	15,685.84	16,359.98	16,648.12	17,926.82	16,945.58	16,170.87	15,813.75	16,219.72	15427.79	14853.69
1.A.2.	Manuf Ind and Constn	4,107.55	4,226.82	3,902.43	4,117.02	4,398.55	4,507.99	4,304.01	4,738.53	4,750.00	4,974.17	5,872.80	5,854.17	5,553.02	5,570.25	5,967.12	6,051.94	5935.40	6300.52
1.A.3.	Transport	5,170.99	5,376.87	5,828.52	5,801.95	6,050.28	6,284.31	7,345.58	7,704.40	9,083.06	10,044.31	10,782.72	11,295.17	11,478.90	11,651.66	12,283.31	13,044.97	13728.23	14377.51
1.A.4.	Other Sectors	10,462.56	10,608.97	9,732.10	9,707.12	9,871.18	9,708.34	9,762.31	9,490.13	9,970.34	9,846.88	10,019.77	10,415.11	10,277.89	10,588.24	10,612.24	11,113.45	10879.15	10564.77
1.B.	Fugitive Emissions	269.96	269.71	263.59	281.68	280.61	280.93	270.84	246.54	199.94	206.42	155.87	225.70	134.35	685.14	137.25	116.75	162.25	123.88
1	Total	31,587.46	32,554.87	32,495.69	32,684.43	33,738.30	34,617.12	36,242.71	37,426.89	39,689.18	41,431.77	43,479.27	45,716.98	44,389.74	44,666.16	44,813.67	46,546.84	46,132.82	46220.36
		Recalculated Estimates in 2010 Submission (Gg CO2eq)																	
1.A.1.	Energy Industries	11,238.54	11,699.00	12,363.63	12,378.59	12,716.77	13,401.40	14,120.58	14,782.31	15,167.24	15,822.28	16,140.48	17,364.19	16,453.29	15,761.31	15,383.33	15,771.30	15,026.99	14,533.80
1.A.2.	Manuf Ind and Constn	3,958.61	4,059.53	3,752.46	3,965.61	4,216.66	4,318.06	4,151.43	4,529.84	4,549.76	4,760.65	5,588.18	5,533.10	5,254.81	5,261.81	5,647.60	5,743.38	5,625.66	5,872.85
1.A.3.	Transport	5,160.32	5,366.33	5,817.25	5,790.22	6,037.13	6,272.02	7,332.73	7,690.71	9,068.62	10,028.18	10,766.26	11,279.71	11,471.12	11,644.17	12,272.39	13,031.89	13,719.23	14,376.11
1.A.4.	Other Sectors	10,539.74	10,660.76	9,785.97	9,756.59	9,893.27	9,726.26	9,750.23	9,453.18	9,938.37	9,768.94	9,943.70	10,313.22	10,187.18	10,474.14	10,512.74	11,006.18	10,774.32	10,507.82
1.B.	Fugitive Emissions	269.96	269.71	263.59	281.68	280.61	280.93	270.84	246.54	199.94	206.42	155.87	225.70	134.35	685.14	137.25	116.75	98.03	123.77
1	Total	31,167.18	32,055.34	31,982.91	32,172.69	33,144.44	33,998.67	35,625.82	36,702.57	38,923.94	40,586.47	42,594.49	44,715.92	43,500.76	43,826.57	43,953.31	45,669.50	45,244.22	45,414.35
		Percentage Change in Total Emissions due to Recalculations																	
1.A.1.	Energy Industries	-2.92	-3.09	-3.18	-3.12	-3.20	-3.14	-3.02	-3.05	-3.31	-3.29	-3.05	-3.14	-2.91	-2.53	-2.72	-2.76	-2.60	-2.15
1.A.2.	Manuf Ind and Constn	-3.63	-3.96	-3.84	-3.68	-4.14	-4.21	-3.54	-4.40	-4.22	-4.29	-4.85	-5.48	-5.37	-5.54	-5.35	-5.10	-5.22	-6.79
1.A.3.	Transport	-0.21	-0.20	-0.19	-0.20	-0.22	-0.20	-0.17	-0.18	-0.16	-0.16	-0.15	-0.14	-0.07	-0.06	-0.09	-0.10	-0.07	-0.01
1.A.4.	Other Sectors	0.74	0.49	0.55	0.51	0.22	0.18	-0.12	-0.39	-0.32	-0.79	-0.76	-0.98	-0.88	-1.08	-0.94	-0.97	-0.96	-0.54
1.B.	Fugitive Emissions	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-39.58	-0.09
1		-1.33	-1.53	-1.58	-1.57	-1.76	-1.79	-1.70	-1.94	-1.93	-2.04	-2.03	-2.19	-2.00	-1.88	-1.92	-1.88	-1.93	-1.74

Table 3.3. Percentage Change in CO_2 Emissions from Energy due to Recalculations

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
											Estimates in 2009 Submission (Gg CO_2eq)								
1.A.1.	Energy Industries	11,158.61	11,617.34	12,279.74	12,297.59	12,634.28	13,317.47	14,031.86	14,692.87	15,080.52	15,732.98	16,050.38	17,266.56	16,345.34	15,643.44	15,283.51	15,657.29	14906.98	14406.63
1.A.2.	Manuf Ind and Constn	3,969.77	4,084.62	3,768.63	3,978.02	4,243.31	4,349.02	4,155.74	4,571.70	4,583.21	4,798.16	5,665.71	5,644.59	5,355.08	5,371.09	5,758.41	5,836.54	5733.78	6088.79
1.A.3.	Transport	5,039.39	5,242.11	5,685.51	5,646.50	5,880.60	6,106.55	7,144.85	7,482.39	8,826.60	9,783.80	10,512.66	11,017.18	11,215.64	11,396.54	12,027.84	12,792.15	13483.34	14143.87
1.A.4.	Other Sectors	10,058.92	10,192.13	9,370.71	9,347.42	9,515.76	9,365.82	9,405.08	9,147.18	9,610.45	9,490.15	9,659.89	10,044.34	9,911.48	10,211.07	10,238.19	10,720.73	10498.80	10195.95
1.B.	Fugitive Emissions	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	38.27	0.00	56.05	0.00	0.00	0.00	0.00	0.00	0.00
1	Total	30,226.69	31,136.20	31,104.59	31,269.54	32,273.96	33,138.86	34,737.54	35,894.15	38,100.78	39,843.36	41,888.64	44,028.71	42,827.54	42,622.14	43,307.94	45,006.72	44,622.90	44,835.25
											Recalculated Estimates in 2010 Submission (Gg CO_2eq)								
1.A.1.	Energy Industries	11,158.61	11,617.34	12,279.74	12,297.59	12,634.28	13,317.47	14,031.86	14,692.87	15,080.52	15,732.98	16,050.38	17,266.56	16,345.34	15,643.44	15,283.51	15,657.29	14,906.98	14,406.63
1.A.2.	Manuf Ind and Constn	3,940.06	4,040.80	3,736.50	3,948.80	4,199.98	4,300.79	4,133.25	4,511.14	4,529.83	4,740.32	5,564.42	5,508.27	5,230.92	5,238.16	5,621.59	5,713.95	5,597.90	5,845.47
1.A.3.	Transport	5,039.39	5,242.11	5,685.51	5,646.50	5,880.60	6,106.55	7,144.84	7,482.38	8,826.58	9,783.77	10,512.66	11,017.18	11,215.64	11,396.54	12,027.84	12,792.15	13,483.34	14,143.78
1.A.4.	Other Sectors	10,052.73	10,179.97	9,363.69	9,342.70	9,505.48	9,353.20	9,396.55	9,128.37	9,600.49	9,481.33	9,653.55	10,029.60	9,906.01	10,200.37	10,245.76	10,724.73	10,501.67	10,244.92
1.B.	Fugitive Emissions	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	38.27	0.00	56.05	0.00	0.00	0.00	0.00	0.00	0.00
1	Total	30,190.80	31,080.22	31,065.44	31,235.60	32,220.34	33,078.01	34,706.49	35,814.76	38,037.43	39,776.66	41,781.01	43,877.66	42,697.91	42,478.50	43,178.69	44,888.13	44,489.90	44,640.80
											Percentage Change in CO_2 Emissions due to Recalculations								
1.A.1.	Energy Industries	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.2.	Manuf Ind and Constn	-0.75	-1.07	-0.85	-0.73	-1.02	-1.11	-0.54	-1.32	-1.16	-1.21	-1.79	-2.42	-2.32	-2.47	-2.38	-2.10	-2.37	-4.00
1.A.3.	Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.4.	Other Sectors	-0.06	-0.12	-0.07	-0.05	-0.11	-0.13	-0.09	-0.21	-0.10	-0.09	-0.07	-0.15	-0.06	-0.10	0.07	0.04	0.03	0.48
1.B.	Fugitive Emissions	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	Total	-0.12	-0.18	-0.13	-0.11	-0.17	-0.18	-0.09	-0.22	-0.17	-0.17	-0.26	-0.34	-0.30	-0.34	-0.30	-0.26	-0.30	-0.43

Table 3.4. Percentage Change in CH_4 Emissions from Energy due to Recalculations

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
									Estimates in 2009 Submission (Gg CO_2eq)									
1.A.1.ustries	0.86	0.68	0.59	0.60	0.69	0.63	0.63	0.45	0.74	0.72	0.80	1.06	1.34	1.51	1.38	0.97	0.82	0.99
1.A.2. Manuf Ind and Constn	24.74	25.98	15.48	17.52	11.49	13.80	16.27	16.63	15.68	14.81	22.82	27.23	25.69	26.96	29.59	32.52	29.05	31.74
1.A.3. Transport	47.72	49.36	53.22	48.14	46.20	49.92	51.48	49.77	51.11	49.57	45.01	42.86	38.41	35.74	33.39	31.34	29.69	28.15
1.A.4. Other Sectors	94.98	96.88	77.62	76.60	65.84	57.84	63.59	55.71	59.41	49.17	50.69	49.61	47.65	48.87	47.34	49.35	47.85	46.52
1.B. Fugitive Emissions	131.08	127.37	122.81	121.76	117.94	114.18	110.09	105.50	92.09	89.36	85.05	91.70	68.95	626.26	65.95	56.58	101.91	59.70
1 Total	299.38	300.28	269.72	264.63	242.16	236.37	242.07	228.05	219.03	203.64	204.36	212.45	182.04	739.34	177.64	170.76	209.33	167.09
									Recalculated Estimates in 2010 Submission (Gg CO_2eq)									
1.A.1. Energy Industries	5.56	5.57	5.61	6.11	6.17	6.58	7.51	7.80	7.74	8.37	9.19	9.64	9.13	8.56	7.49	7.72	7.31	7.31
1.A.2. Manuf Ind and Constn	5.60	5.65	4.74	5.01	4.85	5.03	5.40	5.49	5.92	6.00	7.04	7.41	7.16	7.07	7.88	9.00	8.59	8.45
1.A.3. Transport	47.69	49.22	53.15	48.15	46.21	49.86	51.45	49.71	51.06	49.56	45.01	42.85	38.39	35.71	33.37	31.35	29.67	28.12
1.A.4. Other Sectors	378.91	370.36	315.51	307.25	272.18	246.42	245.96	216.23	228.74	176.62	176.21	168.42	165.85	157.80	154.94	161.87	157.62	153.84
1.B. Fugitive Emissions	131.08	127.37	122.81	121.76	117.94	114.18	110.09	105.50	92.09	89.36	85.05	91.70	68.95	626.26	65.95	56.58	46.86	59.58
1 Total	568.84	558.18	501.83	488.28	447.34	422.06	420.41	384.72	385.56	329.92	322.50	320.02	289.47	835.41	269.62	266.52	250.05	257.30
									Percentage Change in CH_4 Emissions due to Recalculations									
1.A.1. Energy Industries	544.33	715.95	844.16	914.01	791.20	946.77	1094.40	1638.28	940.45	1057.79	1050.94	807.76	579.33	465.78	444.29	695.56	787.97	641.12
1.A.2. Manuf Ind and Constn	-77.37	-78.24	-69.38	-71.42	-57.80	-63.51	-66.80	-66.98	-62.21	-59.48	-69.16	-72.79	-72.12	-73.75	-73.38	-72.33	-70.42	-73.38
1.A.3. Transport	-0.07	-0.29	-0.13	0.01	0.03	-0.13	-0.07	-0.12	-0.09	-0.02	-0.01	-0.02	-0.06	-0.07	-0.07	0.01	-0.09	-0.11
1.A.4. Other Sectors	298.93	282.27	306.50	301.12	313.40	326.00	286.80	288.15	285.02	259.23	247.66	239.50	248.08	222.88	227.32	228.01	229.41	230.40
1.B. Fugitive Emissions	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-54.02	-0.19
1 Total	90.00	85.88	86.05	84.51	84.73	78.56	73.68	68.70	76.03	62.01	57.81	50.63	59.02	12.99	51.78	56.08	19.45	53.99

Table 3.5. Percentage Change in N_2O Emissions from Energy due to Recalculations

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
		Estimates in 2009 Submission (Gg CO_2eq)																	
1.A.1.	Energy Industries	416.92	454.48	488.72	478.47	502.71	517.46	527.49	553.98	604.57	626.28	596.95	659.20	598.89	525.92	528.87	561.45	519.98	446.07
1.A.2.	Manuf Ind and Constn	113.05	116.23	118.32	121.48	143.75	145.18	131.99	150.20	151.11	161.20	184.27	182.35	172.26	172.21	179.12	182.88	172.57	179.99
1.A.3.	Transport	83.88	85.39	89.79	107.30	123.48	127.84	149.24	172.23	205.35	210.93	225.05	235.14	224.85	219.38	222.08	221.48	215.19	205.48
1.A.4.	Other Sectors	308.66	319.95	283.77	283.10	289.58	284.67	293.64	287.25	300.48	307.57	309.19	321.17	318.76	328.30	326.72	343.38	332.50	322.30
1.B.	Fugitive Emissions	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	Total	922.51	976.05	980.60	990.34	1,059.51	1,075.14	1,102.35	1,163.66	1,261.52	1,305.98	1,315.46	1,397.86	1,314.76	1,245.80	1,256.79	1,309.18	1,240.25	1,153.84
		Recalculated Estimates in 2010 Submission (Gg CO_2eq)																	
1.A.1.	Energy Industries	74.37	76.09	78.28	74.89	76.33	77.35	81.22	81.64	78.98	80.93	80.92	87.99	98.82	109.31	92.34	106.29	112.70	119.86
1.A.2.	Manuf Ind and Constn	12.95	13.08	11.23	11.80	11.84	12.24	12.78	13.21	14.01	14.33	16.72	17.42	16.73	16.58	18.14	20.43	19.16	18.93
1.A.3.	Transport	73.25	75.00	78.59	95.56	110.31	115.62	136.45	158.63	190.97	194.85	208.60	219.68	217.10	211.92	211.19	208.39	206.22	204.20
1.A.4.	Other Sectors	108.10	110.43	106.77	106.64	115.61	126.65	107.72	108.59	109.14	110.99	113.94	115.20	115.33	115.97	112.04	119.58	115.03	109.55
1.B.	Fugitive Emissions	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	Total	268.66	274.61	274.87	288.89	314.09	331.85	338.17	362.06	393.10	401.09	420.17	440.28	447.98	453.78	433.70	454.68	453.13	452.55
		Percentage Change in N_2O Emissions due to Recalculations																	
1.A.1.	Energy Industries	-82.16	-83.26	-83.98	-84.35	-84.82	-85.05	-84.60	-85.26	-86.94	-87.08	-86.44	-86.65	-83.50	-79.22	-82.54	-81.07	-78.33	-73.13
1.A.2.	Manuf Ind and Constn	-88.55	-88.75	-90.51	-90.29	-91.77	-91.57	-90.32	-91.21	-90.73	-91.11	-90.92	-90.45	-90.28	-90.37	-89.87	-88.83	-88.90	-89.48
1.A.3.	Transport	-12.67	-12.17	-12.47	-10.94	-10.66	-9.56	-8.57	-7.90	-7.00	-7.62	-7.31	-6.58	-3.45	-3.40	-4.91	-5.91	-4.17	-0.62
1.A.4.	Other Sectors	-64.98	-65.48	-62.37	-62.33	-60.08	-55.51	-63.31	-62.20	-63.68	-63.92	-63.15	-64.13	-63.82	-64.67	-65.71	-65.18	-65.40	-66.01
1.B.	Fugitive Emissions	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	Total	-70.88	-71.87	-71.97	-70.83	-70.36	-69.13	-69.32	-68.89	-68.84	-69.29	-68.06	-68.50	-65.93	-63.58	-65.49	-65.27	-63.46	-60.78

Chapter Four

Industrial Processes

4.1 Overview of the Industrial Processes Sector

The list of activities under *Industrial Processes* in the IPCC reporting format is given in Table 4.1. Some of these activities are well known sources of one particular greenhouse gas, such as cement production for CO_2 or adipic acid production in the case of N_2O, while others may be more important in terms of their indirect greenhouse gas emissions. Major industrial processes within the chemical sector and metal production that are common to many other developed countries have never been an important part of the Irish economy. Consequently, many of the production processes listed in Table 4.1 are not relevant to the inventories of greenhouse gases in Ireland. The four industrial sources that have been covered in the past, mainly due to their emissions of CO_2, are cement and lime production under *2.A Mineral Products* and ammonia and nitric acid production under *2.B Chemical Industry.* The nitric acid and ammonia plants, both operated by Irish Fertilizer Industries, ceased production in 2002 and 2003, respectively. A small amount of limestone is used to abate SO_2 emissions in peat-fired electricity generating stations and limestone is also used by a number of companies as a raw material and thus 2*.A.3 Limestone and Dolomite Use* is a relevant activity in Ireland. The associated CO_2 emissions from this minor source were included in the annual inventories for the first time in the 2006 submission. *2.A.4. Soda Ash Production and Use* is also a minor source of emissions and is reported in this submission for the full time-series 1990-2008.

The process CO_2 emissions for the relevant source categories under *2.A Mineral Products* are largely covered by Directive 2003/87/EC (EP and CEU, 2003) on emissions trading in the EU and full use is made of this data source for the compilation of the national inventory. In general, the annual verified CO_2 emissions in respect of the installations concerned are used directly for the years covered by the ETS and the category-level emission factors indicated by this information are used together with the best available production data to obtain the emissions estimates for other years.

The *Industrial Processes* source category is the only IPCC Level 1 category for which emissions of HFC, PFC and SF_6 are reported in annual inventories. Both potential and actual emissions of the 21 individual substances concerned (Table A.1, Annex A) should be reported for source category *2.F Consumption of Halocarbons and* SF_6 while actual emissions only are required in other source categories (*2.C Metal Production* and *2.E Production of Halocarbons and* SF_6). The IPCC methods estimate potential emissions by equating emissions to total consumption while actual emissions are the estimated losses to air of the substances concerned. There is no production of halocarbons or SF_6 in Ireland and therefore source category *2.F Consumption of Halocarbons and* SF_6 is the only relevant source category of HFC, PFC and SF_6 emissions in the country. All relevant sub-categories are fully covered in Ireland's inventories (Table 4.1), as described below.

Table 4.2 presents the estimates of greenhouse gas emissions for *Industrial Processes* over the period 1990-2008 for the relevant sources in Ireland. They indicate contributions of 5.8 percent and 4.4 percent to total emissions in 1990 and 2008, respectively. As such, the sector is not a particularly important one in the Irish greenhouse gas inventories. Ammonia and nitric acid production were the principal sources of emissions in the sector in 1990, accounting for over two-thirds of the total, but the plants ceased operation in 2002 and 2003, respectively leaving cement production as the dominant emission source thereafter. The combined contribution of HFC, PFC and SF_6 to the total emissions for *Industrial Processes* remains small and highly variable from year to year. Emissions of HFC show a steady increase up to 2008, largely due to the influence of the air conditioning and refrigeration sub-categories, while the emissions of PFC continue to follow the downward trend post 2000 evident in previous submissions. Emissions of SF_6 remain variable from year to year. The estimates given in Table 4.2 for the period 1990-2008 reflect some reallocation between categories 2.A.3 and 2.A.7, which is further described in the following sections.

Table 4.1 Level 3 Source Category Coverage for Industrial Processes

2. Industrial Processes	**CO_2**	**CH_4**	**N_2O**	**HFC**	**PFC**	**SF_6**
A. Mineral Products						
1. Cement Production	All	NA	NA	NA	NA	NA
2. Lime Production	All	NA	NA	NA	NA	NA
3. Limestone and Dolomite Use	All	NA	NA	NA	NA	NA
4. Soda Ash Production and Use	All	NA	NA	NA	NA	NA
5. Asphalt Roofing	NE	NA	NA	NA	NA	NA
6. Road Paving with Asphalt	NE	NA	NA	NA	NA	NA
7. Other	All	NO	NO	NO	NO	NO
B. Chemical Industry						
1. Ammonia Production*	All	NE	NA	NA	NA	NA
2. Nitric Acid Production*	NA	NA	All	NA	NA	NA
3. Adipic Acid Production	NO	NO	NO	NA	NA	NA
4. Carbide Production	NO	NO	NA	NA	NA	NA
5. Other	NO	NO	NO	NO	NO	NO
C. Metal Production						
1. Iron and Steel Production	NO	NO	NO	NA	NA	NA
2. Ferroalloys Production	NO	NO	NO	NA	NA	NA
3. Aluminium Production	NO	NO	NO	NA	NA	NA
4. SF_6 Use in Aluminium and Magnesium Foundries	NA	NA	NA	NA	NA	NO
5. Other	NO	NO	NO	NO	NO	NO
D. Other Production						
1. Pulp and Paper	NE	NE	NE	NA	NA	NA
2. Food and Drink	NE	NE	NE	NA	NA	NA
E. Production of Halocarbons and SF_6						
1. By-product Emissions	NA	NA	NA	NO	NO	NO
2. Fugitive Emissions	NA	NA	NA	NO	NO	NO
3. Other	NA	NA	NA	NO	NO	NO
F. Consumption of Halocarbons and SF_6						
1. Refrigeration and Air Conditioning Equipment	NA	NA	NA	All	All	All
2. Foam Blowing	NA	NA	NA	All	All	All
3. Fire Extinguishers	NA	NA	NA	All	All	All
4. Aerosols/ Metered Dose Inhalers	NA	NA	NA	All	All	All
5. Solvents	NA	NA	NA	All	All	All
6. Semiconductor Manufacture	NA	NA	NA	All	All	All
7. Electrical Equipment	NA	NA	NA	All	All	All
8. Other	NA	NA	NA	All	All	All
G. Other	NA	NA	NA	NO	NO	NO

All : all emission sources covered; NE : emissions not estimated; NO : activity not occurring; NA : not applicable (emissions of the gas do not occur in the source category); IE : emissions included elsewhere
* ammonia and nitric acid plants closed down in June 2002

Table 4.2. Emissions from Industrial Processes 1990-2008

	2.A.1 Cement Production	2.A.2 Lime Production	2.A.3 Limestone and Dolomite Use	2.A.4 Soda Ash Production	2.A.7 Bricks and Ceramics	2.A.7 Glass Production	Consumption of Halocarbons and SF6			Total Industrial Processes
	Gg CO_2	**Gg CO_2**	**Gg CO_2**	**Gg CO_2**	**Gg CO_2**	**Gg CO_2**	***HFC (Gg $CO_{2\,eq}$)***	***PFC (Gg $CO_{2\,eq}$)***	***SF_6 (Gg $CO_{2\,eq}$)***	***All (Gg $CO_{2\,eq}$)***
1990	884.000	214.077	0.151	0.097	5.075	13.325	0.693	0.093	35.405	3,178.550
1991	782.000	192.228	0.136	0.087	4.883	13.056	5.273	7.622	40.635	2,888.684
1992	753.000	162.395	0.128	0.071	4.787	12.587	6.168	15.151	45.866	2,816.162
1993	729.000	204.893	0.106	0.109	4.498	12.520	9.445	30.209	55.350	2,804.765
1994	859.000	205.428	0.128	0.052	4.787	12.307	19.974	45.266	64.835	3,080.851
1995	879.000	187.506	0.181	0.069	5.459	11.966	44.847	75.382	82.827	3,073.122
1996	983.000	198.237	0.166	0.092	5.267	11.625	76.109	103.085	102.062	3,214.942
1997	1,145.000	221.891	0.242	0.100	6.228	11.465	133.349	130.823	132.100	3,666.770
1998	1,059.000	211.657	0.230	0.106	6.084	11.049	191.948	61.870	94.187	3,507.137
1999	1,166.000	170.074	0.253	0.054	6.372	10.957	198.255	195.933	68.866	3,571.780
2000	1,700.904	190.431	0.179	0.070	6.486	10.714	231.228	305.406	55.807	4,195.973
2001	1,851.190	189.395	4.502	0.089	6.125	10.136	253.052	295.984	69.300	4,305.307
2002	1,859.797	190.314	2.171	0.054	5.912	5.131	278.144	212.403	69.952	3,726.954
2003	2,126.951	206.256	2.378	0.063	6.116	0.553	351.443	228.795	118.179	3,041.032
2004	2,295.081	201.539	3.549	0.081	6.232	0.580	387.314	182.427	66.644	3,143.448
2005	2,357.055	183.477	4.292	0.083	7.407	0.481	436.719	168.340	95.462	3,253.316
2006	2,347.851	180.304	2.640	0.062	7.400	0.487	509.173	148.320	67.456	3,263.693
2007	2,374.056	196.715	2.321	0.056	6.831	0.455	500.494	130.579	68.747	3,280.254
2008	2,106.733	187.796	2.707	0.044	3.997	0.307	520.828	106.197	60.829	2,989.437

4.2 Emissions from Mineral Products (2.A)

The IPCC Level 3 emission source categories relevant under *2.A Mineral Products* in 2008 are *2.A.1 Cement Production, 2.A.2 Lime Production, 2.A.3 Limestone and Dolomite Use, 2.A.4 Soda Ash Production and Use* as well as the production of glass and bricks and ceramics under *2.A.7 Other Mineral Products*. Total CO_2 emissions from these activities amounted to 2,301.58 Gg, in 2008 of which cement production accounted for 91.5 percent.

4.2.1 Cement Production (2.A.1)

During the cement manufacturing process, calcium carbonate in the cement kiln feed (typically $CaCO_3$ in limestone) undergoes calcination at high temperature to produce lime (CaO) and CO_2. The activated lime that results from this process combines with silica in the kiln feed to form cement clinker. The emissions of CO_2 are usually calculated from the amount of clinker produced and the stoichiometric ratio of CO_2 to CaO. A small amount of raw material may be converted into cement kiln dust (CKD) due to incomplete calcination. If the CKD is not recycled as part of subsequent kiln input, the CO_2 emissions based on clinker production must be corrected to account for the carbonate fraction lost in CKD.

Up until the year 2000, one company operated two cement plants in Ireland. A second company opened a new cement plant in 2000 and a third cement producer entered the market in 2003, bringing the total number of plants to four. In 2004, plant-specific information relating to CO_2 emissions in 2002 and 2003 was obtained by the EPA for all cement plants for the development of Ireland's First National Allocation Plan (NAP1) under Directive 2003/87/EC (EP and CEU, 2003) on emissions trading in the EU. The reported process CO_2 emissions for each plant in 2002 and 2003 were calculated using the Tier 2 method according to the guidelines for the monitoring and reporting of greenhouse gas emissions in Decision 2004/156/EC that supports Directive 2003/87/EC. This method is fully consistent with the Tier 2 method in the IPCC good practice guidance and its application employs reliable data on clinker production, corrected as appropriate for CKD, and CaO content of the clinker.

As the EU ETS subsequently became operational, plant specific CO_2 emissions and corresponding clinker production data are also available for all cement plants for the years 2004 through 2008 and these data are used directly to report emissions for category 2.A.1 in Ireland. The annual results incorporate verification of fuel use, limestone use, combustion and process CO_2 estimates in accordance with Decision 2004/156/EC. Total process emissions for cement production in 2008 were 2,106.73 Gg CO_2. The plant-specific emission factors for process CO_2 emissions in 2008 ranged from 0.522 to 0.544 t CO_2/ t clinker with an average of 0.534 t CO_2/ t clinker, which is very similar to the 2007 values.

For the two original cement plants that were operated by the single cement producer, the company concerned supplied estimates of process emissions for the years 1990-2001 that it had calculated internally in line with the specific information provided for the years 2002 and 2003 and used for NAP1. The associated values of annual clinker production were not provided. For the purposes of complete and consistent reporting, the inventory agency estimated annual clinker production for the years 1990-2001 based on the plant specific process emission factors available for the two plants for the years from 2002 onwards. This is appropriate, as the company has always used the same local on-site supply of limestone, and the time-series of process CO_2 emissions for cement production overall may therefore be considered consistent for the period 1990-2008. The revised estimates for category 2.A.1 were included in the 2006 submission and no further recalculations have been made since the EU ETS data were adopted as the best available for inventory purposes.

4.2.2 Lime Production (2.A.2)

Statistical data on lime production in Ireland are obtained annually from the lime manufacturers (three companies up to 1998 and two companies thereafter). As in the case of cement production, lime producers provided their own estimates of CO_2 emissions from lime manufacture for the development of NAP1 under Directive 2003/87/EC on ETS. These were calculated in accordance with the methods described in the supporting Decision 2004/156/EC, thus providing detailed information on emission estimates and activity data for another important source of CO_2 emissions in *Industrial Processes*. The CO_2 estimates for lime production in 2008 have been obtained from the ETS returns to the Climate Change Unit of the EPA as for other recent years covered by the scheme and these have been used to confirm the estimates for previous years of the time-series, as given in Table 4.2. The implied emission factor for aggregated lime production was 0.77 t CO_2/t lime in 2008, which is very similar to that for the other years for which ETS data are available. The implied emission factors for the 1990-2004 time-series indicated by the information supplied by the lime producers are in the range 0.75 to 0.88 t CO_2/t lime produced with an average of 0.82 t CO_2/t lime.

4.2.3 Limestone and Dolomite Use (2.A.3)

The CO_2 emissions reported under this category refer to those emissions associated with the use of limestone for flue gas desulphurisation, and since 2006, limestone used by a single tile manufacturer. In previous submissions, CO_2 emissions from limestone used in the manufacture of bricks and ceramics was included under category 2.A.3 but these emissions are now reported under category *2.A.7 Other Mineral Products.* Limestone has been used to capture the sulphur emitted from peat burning in one electricity generating station since 2001 and in a second such plant since 2007. The CO_2 emissions estimates are taken from ETS returns. They are estimated on the basis of limestone quantity used by the companies and an emission factor of 0.44 t CO_2/t limestone, which is the stoichiometric ratio of CO_2 to $CaCO_3$. A further minor use of limestone relevant to *2.A.3 Limestone and Dolomite Use* in Ireland is its application in the purification of sugar produced from sugar beet. However, sugar production ceased in 2006 and the only information on emissions is that obtained under ETS in respect of 2005.

4.2.4 Soda Ash Production and Use (2.A.4)

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. The emissions associated with soda ash use by one company in Ireland are reported by the company under ETS for the years 2005-2008 and have been used directly in the inventory. For the 2010 submission, activity data were sourced by the inventory agency from the company to enable the reporting of a full time-series of emission estimates for the period 1990-2008 using the emission factor of 0.41 t CO_2/t soda ash indicated by the ETS data.

4.2.5 Other Mineral Products (2.A.7)

The emissions of CO_2 from glass production as well as the emissions arising from the use of clays and shale as a raw material in the manufacture of bricks and ceramics are reported under this CRF category. Previously the process emissions from the manufacture of bricks and ceramics were reported under *2.A.3 Limestone and Dolomite Use* while glass production was not treated separately. Similar to other categories under *2.A,* information from individual plants that are participants in the Emissions Trading Scheme is utilised to report the emissions estimates in the national inventory.

In the case of bricks and ceramics, the ETS data for the four companies concerned provide estimates of emissions for the years 2005-2008 along with the corresponding quantities of carbonate input materials and the relevant emission factors. The emission factors for clay bricks and flue liners are in the range 0.44 to 0.48 tonne CO_2/tonne carbonate input while the emission factor for ceramic tiles averages 0.6 tonne CO_2/tonne carbonate input. The emissions for the years prior to ETS are calculated from the companies' estimates of material use and their respective average ETS emission factors.

Glass production is treated as a separate sub-category under 2.A.7 for the first time in the 2008 national inventory and a full time-series of CO_2 emissions has been developed for this submission. The production of bottle glass has been the major source of emissions up to the closure of the plant in 2002. The CO_2 emissions are estimated from the annual production quantities obtained from the company for the development of annual inventories for heavy metals. Equation 2.11 of the 2006 IPCC guidelines and the emission factor of 0.21 kg/CO_2/kg glass are used. Allowance is made for recycled glass, which is assumed to be 5 percent in 1990, increasing to 30 percent in 2002 when the plant closed. In the case of crystal glass, the CO_2 emissions are based on the use of soda ash as reported under ETS, using the emission factor of 0.415 t CO2/t Na_2CO_3, provided by the ETS monitoring and reporting guidelines. The company concerned has supplied estimates for all years 1990-2008. Emissions from the production of glass-based insulation materials is also based largely on soda ash use although small amounts of dolomite and limestone were also used up to 2005. The CO_2 emissions from glass production amounted to 13.3 kt in 1990. This has reduced to 0.3 kt in 2008, due to the closure of the bottle-glass production facility in 2002 and much reduced activity in the other glass industries.

4.3 Emissions from Chemical Industry (2.B)

Emissions of CO_2 and N_2O from ammonia (2.B.1) and nitric acid production (2.B.2) are reported under *2.B Chemical Industry.* Ammonia and nitric acid production in Ireland was undertaken by two plants, both of which were operated by Irish Fertilizer Industries for the production of nitrogenous fertilizers. However, during 1999 and 2000 the major fertilizer manufacturers introduced severe rationalisation and restructuring measures, which resulted in the closure of the nitric acid and ammonia plants in 2002 and 2003, respectively. Fertilizer manufacture in Ireland no longer takes place and all fertilizers are either imported as a finished product or undergo further blending only in Ireland.

4.3.1 Ammonia Production (2.B.1)

Ammonia is the basis of all nitrogen fertilizers and is normally manufactured by synthesis of nitrogen and hydrogen, with natural gas as the basic raw material. Utilising the Haber Bosch process, natural gas, air and water were reacted to produce ammonia in liquid form and CO_2 as a by-product. Urea was one of the main end products of the plant, which was formed when the ammonia produced and the CO_2 by-product reacted together to form prills (small particles) of urea. The other main product, liquid ammonia, was stored and transported to Irish Fertilizer Industries other plant where it underwent further processing (discussed in section 4.3.2 Nitric Acid Production below). Carbon dioxide emissions from ammonia production are estimated from the natural gas feedstocks to the plant as indicated in the national energy balance provided by SEI. In accordance with the 1996 IPCC guidelines, it is assumed that no feedstock carbon is sequestered in urea and the emission factor is 54.94 kg CO_2/TJ, the value for indigenous natural gas, which equates to 2.3 tonne CO_2/tonne natural gas. The CO_2 emissions from ammonia production were 990.23 kt in 1990.

4.3.2 Nitric Acid Production (2.B.2)

Nitric acid is used as raw material mainly in the manufacture of nitrogenous-based fertilizer. It may also be used in the production of adipic acid and explosives, for metal etching and in the processing of ferrous metals. Nitric acid production in Ireland ceased in 2002 due to the liquidation of Irish Fertilizer Industries. Ammonia transported from Irish Fertilizer Industries urea production plant (section 4.3.1) to the ammonium nitrate production plant was oxidised over a catalyst to form nitric acid. The nitric acid was then combined with more ammonia to produce ammonium nitrate which, when solidified into granules or made into bead-like prills, is applied to land using a fertilizer spreader. Other fertilizer blends were also manufactured at the plant. For the years 1990-1995, the inventory agency received direct correspondence from the plant operator specifying the quantities of nitric acid produced and the company's estimates of N_2O emitted during the production process. Four units at this plant produced 338,000 tonnes of nitric acid in 1990 with associated N_2O emissions of 3,340 tonnes. The emissions were estimated from nitrogen loading and the type of catalyst used in the process.

4.4 Emissions of HFC, PFC and SF_6 from Industrial Processes (2.F)

4.4.1 Special Studies

The compilation of emission estimates for fluorinated gases presents major challenges for inventory agencies because they emanate from diverse sources that are entirely different to those traditionally covered by atmospheric emissions inventories and the uses of many of the substances concerned are continuing to change very rapidly in the marketplace. Issues of confidentiality are common among many of the source activities concerned and this also hinders the inventory process and the transparency of reporting in relation to fluorinated gases (f-gases). The first attempts to quantify emissions of HFC, PFC and SF_6 in Ireland were made for the year 1995 for inclusion in Ireland's Second National Communication published in 1997 (DOE, 1997). Little was known at that time about the sources of these emissions and the methodologies to quantify them were not well established. The results for 1995 were therefore regarded as tentative and incomplete. However, the indications were that, in common with emissions from industrial processes in general in Ireland, those of HFC, PFC and SF_6 were likely to be rather small.

In 2000, the EPA commissioned special studies on HFC, PFC and SF_6 emissions, led by the Clean Technology Centre (CTC) at Cork Institute of Technology that were designed to identify the important sources in Ireland and to quantify the emissions in 1998 on the basis of separate bottom-up and top-down methodologies. The reports on these studies (O'Doherty and McCulloch, 2002 and O'Leary *et al*, 2002) describe a very comprehensive investigation into the emissions of fluorinated gases in Ireland and the bottom-up method provided a readily applicable approach that could be used for developing inventories of these gases for other years.

The methodological approach adopted in the special study for 1998 was subsequently used in early 2002, again under contract with CTC (O'Leary, 2002), to compile emissions estimates for HFC, PFC and SF_6 for the time-series 1995 through 2000, which were incorporated in the recalculated inventories submitted in 2002. Estimates were also compiled to the extent possible at that time for 1990, but data were difficult to obtain and it was clear that the use of many of the substances had not become established in the country by then. The focus in this particular follow-up study was on the years from 1995 to 2000, in the knowledge that 1995 could be selected as the base year for emissions of fluorinated gases. The inventory agency subsequently continued reporting for the years up to 2003, based broadly on the CTC approach used for the 1995-2000 time-series.

As part of the work on the 2004 inventory and the general round of improvements conducted for the 2006 submission, the inventory agency decided that it would be useful to again examine, on a contract basis, the known sources of HFC, PFC and SF_6 emissions over an extended time period. The contract was undertaken jointly by CTC and UK consultants NETCEN, the latter having considerable experience in developing emission inventories for the UK. The work and results are fully described in a supplementary document (Adams *et al*, 2005). The intention was to re-assess the use and application of the various substances in the Irish market as a whole, initially to compile the best possible estimates of emissions in 2004, and to make revisions as appropriate for earlier years based on better information, particularly for 1995 (the base year adopted by Ireland with respect to HFC, PFC and SF_6) and for those years (2001-2003) for which the estimates had been produced by the inventory agency. A second objective of the study was to extend the F-gas emissions time-series back to 1990 so that Ireland could make available information that had been lacking for the years 1990-2004, requested under Decision 280/2004/EC, to enable the European Union to complete the inventories at the European level for all years. In performing this update of the previous emission inventories for fluorinated gases, a number of users and distributors of the fluids were contacted and any data obtained were used for estimating emissions of the various gases for the period 2001-2004. Where data allowed, emission estimates were calculated following the guidance for individual sub-categories provided by IPCC good practice guidance. The approach developed by Adams *et* al. (2005) is used for this submission with some minor recalculations due to the availability of new data. Recalculations for HFCs, PFCs and SF_6 are discussed in section 4.6.

Emission estimates for 1990-2008 are shown in Table 4.3. They clearly indicate that the combined emissions of HFC, PFC and SF_6 have generally increased year on year. This trend largely reflects the increasing use of HFCs across a range of applications (e.g. often as replacements in applications where the use of CFC and HCFCs is no longer permitted under the Montreal Protocol) and hence the presence of larger fluid banks from which operational leakage potentially occurs. In contrast, PFC emissions have decreased while emissions of SF_6 fluctuate significantly. This trend is determined principally by their use in the manufacture of semiconductors, for which the reported emissions received directly from manufacturing companies in Ireland show annual fluctuations reflecting changing manufacturing activity in response to the global trends in this market. For the years 1999-2008, this sub-category produced much higher combined emissions of HFC, PFC and SF_6 than any other (in terms of CO_2 equivalent emissions), accounting for half of the annual emissions in these years.

4.4.2 HFC, PFC and SF_6 Time-Series 1990-2008

In the following sections a brief description is provided for the activities for which emissions of HFCs. PFCs and SF_6 are estimated for the time-series 1990-2008. Additional information is provided in O'Doherty and McCulloch (2002), O'Leary *et al.* (2002) and Adams *et al.* (2005). The CRF sectors *2C Metal Production, 2E Production of Halocarbons and SF_6, 2.F.5 Solvents* and *2.F.6 Other applications using ODS substitutes* are not applicable to Ireland therefore the relevant notation keys are used in respect of F-gases in these categories in the CRF.

4.4.2.1 Refrigeration and Air Conditioning (2.F.1)

HFC's and HFC blends have been widely used as replacement refrigerants for CFC and HCFC refrigerants across virtually all refrigeration sub-sectors (i.e. domestic refrigeration, small commercial distribution systems, industrial systems, building air conditioning systems and refrigerated transport). In terms of stationary refrigeration data on the quantities of industrial gases supplied to the refrigeration sector is obtained from chemical suppliers and manufacturers of refrigeration units. Sales data is provided for a range of HFCs and blends corresponding to the individual HFC species HFC-23, HFC-32, HFC-125, HFC-134a, HFC-143a and HFC-152a. Potential emissions from the sector are calculated using a Tier 1 approach as follows:

Potential emissions = production + import – export – destruction

As there is no manufacture of fluorinated gases in Ireland, the production term above is zero. Imported HFCs are calculated using the data supplied as described above. Exports are calculated on the basis of refrigeration unit manufacturers share of exports. In Ireland there is no known destruction of HFCs. Recovered gas is used either in other equipment or exported for recycling or destruction.

A bottom-up approach is not feasible for estimating actual emissions from stationary refrigeration and air conditioning in Ireland due to the lack of data available on equipment types and HFC sales data into equipment sub-categories. Therefore emissions are estimated using a top-down approach based on reported sales data and information on market shares, which are applied to calculate estimates of total HFC sales into the Irish stationary refrigeration and air-conditioning sectors. As a result, emissions arising from sub-sectors *2.IIA.F.1.1 Domestic Refrigeration, 2.IIA.F.1.3 Transport Refrigeration, 2.IIA.F.1.4 Industrial Refrigeration* and *2.IIA.F.1.5 Stationary Air-Conditioning* are reported under *2.IIA.F.1.2 Commercial Refrigeration*.

Emissions of HFCs from sub-category *2.IIA.F.1.6 Mobile Air-Conditioning* are estimated using a Tier 3b bottom-up analysis which utilises national vehicle fleet statistics from the Department of the Environment, Heritage and Local Government and assumed rates of air-conditioning unit penetration in the national vehicle fleet. The methodology used takes account of vehicle lifetime, the percentage of vehicles having HFC in their air-conditioning systems, average charge per unit, product manufacturing emissions, effective lifetime leakage rates (incorporating emissions from normal operating losses and accidental releases arising from collision damage) and decommissioning losses.

4.4.2.2 Foam Blowing (2.F.2)

There are two forms of foam blowing included in this sector, open-cell foam and closed-cell foam. Only closed-cell blowing is of importance in Ireland. Closed-cell foams are imported into Ireland for use in applications including packaging and furniture manufacture. Some of the products include refrigerators (insulation), insulated trucks, other insulation materials, cars, mattresses and toys as well as some packaging and cushioning foams on products. However, not all such foam has necessarily been blown with HFCs. The diverse range of products that could potentially contain HFCs makes it extremely difficult to obtain detailed reliable information for reliable emission estimates. This is acknowledged by the IPCC Good Practice Guidance, in which it is stated that where emissions occur only from imported closed-cell foam, expert judgement or international HFC/PFC production and consumption data sets can be used to develop national emission estimates. Therefore in the estimation of emissions from this category the inventory agency utilises the global sales data for closed-cell foam blowing applications from the Alternative Fluorocarbon Environmental Assessment Study (AFEAS). The HFCs for which emission estimates are made are HFC-134a, HFC-125 and HFC-143a.

The bank of HFCs present in closed-cell foam and foam products in Ireland is estimated based on Irish GDP relative to the GDP of all OECD countries. A default emission factor of 4.5 per cent of the original HFC charged per year (IPCC, 2000) is used to calculate in-life emissions. Product lifetime is estimated at 20 years, however as HFCs have only been in use since 1991 for foam blowing applications, it is assumed that there are no losses from decommissioning. Currently there is no specific destruction of HFCs from foam carried out in Ireland, and any goods containing HFC foams collected at local authority facilities are exported for gas recovery.

4.4.2.3 Fire Extinguishers (2.F.3)

HFCs are used as a partial substitute for halon in fixed fire protection systems. They are most commonly used in fixed flooding systems in the protection of electronic and telecommunications equipment, in military applications, records offices, bank vaults and oil production facilities. There are a number of companies operating these systems in Ireland. The primary HFC used is HFC-227ea with a minor quantity of HFC-23 also utilised. The majority of emissions occur when fire protection systems are triggered either accidentally or due to the occurrence of a fire. Smaller emissions occur during maintenance and filling.

Activity data on the use of HFCs in this sector have been provided by the industry and it is assumed that 97.5 percent of product is HFC-227ea and the remainder is HFC-23. Estimates of annual growth factors based on a value of 12.5 percent from 2000 are used to calculate the quantity of these HFCs in new systems. The emission calculation methodology used for this category is a Tier 3a emission model. The model uses three emission factors for actual emissions to describe the three stages where emissions may occur. The first of these stages is product manufacturing (0.005), which covers losses during the manufacture, storage, transport and installation of the end product. The second stage factor (0.01) covers lifetime emissions, combining operational and accidental releases, and the third stage factor (0.01) covers the disposal of the product due to decommissioning. Potential emissions account for the total available product.

4.4.2.4 Aerosols and Metered Dose Inhalers (2.F.4)

For the purposes of estimating emissions Aerosols and Metered Dose Inhalers are treated separately in the inventory calculations. The category aerosols is one which covers a large number of products. In general there are four major sub-categories; personal-care products (e.g. deodorant, hair care and shaving foams), household products (e.g. air fresheners, furniture polish and oven and fabric cleaners), industrial products (e.g. cleaning sprays, pipe freezers and lubricants) and other general products (e.g. klaxons, tyre inflators and silly string). The two HFCs of interest are HFC-134a with 90 percent of the share and HFC-152a with 10 percent. There is no trade association for aerosol manufacturers or importers in Ireland. As a result little information exists in relation to the Irish market for these products. Following consultations with the British Trade Association (BAMA), O'Leary *et al*. (2002) recommended the use of a population based proxy to estimate Irish emissions from those for the UK, which are based on trade data, on the assumption that the market for aerosols would be similar in Ireland. Emissions of HFC-134a and HFC-152a from aerosols are therefore derived using the UK estimates for lifetime and decommissioning emissions (as used in the UK national GHG inventory) and the ratio of the Irish population (CSO) to the UK population (Office of National Statistics, UK) in each year. The estimate for potential emissions is calculated using the UK trade data and the population ratio.

Emission estimates for Metered Dose Inhalers (MDI) are made on the basis of data received from industry. The HFCs used in MDI's in Ireland are HFC134a and HFC-227. Process losses are based on an analysis of gross stock minus closing stock and usage data of the gases. The MDI market in Ireland is supplied by both Irish manufactured products and imported products. Total emissions are calculated based on reported manufacturing losses in conjunction with in-life emissions. An emission factor of 50 per cent per annum is used to estimate in-life emissions from MDIs, which is consistent with good practice guidance for the category.

4.4.2.5 Semiconductor Manufacture (2.F.7)

The semiconductor industry uses HFCs, PFCs and SF_6 in manufacturing processes. Both HFCs and PFCs are used in the cleaning of chambers used for chemical vapour deposition processes, dry plasma etching, vapour phase soldering and vapour phase blanketing, leak testing of hermetically sealed components and as coolants. Cleaning and etching during semiconductor manufacture account for the majority of emissions from the category. In addition SF_6 is used in the etching processes. There are two main semiconductor manufacturers in Ireland, both of which provide data on the annual use and estimated emissions of HFCs, PFCs and SF_6 in their plants over the full time series 1990-2008.

4.4.2.6 Electrical Equipment (2.F.8)

SF_6 is used for electrical insulation, arc quenching, and for current interruption in equipment used in the transmission and distribution of electricity. The Electricity Supply Board (ESB) is the owner of both the high and low voltage distribution systems and the owner and operator of the medium and lower voltage distribution systems in Ireland. The company has supplied an estimate of SF_6 emissions from their equipment using a Tier 1 approach based on an analysis of opening and closing stocks of SF_6.

4.4.2.7 Other Emission Sources (2.F.9)

This category includes emissions of SF_6 from minor uses within Ireland including emissions from double glazed windows, medical applications, sporting goods and as a gas-air tracer in leak detection. SF_6 was previously used as an insulation gas in double-glazing, however its use has been phased out in response to regulations on F gases and is assumed not to have occurred since 2000. Typically windows are manufactured using air or inert gases such as argon between double-glazing layers. Emission estimations account for opening and closing stock of the gas, assembly losses for Irish manufactured products, stocks in imported windows and leakage once installed. Even though the use of SF_6 was discontinued in window insulation after 2000, the bank of gas in installed units is an emission source and is therefore accounted for in emission estimates.

SF_6 is used in certain medical application such as eye surgery where it is used to seal retinal holes internally and to hold reattached retina in place. Use of the gas is small with one hospital reporting the use of one 10-litre cylinder every three years. Based on this data, it is assumed that a similar quantity is used in a total of 10 hospitals, which undertake similar procedures.

SF_6 is used as a cushioning agent in sports shoes. The use of SF_6 in this type of application is due to its chemically and biologically inert properties and its high molecular weight which means that it does not diffuse across membranes. Thus the gas is not released until the sports shoe is destroyed at the end of its useful life. As there is no specific information available in relation to the use of SF_6 in sports goods in Ireland, a population-proxy is used to estimate emissions based on UK inventory data for the release of SF_6 upon disposal of sporting goods, as the market share of such products is assumed to be similar to that in the UK. Emissions are therefore derived using the annual UK per capita sales for sporting goods and the Irish population in each year. The use of SF_6 in sporting goods was discontinued in 2007, however emissions from their disposal will continue based on an average lifetime of eight years.

The remaining minor uses of SF_6 in Ireland are as a tracer gas for leak detection in the testing of seals on cans containing tennis balls and as a tracer gas for agricultural research to determine the rates of CH_4 emissions from enteric fermentation in cattle. The latter source is considered negligible in an Irish context. The use of SF_6 in leak detection was previously a relatively large source in the period 1990-2004. However the company who used SF_6 for the purpose of leak detection has since ceased trading and this sub category is no longer a source of emissions of SF_6 in the Irish inventory.

4.5 Uncertainties and Time-Series Consistency

As part of the work undertaken by Adams *et al*. (2005) uncertainty analysis was performed for the aggregated emissions derived from a specific consideration of the individual sector uncertainty estimates. An iterative Monte Carlo simulation procedure was used to estimate uncertainties in total and aggregated HFC, PFC and SF_6 emissions. The use of Monte Carlo Simulation complies with IPCC Good Practice Tier 2 approaches to uncertainty estimation.

Emission estimates are made using the same methodology and data sources for each year of the time series 1995-2008 and are therefore consistent over this period. Estimates of F gases emissions pre 1995 are in some cases made using alternative techniques such as interpolation between years for which data is available. This approach is used in particular for the sectors *2.F.1 Refrigeration and air conditioning* and *2.F.8 Electrical Equipment* for which do activity data is available for the years 1991-1994 inclusive.

As the emission estimates for sectors *2.A.1, 2.A.2, 2.A.3, 2.A.4* and *2.A.7* are estimated from individual plant data, which are subject to verification under Directive 2003/87/EC, their validity is fully established in the context of the companies' documented methods and data and the associated guidance on emissions estimation methods provided by Decision 2004/156/EC (CEC, 2004). Such verification allows for accurate accounting of combustion emissions and process emissions separately.

4.6 Recalculations for *Industrial Processes*

Only a number of relatively minor recalculations have been undertaken in the industrial processes sector for this reporting period when compared to emission estimates reported in the 2009 NIR and are quantified in Table 4.4. These minor recalculations are as follows;

(a). Minor revision to activity data in 2.A.3 Limestone and Dolomite Use for all years from 1990-1999;

(b). Reallocation of process CO_2 emissions from Soda Ash use (in Glass production facilities) previously reported in 2.A.4 to sub category 2.A.7.1 Glass production;

(c). Estimates of process CO_2 emissions from 2.A.7.1 Glass Production provided for the first time for all years from 1990-2008;

(d). Minor revision to process CO_2 emission factor in sub category 2.A.7 Bricks and Tiles for all years from 1990-2004.

Minor recalculations were undertaken in relation to HFC use in *2.IIA.F.1.6 Mobile Air-Conditioning* and *2.IIA.F.1.3 Transport Refrigeration.* With respect to *2.IIA.F.1.6 Mobile Air-Conditioning* the recalculation undertaken was due to the inclusion of decommissioning losses from end of life vehicles which had heretofore not been estimated. In the irish inventory a default vehicle lifetime of 12 years is assumed. The use of HFCs in MAC units was first introduced in 1993 therefore decommissioning losses only occur from 2005 onwards. This source of emissions was previously inadvertently omitted and is now included for the years 2005, 2006, 2007 and 2008. The net effect of this recalculation is an increase in emissions from this source of 1.2 Gg, 1.5 Gg, and 2.0 Gg CO_2 equivalent, respectively for 2005, 2006 and 2007. The inclusion of previously unreported manufacturing loss data by one of the installations that provide data for inclusion in *2.IIA.F.1.3 Transport Refrigeration* results in a net increase in emissions from this source of 1.1 Gg CO_2 equivalent in 1997 (first year for which the recalculation comes into effect) to 2.9 Gg CO_2 equivalent in 2007.

4.7 Improvements in *Industrial Processes*

The inventory agency will continue to use verified CO_2 emissions estimates that are reported under the EU emissions trading scheme as the most reliable data for emission sources within category *2.A*. The agency also plans to continue the practice of outsourcing contracts on a periodic basis to re-examine and extend the inventory time-series for emissions of F-gases. This approach has been found to be an efficient way of compiling the estimates for sources and gases that the inventory experts in the EPA have not worked on in detail in the past.

Table 4.3. Emissions of HFC, PFC and SF_6 from Industrial Processes 1990-2008 (Gg CO_2 eq)

IPCC Source Category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
HFCs																			
2.F.1 Refrigeration and Air-Conditioning	NO	3.322	3.512	3.690	3.984	4.481	7.145	21.581	42.377	49.256	52.645	49.094	64.505	112.523	135.164	153.045	196.885	175.357	172.363
2.F.1 Mobile Air Conditioning	NO	NO	NO	1.222	5.068	10.141	16.357	25.077	38.230	54.119	70.461	83.365	96.376	110.148	126.120	147.185	168.510	190.197	206.122
2.F.2 Foams	NO	NO	0.016	0.063	0.303	0.644	1.107	1.779	3.619	5.222	6.275	9.211	11.499	13.636	17.008	19.559	21.744	23.560	24.980
2.F.3 Fire-extinguishers	0.219	0.700	1.179	1.677	2.235	2.839	3.496	4.210	4.988	5.834	6.755	7.806	9.026	10.385	11.915	13.636	15.571	17.749	20.199
2.F.4 Aerosols	0.006	0.648	0.721	1.782	7.101	24.917	45.049	76.010	98.777	73.351	80.027	86.350	77.862	83.896	77.341	79.331	81.666	83.876	85.764
2.F.4 Metered Dose Inhalers	NO	NO	NO	NO	NO	NO	0.020	0.059	0.081	1.053	2.686	14.126	16.992	18.211	18.409	21.738	21.638	6.361	7.773
2.F.7 Semiconductor manufacture	0.468	0.604	0.739	1.011	1.282	1.825	2.937	4.633	3.877	9.418	12.379	3.101	1.884	2.644	1.357	2.225	3.159	3.393	3.627
TOTAL HFC	**0.693**	**5.273**	**6.168**	**9.445**	**19.974**	**44.847**	**76.109**	**133.349**	**191.948**	**198.255**	**231.228**	**253.052**	**278.144**	**351.443**	**387.314**	**436.719**	**509.173**	**500.494**	**520.828**
PFCs																			
2.F.7 Semiconductor manufacture	0.093	7.622	15.151	30.209	45.266	75.382	103.085	130.823	61.870	195.933	305.406	295.984	212.403	228.795	182.427	168.340	148.320	130.579	106.197
TOTAL PFC	**0.093**	**7.622**	**15.151**	**30.209**	**45.266**	**75.382**	**103.085**	**130.823**	**61.870**	**195.933**	**305.406**	**295.984**	**212.403**	**228.795**	**182.427**	**168.340**	**148.320**	**130.579**	**106.197**
SF_6																			
2.F.7 Semiconductor manufacture	0.478	4.732	8.986	17.495	26.003	43.020	62.140	81.260	52.580	16.730	31.070	20.435	28.584	59.917	32.647	65.554	27.516	30.199	41.139
2.F.8 Electrical equipment	21.510	22.466	23.422	24.378	25.334	26.290	26.386	37.284	25.238	34.990	7.787	32.050	22.786	38.446	21.553	23.518	28.106	29.827	10.898
2.F.9 Other - window soundproofing	0.431	0.451	0.472	0.492	0.512	0.532	0.551	0.570	0.590	0.465	0.333	0.195	0.193	0.191	0.189	0.187	0.185	0.183	0.181
2.F.9 Other - medical applications	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797	0.797
2.F.9 Other - sporting goods	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.793	3.695	3.632	3.635	5.403	6.640	5.364	5.407	10.852	7.741	7.813
2.F.9 Other - gas-air tracers	12.189	12.189	12.189	12.189	12.189	12.189	12.189	12.189	12.189	12.189	12.189	12.189	12.189	12.189	6.095	0.000	0.000	0.000	0.000
TOTAL SF_6	**35.405**	**40.635**	**45.866**	**55.350**	**64.835**	**82.827**	**102.062**	**132.100**	**94.187**	**68.866**	**55.807**	**69.300**	**69.952**	**118.179**	**66.644**	**95.462**	**67.456**	**68.747**	**60.829**
TOTAL HFCs, PFCs and SF_6	**36.191**	**53.531**	**67.184**	**95.004**	**130.075**	**203.056**	**281.256**	**396.273**	**348.006**	**463.053**	**592.441**	**618.336**	**560.499**	**698.417**	**636.386**	**700.521**	**724.949**	**699.820**	**687.854**

Table 4.4. Percentage Change in Total Emissions from Industrial Processes due to Recalculations 1990-2007

			1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
											Estimates in 2009 Submission (Gg CO_2eq)									
2.A.1	Cement Production	CO_2	884.00	782.00	753.00	729.00	859.00	879.00	983.00	1,145.00	1,059.00	1,166.00	1,700.90	1,851.19	1,859.80	2,126.95	2,295.08	2,357.06	2347.85	2374.06
2.A.2	Lime Production	CO_2	214.08	192.23	162.40	204.89	205.43	187.51	198.24	221.89	211.66	170.07	190.43	189.40	190.31	206.26	201.54	183.48	180.30	196.71
2.A.3	Limestone and Dolomite Use	CO_2	0.11	0.10	0.09	0.07	0.09	0.13	0.12	0.17	0.16	0.18	0.18	4.50	2.17	2.38	3.56	4.29	2.64	2.32
2.A.4	Soda Ash Production and Use	CO_2	0.42	0.41	0.39	0.43	0.37	0.39	0.41	0.42	0.25	0.30	0.55	0.54	0.41	0.33	0.35	0.35	0.37	0.36
2.A.7	Bricks and Tiles	CO_2	5.14	4.94	4.84	4.54	4.84	5.54	5.34	6.34	6.19	6.49	6.66	6.30	6.04	6.24	6.36	7.41	7.40	6.83
2.A.7	Glass Production	CO_2	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.B.1	Ammonia Production	CO_2	990.23	1,030.32	1,003.56	946.19	1,056.63	973.44	922.85	1,073.12	1,058.81	942.82	882.12	1,040.28	810.28	0.30	NO	NO	NO	NO
2.B.2	Nitric Acid Production	N_2O	1,035.40	812.45	812.45	812.45	812.45	812.45	812.45	812.45	812.20	812.20	812.45	584.35	292.18	NO	NO	NO	NO	NO
2.F.7	Consumption of Halocarbons and SF6	HFCs	0.69	5.27	6.17	9.44	19.97	44.85	76.11	132.28	190.71	197.13	230.22	251.49	276.52	349.98	386.44	435.06	506.96	497.62
2.F.7	Consumption of Halocarbons and SF6	PFCs	0.09	7.62	15.15	30.21	45.27	75.38	103.09	130.82	61.87	195.93	305.41	295.98	212.40	228.79	182.43	168.34	148.32	130.58
2.F.7	Consumption of Halocarbons and SF6	SF_6	35.40	40.64	45.87	55.35	64.83	82.83	102.06	132.10	94.28	69.01	55.96	69.49	70.31	118.69	67.09	95.96	68.60	73.20
2	Total		3,165.57	2,875.97	2,803.91	2,792.58	3,068.88	3,061.50	3,203.66	3,654.60	3,495.13	3,560.13	4,184.88	4,293.51	3,720.42	3,039.91	3,142.84	3,251.94	3,262.44	3,281.68
											Recalculated Estimates in 2010 Submission (Gg CO_2eq)									
2.A.1	Cement Production	CO_2	884.00	782.00	753.00	729.00	859.00	879.00	983.00	1,145.00	1,059.00	1,166.00	1,700.90	1,851.19	1,859.80	2,126.95	2,295.08	2,357.06	2,347.85	2,374.06
2.A.2	Lime Production	CO_2	214.08	192.23	162.40	204.89	205.43	187.51	198.24	221.89	211.66	170.07	190.43	189.40	190.31	206.26	201.54	183.48	180.30	196.71
2.A.3	Limestone and Dolomite Use	CO_2	0.15	0.14	0.13	0.11	0.13	0.18	0.17	0.24	0.23	0.25	0.18	4.50	2.17	2.38	3.55	4.29	2.64	2.32
2.A.4	Soda Ash Production and Use	CO_2	0.10	0.09	0.07	0.11	0.05	0.07	0.09	0.10	0.11	0.05	0.07	0.09	0.05	0.06	0.08	0.08	0.06	0.06
2.A.7	Bricks and Tiles	CO_2	5.07	4.88	4.79	4.50	4.79	5.46	5.27	6.23	6.08	6.37	6.49	6.12	5.91	6.12	6.23	7.41	7.40	6.83
2.A.7	Glass Production	CO_2	13.33	13.06	12.59	12.52	12.31	11.97	11.63	11.46	11.05	10.96	10.71	10.14	5.13	0.55	0.58	0.48	0.49	0.45
2.B.1	Ammonia Production	CO_2	990.23	1,030.32	1,003.56	946.19	1,056.63	973.44	922.85	1,073.12	1,058.81	942.82	882.12	1,040.28	810.28	0.30	NO	NO	NO	NO
2.B.2	Nitric Acid Production	N_2O	1035.40	812.45	812.45	812.45	812.45	812.45	812.45	812.45	812.20	812.20	812.45	584.35	292.18	NO	NO	NO	NO	NO
2.F.7	Consumption of Halocarbons and SF6	HFCs	0.69	5.27	6.17	9.44	19.97	44.85	76.11	133.35	191.95	198.25	231.23	253.05	278.14	351.44	387.31	436.72	509.17	500.49
2.F.7	Consumption of Halocarbons and SF6	PFCs	0.09	7.62	15.15	30.21	45.27	75.38	103.09	130.82	61.87	195.93	305.41	295.98	212.40	228.79	182.43	168.34	148.32	130.58
2.F.7	Consumption of Halocarbons and SF6	SF_6	35.40	40.64	45.87	55.35	64.83	82.83	102.06	132.10	94.19	68.87	55.81	69.30	69.95	118.18	66.64	95.46	67.46	68.75
2	Total		3,178.55	2,888.68	2,816.16	2,804.76	3,080.85	3,073.12	3,214.94	3,666.77	3,507.14	3,571.78	4,195.80	4,304.40	3,726.33	3,041.03	3,143.45	3,253.32	3,263.69	3,280.25

Table 4.4. contd. Percentage Change in Total Emissions from Industrial Processes due to Recalculations

			Percentage Change in Total Emissions due to Recalculations																	
2.A.1	Cement Production	CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.A.2	Lime Production	CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.A.3	Limestone and Dolomite Use	CO_2	43.04	43.04	43.04	43.04	43.04	43.04	43.04	43.04	43.04	43.04	-0.07	0.00	0.00	0.00	-0.29	0.00	0.00	0.00
2.A.4	Soda Ash Production and Use	CO_2	-76.82	-78.74	-81.96	-74.74	-86.07	-82.37	-77.85	-76.37	-57.77	-81.68	-87.20	-83.67	-86.92	-80.80	-76.44	-76.52	-83.33	-84.48
2.A.7	Bricks and Tiles	CO_2	-1.24	-1.13	-1.07	-0.88	-1.07	-1.43	-1.34	-1.75	-1.70	-1.80	-2.59	-2.72	-2.10	-2.04	-2.00	0.00	0.00	0.00
2.A.7	Glass Production	CO_2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.B.1	Ammonia Production	CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA	NA	NA	NA
2.B.2	Nitric Acid Production	N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA	NA	NA	NA	NA
2.F.7	Consumption of Halocarbons and SF6	HFCs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.81	0.65	0.57	0.44	0.62	0.59	0.42	0.23	0.38	0.44	0.58
2.F.7	Consumption of Halocarbons and SF6	PFCs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.F.7	Consumption of Halocarbons and SF6	SF_6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.10	-0.21	-0.28	-0.27	-0.50	-0.43	-0.66	-0.52	-1.66	-6.08
2	Total		0.41	0.44	0.44	0.44	0.39	0.38	0.35	0.33	0.34	0.33	0.26	0.25	0.16	0.04	0.02	0.04	0.04	-0.04

Chapter Five

Solvent and Other Product Use

5.1 Overview of *Solvent and Other Product Use* Sector

This IPCC source sector is considered separately because of its importance in relation to the emissions of NMVOC (non-methane volatile organic compounds), one of the indirect greenhouse gases, which result from the use of solvents and various other volatile compounds. However, some minor direct uses of N_2O (such as anaesthesia) are covered in this source sector and the IPCC reporting format also explicitly provides for the inclusion of CO_2 emissions that result from the oxidation of the carbon in VOC emissions. This is consistent with the overall approach adopted for estimating CO_2 from the combustion of fuels using the sectoral approach (Section 3.2), where the CO_2 emissions are based on the full carbon content of the fuel even though some of the carbon is usually emitted as NMVOC or CO. The Irish inventories include an estimate of CO_2 emissions in this way but emissions associated with the direct use of N_2O are not estimated.

The activity data used for computing estimates of CO_2 emissions in *Solvent and Other Product Use* are the mass emissions of NMVOC computed for the relevant source categories (3*.A Paint Application, 3.B Degreasing and Dry Cleaning, 3.C Chemical Products and 3.D Other Solvent Uses*). The Irish data used for this purpose are the VOC emissions compiled according to the CORINAIR methodology for reporting to UNECE under the Convention on Long Range Transboundary Air Pollution (CLRTAP) (UNECE, 1999). As part of the work on recalculations for the 2002 submission, Ireland produced a revised and consistent time-series of such NMVOC emissions estimates based on the results of detailed analysis and investigations for 1998 (Finn et al, 2001). The CO_2 emissions are derived by assuming that 85 percent of the mass emissions of NMVOC in the four categories is converted to CO_2.

5.2 NMVOC and CO_2 Inventory Time Series

Emission control strategies are being implemented in Ireland to comply with a limit of 65 kt for total emissions of NMVOC in 2010 under the National Emissions Ceilings Directive (EP and CEU, 2001). The levels of solvent use and the emissions from solvents are changing substantially in response to product replacement and reformulation and emission controls being implemented under Integrated Pollution Control (IPC) and the Solvents Directive (CEC, 1999). In these circumstances, the inventories of VOC emissions from solvent use over recent years were reassessed as part of the general improvements conducted for Irish emission inventories during 2005. The inventory agency commissioned a project to carry out in-depth analysis of the specified NMVOC source categories (CTC, 2005) in order to compile the best possible estimates of emissions in 2004 as a follow-up to the earlier commissioned work and to revise the inventories for the years 1998-2003 as necessary in the light of new information. The revised estimates for these target years indicated lower NMVOC emissions than had been previously reported and used as the basis for CO_2 in the sector *Solvent and Other Product Use.*

A bottom-up approach was possible for activities subject to IPC licensing in the four source categories. Relevant data on emissions and solvent use were extracted from their electronic or paper Annual Environmental Reports (AERs) or Pollution Emissions Registers (PERs). Where such information was not available, European PERs were assessed. Top-down methods were used for activities not covered by the IPC licensing system. These included the use of paints and the use of domestic solvents, the two principal source categories. Input, usage and emissions data for each individual activity was collated into IPC and non-IPC spreadsheets and emissions were estimated by applying EMEP/CORINAIR methods, default emission factors and general guidance as appropriate. Scaling up to national level was applied where necessary.

The estimates of CO_2 emissions from *Solvent and Other Product Use* for the period 1990-2008 are presented in Table 5.1. The largest contributor to overall emissions is the domestic solvent use sub-category. It is also to be noted that emissions from this sub-category have increased while those from the majority of sub-categories are decreasing. The main drivers are considered to be the increased number of vehicles, growth in the number of individual households, and higher per-capita consumption of non-aerosol automotive products, cosmetics, toiletries, and household products. It should be noted that UK emission factors together with Irish statistics for number of vehicles, persons and households were used in the absence of any other data. One of the only two other significant sub-categories for which emissions are increasing is industrial application of paint in the wood products sector. This is as a result of an expansion in activity in the sub-category as well as the continued use of conventional high solvent content coatings. The vast majority of these companies are small operations outside the remit of IPC.

Emissions from architectural paint use are decreasing (even while paint sales are increasing) as a result of an increased market share for water-based paints and a reduction in the VOC content of water based paints (VOC content of solvent based paints remains more or less static). From discussions with industry, one of the key drivers for the decrease in solvent use in architectural paint has been as a result of pressure from some of the larger retailers. The decrease in VOC emissions from architectural painting should be set to continue with the advent of the deco-paints Directive (EP and CEU, 2004b) and can only benefit from continued and expanded retailer/consumer pressure. There have been significant drops in both printing and wood impregnation. The decrease in printing is principally due to the installation of abatement equipment in the plant, which is the largest user of solvents. The decrease in the use of wood preservatives can be attributed to several site closures and to the switch from solvent-borne to water-borne wood preservatives.

Other industrial paint application and other manufacturing taken together show a decrease in emissions between 1998 and 2008. The diversity within these sectors is very large in terms of the type of process, the products made, and the scale involved. There have been closures, particularly of a few of the large emitters, which have decreased emissions, but there has also been some new processes licensed. In addition there is a large degree of uncertainty associated with the non-IPC element of the emissions estimates for these sources. However, the study found that there are specific instances of IPC licensed sites reducing VOC emissions through prevention at source or through abatement.

5.3 Recalculations for Solvents and Other Product Use

Recalculations for Solvent and Product Use are minor and are as a result of revised activity data for *3.A. Paint Application*, *3.B. Degreasing, dry cleaning and electronics* and *3. D. Other Use of Solvents*. The net effect of these recalculations is an increase in CO_2 emissions for the Solvent and Other Product Use sector of approximately one percent in 1999 and 2007 with smaller increases of up to 0.3 percent evident in intervening years (Table 5.2).

Table 5.1 NMVOC and CO_2 Emissions from Solvent and Other Product Use 1990-2008

Year	3A Paint Application	3B Degreasing, dry cleaning, electronics	3C Chemical Products Manufacturing & Processing	3D Other Use of Solvents	Total NMVOC Emissions	Estimated CO_2 emissions from NMVOC
Mg NMVOC						Gg
1990	6,535	2,727	3,538	12,686	25,486	79.431
1991	6,646	2,727	3,538	13,120	26,031	81.129
1992	6,863	2,727	3,538	13,060	26,188	81.618
1993	7,064	2,727	3,538	12,953	26,282	81.912
1994	7,337	2,715	3,538	13,018	26,607	82.925
1995	7,593	2,919	3,538	13,087	27,137	84.578
1996	7,919	2,618	3,538	13,054	27,128	84.549
1997	8,195	2,433	3,538	13,144	27,309	85.113
1998	8,612	2,110	3,538	13,257	27,517	85.761
1999	8,285	2,019	3,370	12,946	26,620	82.966
2000	8,084	1,883	3,203	12,165	25,335	78.961
2001	8,389	1,659	3,035	12,138	25,222	78.607
2002	8,782	1,067	2,868	11,980	24,696	76.971
2003	8,855	1,142	2,700	11,859	24,557	76.537
2004	9,028	1,122	2,532	11,967	24,649	76.822
2005	9,383	1,228	2,466	12,175	25,251	78.700
2006	9,882	1,350	2,401	12,538	26,171	81.566
2007	10,218	1,285	2,335	13,103	26,941	83.965
2008	10,552	1,248	2,269	13,517	27,585	85.973

Table 5.2 Recalculations for Solvent and Other Product Use 1990-2007

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
									Estimates in 2009 Submission (Gg)										
3.A	Paint Application	6.535	6.646	6.863	7.064	7.337	7.593	7.919	8.195	8.612	8.285	8.084	8.389	8.782	8.855	9.028	9.382	9.790	10.164
3.B	Degreasing, dry cleaning, electronics	2.727	2.727	2.727	2.727	2.715	2.919	2.618	2.433	2.110	1.746	1.883	1.659	1.067	1.142	1.116	1.222	1.344	1.279
3.C	Chemical Products and Manufacturing & Processing	3.538	3.538	3.538	3.538	3.538	3.538	3.538	3.538	3.538	3.370	3.203	3.035	2.868	2.700	2.532	2.466	2.401	2.335
3.D	Other Use of Solvents	12.686	13.120	13.060	12.953	13.018	13.087	13.054	13.144	13.257	12.946	12.165	12.138	11.978	11.858	11.959	12.166	12.560	12.913
3	Total NMVOC emissions	25.486	26.031	26.188	26.282	26.607	27.137	27.128	27.309	27.517	26.347	25.335	25.222	24.695	24.556	24.635	25.236	26.095	26.691
3	Estimated CO_2 from NMVOC	79.431	81.129	81.618	81.912	82.925	84.578	84.549	85.113	85.761	82.115	78.961	78.607	76.966	76.532	76.778	78.653	81.328	83.187
									Recalculated Estimates in 2010 Submission (Gg)										
3.A	Paint Application	6.535	6.646	6.863	7.064	7.337	7.593	7.919	8.195	8.612	8.285	8.084	8.389	8.782	8.855	9.028	9.383	9.882	10.218
3.B	Degreasing, dry cleaning, electronics	2.727	2.727	2.727	2.727	2.715	2.919	2.618	2.433	2.110	2.019	1.883	1.659	1.067	1.142	1.122	1.228	1.350	1.285
3.C	Chemical Products and Manufacturing & Processing	3.538	3.538	3.538	3.538	3.538	3.538	3.538	3.538	3.538	3.370	3.203	3.035	2.868	2.700	2.532	2.466	2.401	2.335
3.D	Other Use of Solvents	12.686	13.120	13.060	12.953	13.018	13.087	13.054	13.144	13.257	12.946	12.165	12.138	11.980	11.859	11.967	12.175	12.538	13.103
3	Total NMVOC emissions	25.486	26.031	26.188	26.282	26.607	27.137	27.128	27.309	27.517	26.620	25.335	25.222	24.696	24.557	24.649	25.251	26.171	26.941
3	Estimated CO_2 from NMVOC	79.431	81.129	81.618	81.912	82.925	84.578	84.549	85.113	85.761	82.966	78.961	78.607	76.971	76.537	76.822	78.700	81.566	83.965
									Percentage Change in Total Emissions due to Recalculations										
3.A	Paint Application	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.94	0.53
3.B	Degreasing, dry cleaning, electronics	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.64	0.00	0.00	0.00	0.00	0.54	0.50	0.45	0.48
3.C	Chemical Products and Manufacturing & Processing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.D	Other Use of Solvents	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.06	0.07	-0.17	1.47
3	Total NMVOC emissions	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04	0.00	0.00	0.01	0.01	0.06	0.06	0.29	0.94
3	Estimated CO_2 from NMVOC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04	0.00	0.00	0.01	0.01	0.06	0.06	0.29	0.94

Chapter Six

Agriculture

6.1 Overview of Agriculture Sector

Table 6.1 lists the IPCC Level 3 source categories in *Agriculture,* where CH_4 and N_2O are the key greenhouse gases. The agricultural activities of particular importance in Ireland are those under *4.A Enteric Fermentation, 4.B Manure Management* and *4.D Agricultural Soils* only, some of which are identified as being among the largest greenhouse gas emission sources in the country (Chapter Two and Chapter Three). The inventory time-series for the years 1990-2008 contains emission estimates for all relevant sources and gases in these three important source categories. The availability of better up-to-date data and the completion of major national research in agriculture in 2004 and 2005 has facilitated major improvements in methodologies and in the manner of data application for many of the sources concerned. Source categories *4.C Rice Cultivation, 4.E Prescribed Burning of Savannas* and *4.F Field Burning of Agricultural Residues* are not relevant to Ireland and the notation key NO is used in relation to all associated emissions in the CRF. Although the practice of field burning of agricultural residues did exist on a small scale in the past, the emissions are considered negligible, and it has been discontinued since the mid 1990s.

The methods provided by the IPCC good practice guidance are applied as completely as possible for agricultural emission sources under Irish circumstances. The IPCC methods require considerable information detail on activity data, emission factors and other input parameters needed for the emission calculations. There were major changes in the inventories for *Agriculture* in the 2006 submission with the adoption of Tier 2 methods for CH_4 emissions from enteric fermentation in cattle and robust improvement in estimates of emissions from manure management based on the results of major research and an extensive farm facilities survey (Hyde et al., 2008). This research, together with other relevant work related to the development of an elaborate new NH_3 inventory for agriculture in 2005 and regulations on the implementation of Good Agricultural Practices for the protection of Waters in SI 101 of 2009 (DEHLG, 2009) has facilitated the application of a large amount of country-specific information underlying the various estimates of emissions. The same approach and methods are used for the purposes of this submission while further development and minor updating of the underlying activity data remains part of the ongoing work and assessment in relation to agricultural emissions.

Because of the importance of agriculture in the country, Ireland has very extensive and up-to-date statistical data on all aspects of the sector, compiled and published by the Central Statistics Office (CSO). This is the official source of the basic data for inventory purposes, except for synthetic fertilizer use and poultry population statistics, for which annual data are obtained from the Department of Agriculture, Fisheries and Food (DAFF). The CSO and DAFF are key data providers whose annual statistical inputs to the inventory agency are covered by MOU in Ireland's national system (Figure 1.1 and Table 1.1). The time-series of key agricultural statistics as used for the various activity data (livestock populations and fertilizer use) is given in Annex E. It may be noted that in the case of cattle, the populations related to housing (Table E.1 (a)) are different to those for pasture (Table E.1 (b)) to take full account of the respective production systems as they affect emissions. The manner in which the populations are applied is explained in the documentation boxes of the CRF tables. The publication of separate census data for June and December annually and the application of these statistics in order to achieve the most representative activity data for the different emissions categories related to cattle and some other livestock explains differences that are often seen between national and FAO statistics for agriculture. Ireland has high quality agricultural statistics and differences with FAO are to be expected, but they are of no consequence to the emissions estimates.

Table 6.1. Level 3 Source Category Coverage for Agriculture

Agriculture	**CO_2**	**CH_4**	**N_2O**
A. Enteric Fermentation			
1. Cattle	NA	All	NA
Dairy Cattle	NA	All	NA
Non-Dairy Cattle	NA	All	NA
2. Buffalo	NA	NO	NA
3. Sheep	NA	All	NA
4. Goats	NA	All	NA
5. Camels and Llamas	NA	NO	NA
6. Horses	NA	All	NA
7. Mules and Asses	NA	All	NA
8. Swine	NA	All	NA
9. Poultry	NA	NE	NA
10. Other	NA	NO	NA
B. Manure Management			
1. Cattle	NA	All	All
Dairy Cattle	NA	All	All
Non-Dairy Cattle	NA	All	All
2. Buffalo	NA	NO	NO
3. Sheep	NA	All	All
4. Goats	NA	All	All
5. Camels and Llamas	NA	NO	NO
6. Horses	NA	All	All
7. Mules and Asses	NA	All	All
8. Swine	NA	All	All
9. Poultry	NA	All	All
10. Anaerobic Lagoons	NA	NA	NA
11. Liquid Systems	NA	All	All
12. Solid Storage and Dry Lot	NA	All	All
13. Other	NA	NO	NO
C. Rice Cultivation	NO	NO	NO
D. Agricultural Soils			
1. Direct Soil Emissions	IE*	NE	All
2. Pasture Range and Paddock Manure	NA	NO	All
3. Indirect Emissions	NA	NO	All
4. Other	NO	NO	NO
E. Prescribed Burning of Savannas	NO	NO	NO
F. Field Burning of Agricultural Residues	NO	NO	NO
G. Other	NO	NO	NO

All: all emission sources covered; NE: emissions not estimated; NO: activity not occurring; NA: not applicable (activity exists but no emissions of the gas occurs); IE: emissions included elsewhere
** CO_2 emissions from Liming of Agricultural Lands included in category 5.B of LULUCF (Chapter Seven)*

In 2008, the emissions from Agriculture were 17,575.46 Gg CO_2 equivalent or 26 percent of national emissions. This proportion has decreased in relative terms from 35 percent in 1990 as the emissions from energy use increased significantly while emissions from Agriculture have decreased by about 8 percent. Methane accounted for 62.3 percent and N_2O accounted for 37.7 percent of the emissions in the sector in 2008. The CH_4 emissions from enteric fermentation in cattle and the N_2O emissions associated with large inputs of chemical and organic nitrogen to agricultural soils are the major emission categories.

6.2 CH_4 Emissions from Enteric Fermentation (4.A)

6.2.1 Overall Approach

Implementation of the IPCC good practice guidance for GHG inventories requires that Parties use Tier 2 (i.e. detailed country-specific) methods for key sources of emissions. Prior to the inventory submission in 2006, Ireland used Tier 1 methods to estimate CH_4 emissions from enteric fermentation. At the time this basic approach showed that enteric fermentation in dairy and non-dairy cattle produced 8.5 percent and 3.6 percent respectively, of total GHG emissions in 2003. It also showed that in 1990, enteric fermentation in non-dairy cattle was the single largest individual source of greenhouse gas emissions in Ireland, accounting for 9.6 percent of the national total. In addition the recommendation to use Tier 2 methods had also been made in several reports on the review of Ireland's inventory submissions to the UNFCCC. As a result, a major research project funded by the EPA was undertaken to provide appropriate Tier 2 emission factors for CH_4 from enteric fermentation for the Irish cattle herd. The results of this research (O'Mara, 2006) were applied for the first time in the 2006 submission and the procedure continues to be used to derive the annual emission factors.

In the approach, the Irish cattle herd is characterised by 11 principal animal categories as shown in Table 6.2, for which annual census data are published by the CSO. In-depth analysis of production systems and the associated animal feed and energy requirements was conducted for all categories within the Irish cattle population to determine CH_4 production. Substantial further subdivision was incorporated for dairy and beef cattle to adequately describe the wide range of cattle rearing and finishing systems applicable in Ireland. In total, dairy cows were covered by 12 systems and 18 system types were analysed for suckler cows, while up to 30 systems were examined for both male and female beef cattle. The exercise to develop Tier 2 emission factors for the 11 animal categories shown in Table 6.2 was initially carried out for the 2003 national herd and was then repeated for 1990. The approach has been applied again for this submission with country-specific emission factors for 2008 developed by the inventory team using the methodologies derived in the research project. The following paragraphs outline the approach and a detailed description of the comprehensive study and the analysis underlying the emission factors is available (O'Mara, 2006).

Table 6.2 Animal Classifications for Cattle Population

Cattle Type	Classification
Breeding cattle	Dairy cows, Suckler (Beef) cows
Beef cattle	Male < 1 year, Male 1 – 2 years, Male > 2 years, Female < 1 year, Female 1 – 2 years, Female > 2 years
Other cattle	Breeding bulls, Dairy in-calf heifers, Beef in-calf heifers

6.2.2 Enteric Fermentation in Breeding Cattle

For both dairy cows and suckler cows, the country is divided into three regions: (1) south and east, (2) west and midlands, and (3) north-west, coinciding with the regions used for the implementation of regulations on good agricultural practice (DEHLG, 2006). This division facilitates in-depth analysis for separate regions with different lengths of winter housing and takes account of different animal feeding practices. The cattle production systems in each region are defined in terms of calving date, the dates of winter housing and spring turn-out to grass, milk yield and composition, forage and concentrate feeding level, cow live-weight and live-weight change and lactation period. The number of cows in each category given by CSO statistics is allocated to the three regions identified above using the Cattle Movement Monitoring System (CMMS) and Animal Identification and Movement (AIM) system reports published by the Department of Agriculture, Fisheries and Food (DAFF, 2004; 2005; 2006; 2007; 2008, 2009). The CSO produces two censuses of animal numbers per year, one reflecting the number of animals in the national herd in June and the other referring to populations in December. For the purposes of calculating emissions from breeding cattle, an average of the number in each category of breeding animals present in the national herd in June and December is used.

In the approach outlined by O'Mara (2006), the daily energy requirement of cows in each region is calculated by month or part thereof based on maintenance requirements, milk yield and composition, requirements for foetal growth and gain or loss of bodyweight using the French energy system (INRA, 1989). In this system, net energy requirement is defined in terms of *unites fourragere lait* (UFL), where 1 UFL is the net energy value of 1 kg of barley at 86 percent dry matter and is equal to 7.11 MJ net energy for lactation (NE_l). This international energy system, which is well established and used locally in Ireland, was considered more appropriate to the local conditions than the system and equations used by the IPCC guidelines and IPCC good practice guidance. The energy gains and losses refer to intra-annual changes for the animal and do not mean that average body weight for animals in the dairy herd is increasing from year to year. The live-weight of 535 kg for dairy cows is an indicative weight supplied by the Department of Agriculture, Fisheries and Food as dairy cow live-weights are not in general monitored on farms. It is adopted as the reference point for the annual emission factor derivation for the herd and is chosen to be consistent with other parameters relevant to the estimation of emissions from cattle, e.g. nitrogen excretion rate.

The important equations are:

Maintenance NE_l requirements (MJ) = 9.96 + (0.6 x LW/100), where LW is live-weight.
A 10 percent activity allowance was added for the housed period and a 20 percent allowance was added for the grazing period as outlined by INRA (1989);

NE_l (MJ) required per kg milk = 0.376 * fat content + 0.209 * protein content + 0.948;

Pregnancy: mean of 12.1 MJ NE_l /day for the last 3 months of pregnancy;

Live-weight change: each kg live-weight lost contributed 24.9 MJ NE_l to energy requirements, while each kg of live-weight gained required 32 MJ NE_l.

The composition of the diet of cows in each region was described by month or part thereof and daily intake was calculated by reference to the daily energy requirement. The concentrate allowance was fixed while forage intake varied according to energy requirements. Daily methane emissions (MJ/day) were calculated from digestible energy intake using the equation of Yan et al. (2000).

$$CH_4 = DEI * [\ 0.096 + (0.035 \times S_{DMI}/T_{DMI})\ ] - 2.298 * (FL - 1)$$

where DEI is digestible energy intake (MJ/day), S_{DMI} and T_{DMI} are silage and total dry matter intakes (kg/day), respectively, and FL is feeding level (multiples of the maintenance energy requirement).

A constant methane conversion rate of 0.065 of gross energy intake is applied when the diet consists of grazed grass and 3 kg or less of concentrate supplement per day. This is based on a large New Zealand database of measurements for grazing animals on similar production systems to those in Ireland. A methane output of 21.6 g/kg DM is used for pasture diets with a grass GE content of 18.45 MJ/kg, which is equivalent to 6.5 percent of GE (Harry Clark, Personal Communication). Daily CH_4 emissions are summed to give annual emissions for cows in each region, and a weighted national average emission factor is then calculated.

6.2.3 Enteric Fermentation in Beef Cattle

Emission factors for the beef cattle categories given in Table 6.3 are determined by calculating lifetime emissions for the animal and by partitioning between the first, second and third years of the animal's life. This approach allows the published CSO animal populations for June to be used directly as the activity data most representative of the inventory year for enteric fermentation while taking into account the movement of cattle from one category to another, as enumerated by the June census, up to two times in their three-year lifetime (O'Mara, 2006).

Analysis is undertaken for a total of 11 separate production systems covering the three groups of male and female beef cattle given in Table 6.3 after the proportion of the herd in each category is calculated using the CMMS/AIM reports published by the Department of Agriculture, Fisheries and Food (DAFF, 2004; 2005; 2006; 2007; 2008, 2009). Important parameters such as housing dates (expert opinion), turnout dates (expert opinion) and live-weight gains (expert opinion reconciled with actual national carcass weights) during winter housing periods and grazing seasons are defined for each system (O'Mara, 2006). The most important parameter is live-weight gain, as it directly affects the energy requirement and thus the feed intake. There is little statistical information on the live-weight gain of the different types of cattle in the cattle herd, but the weight of carcasses of all slaughtered cattle is recorded by the Department of Agriculture, Fisheries and Food. Using data for the average carcass weight of male and female cattle, appropriate live-weight gains are applied to the various life stages of each animal category, such that when all categories are combined, that data is consistent with the national statistics for carcass weight (plus or minus 10 kg difference).

Given these data for live-weight and live-weight gain, O'Mara (2006) estimated the energy requirements of animals during the winter housing periods and grazing seasons of the animals lifetime using the INRAtion computer programme, version 3.0. This programme was devised by the French research organisation Institute National de la Recherche Agronomique (INRA) and is based on the net energy system for cattle. In version 3 of INRAtion, some adaptation for Irish conditions was made to the equations for estimating the energy requirements of growing and finishing animals (O'Mara, 1997, Crowley, 2001 and Crowley *et al*, 2002). Net energy requirements of growing beef cattle are defined in terms of UFL, as in the case of dairy cattle, while for finishing cattle, net energy requirements are defined in terms of UFV (from the French *unite fourragere viande*) where 1 UFV is the net energy value of 1 kg of barley for meat production and is equal to 7.61 MJ NE_{mg}.

The composition of the diet in each system is described by grazing season and winter housing period and daily intake is calculated by reference to the daily energy requirement.

The concentrate allowance is fixed while forage intake is varied according to energy requirements. The Irish modifications to the INRAtion programme were predominantly for animals at weanling and finishing stages (i.e. at times that concentrates were likely to be fed). No modifications were made for 'heavy' growing animals, (typically animals in their second grazing season or later that were not being finished). For animals in these stages, intakes were adjusted as appropriate by expert opinion. Daily methane emissions were calculated using the equation of Yan et al. (2000), however a constant of 0.065 of gross energy intake was applied when the diet was grazed grass plus 3 kg or less of concentrate supplement/day. Daily emissions are aggregated to give annual emissions per system and a weighted national average emission factor is then calculated.

6.2.4 Enteric Fermentation in Other Cattle

Bulls for breeding and in-calf heifers account for approximately 7 percent of the national cattle herd. Separate production systems were not defined for these categories because of lack of published data on their feed intake and the small number of animals involved (O'Mara, 2006). Bulls for breeding are mostly of continental breeds, and their emission factors are based on those for late maturing male beef cattle of suckler origin in their second year. The emission factor for animals in this category is determined by an applicable period of 310 days in their second year, which is adjusted upwards to the full period of 365 days in the case of breeding bulls.

In-calf heifers are assigned the same emission factors as female beef cattle in their second year (i.e. corresponding to category 1–2 years old). In-calf heifers only need emissions associated with the period March – December of their second year to be accounted for, as they are subsequently enumerated as dairy or suckler cows in the CSO animal census thereafter. Female beef cattle in the category 1-2 years old are assumed to be slaughtered on 3rd February of their third year (O'Mara, 2006). Adjustment for the slightly longer period is not made in respect of in-calf heifers, as they are carrying a calf in addition to normal growth.

6.2.5 Summary of Tier 2 Emission Factors for Cattle

The Tier 2 emission factors developed by the detailed analysis outlined above for the years 2008, 2007 and 1990 are summarised in Table 6.3 for the 11 principal categories chosen to characterise the Irish cattle herd. Emission factors for the full time series 1990–2008 in respect of the 11 principal categories are presented in Table E.2 of Annex E. The emission factor for dairy cows in 1990 is very close to the IPCC default emission factor of 100 kg CH_4/head/year for highly productive dairy cattle in Western Europe. The corresponding value for 2008 indicates an increase of 7.7 percent from 1990 in line with increased milk yield, which is not captured by the Tier 1 approach used prior to 2006. As such, annual milk yield may be used as a convenient basis for deriving aggregate weighted emission factors for dairy cattle in other years. The emission factors for beef cattle indicate an overall weighted average of approximately 40 kg/head, compared to the value of 50 kg/head previously used in the tier 1 approach. Little change is indicated between 1990 and 2008, except in the case of male cattle in the category of animals greater than two years old. This is explained by the earlier finishing time for male beef cattle since the BSE crisis that affected agriculture during the 1990s.

Table 6.3 Tier 2 CH_4 Emission Factors for 1990, 2007 and 2008

	Enteric Fermentation (kg/head/year)			Manure Management (kg/head/year)		
	2008	2007	1990	2008	2007	1990
Dairy cows	109.21	110.22	101.38	20.50	20.60	21.57
Suckler cows	75.92	73.87	74.03	14.25	13.85	14.02
Male cattle < 1 year	29.71	29.69	30.46	8.63	8.59	9.73
Male cattle 1 - 2 years	59.07	59.19	62.22	13.78	13.85	16.68
Male cattle > 2 years	36.98	38.58	55.08	1.82	2.02	4.57
Female cattle < 1 year	27.72	27.77	27.05	8.28	8.27	8.79
Female cattle 1 - 2 years	47.00	46.60	53.54	9.95	9.79	14.74
Female cattle > 2 years	22.55	22.42	21.65	0.34	0.34	0.33
Bulls for breeding	81.55	81.55	86.38	18.95	18.95	23.79
Dairy in-calf heifers	50.16	50.16	51.82	10.93	10.93	13.40
Beef in-calf heifers	53.68	53.68	55.42	12.87	12.87	15.61

6.2.6 Enteric Fermentation in Other Livestock

The type of information used to derive the Tier 2 emission factors for cattle is not available for other important livestock categories in Ireland, such as sheep and swine. Therefore, the inventory agency continues to use the Tier 1 approach for enteric fermentation for all livestock categories other than cattle. The emission factors used are generally those for Western Europe given in Table 4.3 of the IPCC Guidelines. However, in order to fully utilize the detailed CSO breakdown in respect of sheep and swine populations, the base emission factors from IPCC are adjusted in each case on the basis of animal weight, as shown in Table E.2 of Annex E. As a result, the implied emission factors produced by the CRF related to total populations of sheep and swine in Ireland are lower than the base default values for these animal categories.

6.3 CH_4 Emissions from Manure Management (4.B)

6.3.1 CH_4 emissions from manure management in cattle

The decomposition of the organic material in animal manures may be a significant source of CH_4 emissions if anaerobic conditions prevail in the animal waste management systems being used. The estimation of such emissions requires information on the quantity of manure production for the animal groups concerned, the type of waste management systems employed and the CH_4 production potential of the wastes. New information obtained from a national farm facilities survey (Hyde et al., 2008) and the work on emission factors for enteric fermentation in cattle described in section 6.2 is the basis of the CH_4 emission factors for manure management. The results of the farm facilities survey provide a much improved representation of animal waste allocation among the relevant waste management systems in the country while the excretion of organic matter by cattle is fully characterised as part of the analysis of their feed and energy requirements relating to enteric fermentation. Table E.4 of Annex E outlines the main results of the farm facilities survey pertinent to inventory calculations.

The analysis of the feeding regime for cattle (O'Mara, 2006) included a full evaluation of the organic matter content of the feeds applicable to the 11 categories that characterise the national herd, which facilitates the estimation of their respective levels of organic matter excretion. The emission factors for manure management are derived using the quantified organic matter excretion as volatile solids (VS), the methane production potential (B_O) of animal waste, the allocation to animal waste management system based on the farm facilities survey and the corresponding values of MCF (methane conversion factor) given for the cool climate zone in Table 4.10 of the IPCC good practice guidance. Ireland uses the value of 0.24 m^3 CH_4/kg VS (the value for dairy cattle in the IPCC good practice guidance) for B_O for all cattle because agricultural experts advise that no difference would be expected between the methane potential of dairy cattle manures and non-dairy cattle manures in Ireland, given the similarity of their grass-based feeding systems. The emission factors for cattle are given in Table 6.3.

6.3.2 CH_4 emissions from manure management in other livestock

The estimation of CH_4 emissions from domestic livestock includes the derivation of the emission factors for manure management for sheep, swine, horses and poultry. The allocations to animal waste management system are again based on the Farm Facilities survey (Hyde et al., 2008) and appropriate values of B_O and VS are taken from the IPCC Guidelines while MCF is again as given in Table 4.10 of the IPCC good practice guidance. The application of the manure management emission factors for sheep, horses and poultry means that all CH_4 emissions from livestock are included in current estimates. The CH_4 emissions from manure management in 2008 amounted to 24.4 percent of those from enteric fermentation.

6.4 N_2O Emissions from Manure Management (4.B)

Nitrogen excretion rates have been adopted in Ireland for all animal categories for which annual census data are published by the CSO. These rates of nitrogen excretion are endorsed by the Department of Agriculture, Fisheries and Food and by TEAGASC for national use and guidance for farmers in relation to implementation of the Nitrates Directive Action Programme and SI 101 of 2009 (DEHLG, 2009). In the case of cattle, the excretion rates are consistent with the nitrogen content of cattle feeds and the quantities excreted by the animal, as analysed in conjunction with the determination of Tier 2 CH_4 emission factors for cattle. The published nitrogen excretion rates are used by the inventory agency, along with the information on the allocation of animal manures to each applicable animal waste management system from the Farm Facilities Survey (Hyde et al., 2008) as the basis of CRF Table 4.B (b).

Approximately two-thirds of animal manure nitrogen is excreted at pasture annually, reflecting the relatively short period that cattle are housed in Ireland and a significant contribution from the large sheep population. Animal manures excreted at pasture are unmanaged and the associated emissions are accounted for under agricultural soils (Section 6.5.1). In 2008 the bulk of animal manures in housing are managed in liquid storage systems (93.8 percent and 71.9 percent for dairy cattle and other cattle, respectively and 100 percent for swine) for eventual spreading on agricultural lands. The remainder of animal manures produced in-house are in solid manure systems. The emission factors given by the IPCC good practice guidance indicate that 1 kg of nitrogen per tonne of nitrogen handled in liquid manure storage systems is lost as N_2O while the corresponding loss is 20 kg per tonne for nitrogen in solid manure storage systems. These default emission factors, for which uncertainty ranges up to 100 percent, are assigned in the IPCC good practice guidance, are used to estimate N_2O emissions from manure management in Ireland. The N_2O emissions from manures managed in liquid and solid storage systems in 2008 amounted to 1.21 Gg N_2O.

6.5 N_2O Emissions from Agricultural Soils (4.D)

Agricultural soils are the principal source of N_2O emissions in Ireland. The IPCC methodologies for the source categories concerned involve a simple accounting of all inputs of nitrogen to agricultural soils and the subsequent application of default rates of nitrogen loss to the atmosphere as N_2O. The primary nitrogen inputs are subject to complex processes and partitioning between various nitrogen compounds within soils and the emissions are highly dependent on soil properties and meteorology. The methodologies are therefore simplified and they are based on a consideration of separate direct and indirect contributions to national emissions. Ireland uses the IPCC good practice guidance methodology completely to estimate N_2O emissions from agricultural soils and the procedure may be followed from the description below. Values for each of the terms used in the calculation of direct and indirect soil emissions for the full time series 1990-2008 are presented in Table E.3 of Annex E.

6.5.1 Direct Soil Emissions (4.D.1)

According to the IPCC good practice guidance the direct emissions of N_2O to be reported in CRF sub-category 4.D.1 Direct Soil Emissions may be calculated in a Tier 1 approach from

$$N_2O_{direct} = [(F_{SN} + F_{AM} + F_S + F_{BN} + F_{CR}) * EF_1]+ [F_{OS} * EF_2]$$

where

N_2O_{direct} = the direct emissions of N_2O
F_{SN} = amount of synthetic fertilizer nitrogen applied to soils, adjusted for the amount that volatilizes as NH_3 and NO_X
F_{AM} = amount of animal manure nitrogen applied directly to soils, adjusted for the amount that volatilizes as NH_3 and NO_X
F_S = amount of organic nitrogen in sludge applied to agricultural soils
F_{BN} = amount of nitrogen fixed by nitrogen-fixing crops
F_{CR} = amount of nitrogen in crop residues returned to soils
F_{OS} = the area of cultivation of organic soils
EF_1 = N_2O emission factor for emissions from direct nitrogen inputs (kg N_2O-N/kg N)
EF_2 = N_2O emission factor for emissions from cultivation of organic soils (kg N_2O-N/kg N)

The estimates of direct N_2O emissions from agricultural soils for the years 1990-2008 take into account the nitrogen inputs from all these sources, except that due to the cultivation of organic soils. Tillage farming in Ireland is concentrated in the south and southeast of the country while the bulk of organic soils occur in the midlands and west. Consequently, nitrogen inputs due to the cultivation of organic soils can be taken as negligible. The equation for estimating N_2O emissions in Ireland reported in sub-category *4.D.1 Direct Soil Emissions* therefore becomes

$$N_2O_{direct} = (F_{SN} + F_{AM} + F_S + F_{BN} + F_{CR})*EF_1$$

Where

$F_{SN} = N_{fert} * (1-Frac_{GASF})$

$F_{AM} = [N_{ex} * (1- Frac_{GRAZ}) * (1- Frac_{GASM1})] - N_2O\text{-}N_{hs}$

$F_S = SS_l * NSSF$

$F_{BN} = \Sigma_i Crop_i * (1 + Res_i/Crop_i) * DMF_i * NCRF_i$

$F_{CR} = \Sigma_j Crop_j * Res_j/Crop_j * DMF_j * NCRF_j$

and

N_{fert} = total amount of synthetic fertilizer nitrogen applied to soils (kg N)
$Frac_{GASF}$ = fraction of synthetic fertilizer nitrogen that volatilizes as NH_3 (0.016 in 2008)
N_{ex} = total amount of animal manure nitrogen excreted by livestock (kg N)
$Frac_{GRAZ}$ = fraction of N_{ex} that is excreted by livestock during grazing (0.66 in 2008)
$Frac_{GASM1}$ = fraction of animal manure nitrogen that volatilizes as NH_3 during housing, manure storage and landspreading (0.485 in 2008)
$N_2O\text{-}N_{hs}$ = amount of animal manure nitrogen emitted as N_2O in housing and storage (kg N_2O-N)
SS_l = quantity of sewage sludge spread on agricultural lands (kt)
NSSF = nitrogen fraction of sewage sludge (3 percent of dry solids)
$Crop_i$ = production of nitrogen-fixing crop i (kt)
$Res_i/Crop_i$ = residue to crop product mass ratio of nitrogen-fixing crop i
DMF_i = dry matter fraction of nitrogen-fixing crop i
$NCRF_i$ = nitrogen fraction of nitrogen-fixing crop i
$Crop_j$ = production of crop j (including nitrogen-fixing crops) (kT)
$Res_j/Crop_j$ = residue to crop product mass ratio of crop j (including nitrogen-fixing crops)
DMF_j = dry matter fraction of crop j (including nitrogen-fixing crops)
$NCRF_j$ = nitrogen fraction of crop j (including nitrogen-fixing crops)

The annual statistics on nitrogen fertilizer use (N_{fert}) are obtained from the Department of Agriculture, Fisheries and Food while the organic nitrogen inputs (N_{ex}) are known from the analysis in the previous section in relation to manure management. Significant proportions of the nitrogen applied to soils in synthetic fertilizers and animal manures are normally volatilized as NH_3 with some additional conversion to NO_X. These proportions, $Frac_{GASF}$ and $Frac_{GASM}$ respectively in the IPCC guidelines, must be taken into account in order to determine the amount of nitrogen available for direct N_2O production. The IPCC good practice guidance gives the default proportions of chemical fertilizer and animal manure nitrogen lost in this way as 10 percent and 20 percent, respectively. The volatilization rates for Ireland are however determined from an elaborate NH_3 inventory for agriculture (McGettigan et al, 2009) and it is assumed that nitrogen lost as NO_X is negligible in comparison to NH_3. In addition, $Frac_{GASM}$ is split into $Frac_{GASM1}$ and $Frac_{GASM2}$ with $Frac_{GASM1}$ referring to NH_3-N losses from animal manures in housing, storage and landspreading and $Frac_{GASM2}$ being the proportion of nitrogen excreted at pasture that is volatilised as NH_3. The 2008 values of $Frac_{GASM1}$ and $Frac_{GASM2}$ are 0.485 and 0.036, respectively indicating an overall volatilisation rate of 0.189 for animal manure nitrogen.

The expression for F_{AM} given above is used to estimate the amount of animal manure nitrogen ultimately available for direct application to agricultural soils. It is more precise than that given in the IPCC good practice guidance, as the nitrogen in animal manures emitted as

N_2O and as NH_3 during animal housing and storage of manures is deducted from total nitrogen excreted in housing. Accordingly, the fraction $Frac_{GASM1}$ used here refers to the loss of nitrogen by volatilization as NH_3 during housing and storage together with that from landspreading. These modifications have been made to achieve more accurate accounting of nitrogen and to maintain consistency with Ireland's Tier 2 inventory of NH_3. The fractions $Frac_{GASF}$ and $Frac_{GASM1}$ are estimated at 0.016 and 0.485, respectively in 2008 from the NH_3 inventory. Published estimates of sludge production (O'Leary et al, 1997; O'Leary and Carty, 1998; O'Leary et al, 2000; Smith et al, 2003; Smith et, 2004; Smith et al, 2007; Monaghan et al, 2009) and the proportion applied on agricultural lands are used to estimate F_S on the basis of 3 percent nitrogen content in sewage sludge with typical dry solids content of 25 percent (Fehily Timoney, 1985). The estimate of F_S is included in N_2O_{direct} without deduction for volatilisation and the value is added to F_{AM} for reporting purposes in CRF Table 4.D. Although the amount of sludge spreading on land is increasing, it contributed less than 1 percent of the organic nitrogen input to agricultural soils in 2008.

The Tier 1b method given by the IPCC good practice guidance is used to estimate the nitrogen contributions from nitrogen-fixing crops (F_{BN}) and from crop residues (F_{CR}) returned to the soil. Annual crop production statistics and the default values of nitrogen content and other input parameters given by the IPCC good practice guidance are the basis for these estimates. The IPCC default value of 0.0125 kg N_2O-N/kg N is currently used for EF_1 to estimate direct emissions of N_2O from the inputs calculated from the above equations. The direct emissions of N_2O in 2008 for category *4.D.1 Direct Soil Emissions* amounted to 7.66 Gg, of which synthetic fertilizers accounted for 5.97 Gg, 1.46 Gg was due to land spreading of animal manures and crops (N-fixing and crop residue) produced 0.23 Gg. The contribution from crops in Ireland is small relative to other nitrogen sources and it fluctuates significantly in response to the yearly fluctuation in the area grown of the relevant crops.

6.5.2 Pasture Range and Paddock Manure (4.D.2)

The direct N_2O emissions associated with nitrogen excretion by animals during grazing is not allocated to sub-category *4.D.1 Direct Soil Emissions* but is reported instead in the CRF under *4.D.2 Pasture Range and Paddock Manure*. The amount of organic nitrogen input concerned is large in Ireland, as shown by the value of 0.66 for $Frac_{GRAZ}$ in 2008, due to the relatively short period that cattle remain in housing and the contribution from large sheep populations, the majority of which are not housed. The value of nitrogen input for this activity is available from CRF Table 4.B(b). The direct N_2O emission factor (EF_3) for this nitrogen input is 0.02 kg N_2O-N/kg N and the estimate of emissions in 2008 was 8.59 Gg.

6.5.3 Indirect Emissions (4.D.3)

The IPCC methodology for indirect emissions reported in CRF sub-category *4.D.3 Indirect Emissions* is based on a simple approach that allocates emissions of N_2O due to nitrogen deposition resulting from NH_3 and NO_X emissions in agriculture and from nitrogen leaching to the country that generated the source nitrogen. The contributions from NH_3 and NO_X emission sources in other sectors, such as transport and stationary combustion, are excluded and the import of nitrogen from other countries through atmospheric transport and runoff is not considered. Accordingly, the total nitrogen volatilized as NH_3, deducted from total nitrogen inputs in synthetic fertilizers and animal manures for estimating the amount contributing to direct N_2O emissions as described in the previous section, becomes the input value of nitrogen used to calculate indirect emissions due to deposition, as follows

$$N_2O_{indirect\text{-}dep} = [(N_{fert} * Frac_{GASF}) + ((N_{ex} * (1 - Frac_{GRAZ}) * Frac_{GASM1})) + (N_{ex} * Frac_{GRAZ} * Frac_{GASM2})] * EF_4$$

$$N_2O_{indirect\text{-}leach} = [\ N_{fert} + F_{AW} + N_{ex} * Frac_{GRAZ})\ ] * Frac_{LEACH} * EF_5$$

where

$N_2O_{indirect\text{-}dep}$ = the indirect emissions of N_2O due to atmospheric nitrogen deposition
$N_2O_{indirect\text{-}leach}$ = the indirect emissions of N_2O due to nitrogen leaching
$Frac_{GASM2}$ = fraction of animal manure nitrogen that volatilizes as NH_3 during grazing (0.036 in 2008)
$Frac_{LEACH}$ = fraction of synthetic fertilizer nitrogen and animal manure nitrogen that leaches from agricultural soils (0.1 in 2008)
EF_4 = N_2O emission factor for nitrogen inputs from atmospheric deposition
EF_5 = N_2O emission factor for nitrogen leaching

The expressions for $N_2O_{indirect\text{-}dep}$ and $N_2O_{indirect\text{-}leach}$ are slightly modified to be consistent with those for estimating direct emissions in section 6.5.1 and to account for the two separate volatilisation fractions $Frac_{GASM1}$ and $Frac_{GASM2}$. There is no contribution to $N_2O_{indirect\text{-}dep}$ from F_S, the nitrogen input from sludge spreading, but F_S increases $N_2O_{indirect\text{-}leach}$ through its inclusion in F_{AW}. The default value for $Frac_{LEACH}$, the fraction of nitrogen lost through leaching, in the IPCC Guidelines is 30 percent. Estimates of the nitrogen loads in Irish rivers reported under the OSPAR Convention (NEUT, 1999) suggest that approximately 10 percent of all applied nitrogen in Irish agriculture is lost through leaching. This level of leaching is also indicated by farm budget studies where the nitrogen runoff equivalent to 60 kg N/ha has been measured in streams adjoining farmland receiving 200 kg N/ha from chemical fertilizer and 100 kg N/ha from animal manures per year. The value of 0.1 is considered to be a more realistic estimate of $Frac_{LEACH}$ than the default value of 0.3 and it is used for 2008, as it was for previous years.

The IPCC default values of the emission factors EF_4 and EF_5 (0.01 kg N_2O-N/kg NH_3-N emitted for synthetic fertilizer and animal waste nitrogen and 0.025 kg N_2O-N/kg N leached) are used to estimate indirect N_2O emissions. Total indirect emissions in 2008 amounted to 3.89 Gg N_2O, or approximately 50 percent of direct emissions from soils (sub-category 4.D.1).

6.6 Uncertainties and Time-Series Consistency

Uncertainties in estimates of emissions from the agriculture sector have been reduced through the use of Tier 2 methods for the calculation of CH_4 emissions from enteric fermentation and manure management. In addition, the use of country-specific information in relation to manure management has reduced the uncertainties associated with the estimation of N_2O from manure management and agricultural soils. A comparison of the uncertainties associated with emission estimates prior to the use of Tier 2 methodologies for CH_4 and the use of country-specific information in relation to manure management are shown in Table 6.4. Large uncertainties still remain in relation to the N_2O emissions from the agricultural sector. .

The emission time series for agriculture 1990–2008 is consistent. Key activity data such as disaggregated animal number and fertiliser use statistics are available for all years and are used in a consistent manner. Tier 2 methodologies for categories 4.A and 4.B are used in conjunction with the key activity data to provide emission estimates for all years in the time series 1990-2008.

Table 6.4 Uncertainties in Activity Data and Emission Factors in Agriculture

		Pre 2006		Post 2006	
		Activity Data Uncertainty	Emission Factor Uncertainty	Activity Data Uncertainty	Emission Factor Uncertainty
4.A Dairy Cattle	CH_4	1	20	1	15
4.A Other Cattle	CH_4	1	30	1	15
4.A Other Livestock	CH_4	1	50	1	30
4.B Dairy Cattle	CH_4			1	15
4.B Other Cattle	CH_4	32	50	1	15
4.B Other Livestock	CH_4			1	30
4.B Liquid System	N_2O	32	100	11.2	100
4.B Solid Storage and Dry lot	N_2O			11.2	100
4.D Direct Soil emissions	N_2O			11.2	100
4.D Pasture Rand and Paddock	N_2O	32	100	11.2	100
4.D Indirect Emissions	N_2O			11.2	100

6.7 Quality Assurance and Quality Control

A spreadsheet system developed for the 2006 submission is used to estimate emissions from *Agriculture* in an efficient and transparent manner, which takes into account the strong links to Ireland's Tier 2 inventory of NH_3 in *Agriculture* and other factors relevant to a more complete country-specific application of the IPCC good practice guidance. The general QA/QC procedures set down in Ireland's QA/QC plan (section 1.6) have been undertaken in this compilation and inventory management system, from which the time-series outputs may be readily imported to the CRF Reporter. The spreadsheets incorporate transparent linking between input data statistics and calculations as well as internal checks on the calculations and the outputs are directly compatible with the CRF Reporter. The entire compilation for 2006 and all-previous years was reviewed externally by a technical person from the Department of Agriculture, Fisheries and Food as an important element of quality assurance for the 2008 submission. No further reviews of this type are being undertaken until there is a major methodological change for the sector and normal QA/QC procedures are considered to suffice for the status of inventory now achieved for *Agriculture*.

The collaboration between inventory experts and researchers involved in developing the improved inventory methodologies for both CH_4 and NH_3 adds significantly to the quality and reliability of the emissions estimates for agriculture. The ongoing assessment and endorsement of the outcomes by other experts in TEAGASC and the DEHLG according to the IPCC good practice guidance is being maintained by the inventory agency and is an important part of the overall QA/QC procedures being undertaken on an annual basis. Similar to the 2008 submission a member of the inventory team undertook a re-examination of some of the underlying assumptions in relation to a number of the disaggregated animal categories and animal number statistics and other activity data underlying Tier 2 CH_4

estimates. In addition in light of requirements by intensive agricultural practices to report emissions of NH_3, CH_4 and N_2O under the European Pollutant Release and Transfer Register (EPRTR) some minor changes have occurred in relation to emission estimates from the national pig population. The effect of these QA/QC procedures is described in detail in the following section (section 6.8).

6.8 Recalculations in Agriculture

Very minor changes were made for the 2010 submission regarding the estimation of emissions of CH_4, N_2O and NH_3 from manure management for pigs to ensure that the data used were consistent with those applied for compiling emissions estimates for individual pig production units under the EPRTR. The country-specific emission factors for NH_3 adopted for EPRTR reporting based on national research were taken into account in the calculation of indirect N_2O emissions for 2008 and the estimates for all years up to 2007 were recalculated. The changes to N_2O and CH_4 emission factors are minor and reflect more precise information on individual pig sub-category live-weights. The revised emission factors are only marginally lower than those previously used and the effect of the change on emissions is insignificant (CRF Table 8a).

Other minor recalculations were made to account for a revision in sheep population statistics and these are outlined in more detail in Chapter 10 Recalculations and Improvements. The results of the recalculations by category and gas are given in Table 6.5.

6.9 Improvements in Agriculture

Clearly, it is important that high priority is given to emissions of CH_4 and N_2O from agricultural sources in Ireland so that they may be quantified as reliably as possible, given their large overall contributions to the national total (Chapter Three). A large number of input variables determine the emissions in the case of both gases and the final results are very sensitive to changes in many of these variables. Assumptions relating to some calculation parameters have an important bearing on the results. While the IPCC methodologies for the agricultural emission sources that are relevant in Ireland are now very comprehensive, they remain generalised and necessarily simplified, considering the complex systems and processes that produce the CH_4 and N_2O emissions. The key to developing better estimates and reducing uncertainty is to take full account of national circumstances of climate, soil types, livestock and crop production practices, management systems and other influencing factors in a robust and justifiable manner when applying these methodologies. This has been largely achieved in the case of both CH_4 and N_2O emissions associated directly with animal production, such as those from enteric fermentation and manure management. However, this is not possible for estimating N_2O emissions from soils using the current IPCC approach and the recommended simple default emission factors. A much more in-depth model approach is needed to take account of all the factors that determine such emissions and to capture the inter-annual variation in the national emission rate. The inventory agency continues to engage with researchers working on N_2O emissions from soils, with a view to adopting a methodology that systematically accounts for the influences of soil type, fertilizer type and application rates, temperature and rainfall, which are not captured by the current IPCC methodology. However, the lack of reliable data in relation to the key soil properties including bulk density and organic carbon content has delayed the full application of such a methodology at national level.

Both the EPA and the Department of Agriculture, Fisheries and Food are actively pursuing the opportunities for N_2O emissions research in Ireland with a number of projects being currently funded. Recently published research at both field and lysimeter scales conducted in Ireland suggest that N_2O emission rates from agricultural soils may be substantially higher than the value of 1.25 percent given by the current IPCC default emission factor. The high inter-annual and spatial variability in emission estimates found in these studies requires further investigation and long-term emission datasets are required.

Table 6.5 Percentage change in emissions from Agriculture due to Recalculations

			1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
			Estimates in 2009 Submission (Gg)																	
4.A	Enteric Fermentation	CH_4	452.08	456.26	459.12	461.04	458.83	458.72	469.20	479.45	486.98	475.11	452.53	447.87	444.79	440.87	440.22	437.48	435.36	421.01
4.B	Manure Management	CH_4	110.88	111.89	112.96	113.19	112.41	111.98	115.90	118.71	120.31	115.81	110.07	110.02	110.03	108.28	107.62	107.25	106.30	102.78
4.B	Manure Management	N_2O	1.28	1.32	1.33	1.35	1.35	1.37	1.38	1.41	1.45	1.47	1.39	1.34	1.31	1.30	1.29	1.29	1.28	1.24
4.D.1	Direct Soil emissions	N_2O	9.23	9.07	8.85	9.19	9.74	10.26	10.03	9.34	10.41	10.65	9.87	9.05	8.93	9.45	9.02	8.71	8.36	7.91
4.D.2	Pasture Range and Paddock	N_2O	9.04	9.19	9.35	9.34	9.33	9.32	9.57	9.79	10.03	9.77	9.33	9.23	9.12	9.13	9.11	9.10	8.98	8.65
4.D.3	Indirect emissions	N_2O	4.34	4.35	4.34	4.44	4.54	4.64	4.69	4.60	4.88	4.90	4.63	4.38	4.31	4.39	4.27	4.22	4.16	3.97
4	Total Methane	CH_4	562.96	568.14	572.08	574.23	571.24	570.70	585.09	598.16	607.29	590.92	562.60	557.89	554.82	549.15	547.84	544.73	541.66	523.79
4	Total Nitrous oxide	N_2O	23.89	23.93	23.87	24.31	24.95	25.59	25.68	25.15	26.78	26.79	25.23	24.00	23.66	24.27	23.69	23.32	22.77	21.77
4	Total (CO_2 eq)	CO_2 eq	19,228.57	19,349.71	19,412.26	19,596.26	19,731.77	19,917.49	20,246.33	20,358.36	21,054.92	20,714.54	19,634.93	19,157.13	18,987.17	19,056.44	18,849.54	18,667.67	18,434.64	17,747.86
			Recalculated Estimates in 2010 Submission (Gg)																	
4.A	Enteric Fermentation	CH_4	452.07	456.24	459.10	461.03	458.82	458.71	469.18	479.43	486.97	475.10	452.52	447.31	443.96	440.05	440.20	437.46	435.35	421.00
4.B	Manure Management	CH_4	110.69	111.67	112.73	113.03	112.27	111.84	115.68	118.51	120.12	115.57	109.89	109.82	109.86	108.09	107.46	107.08	106.17	102.64
4.B	Manure Management	N_2O	1.28	1.32	1.33	1.35	1.35	1.37	1.38	1.41	1.45	1.47	1.39	1.34	1.31	1.30	1.29	1.29	1.28	1.24
4.D.1	Direct Soil emissions	N_2O	9.23	9.07	8.85	9.19	9.74	10.25	10.03	9.34	10.41	10.65	9.87	9.05	8.93	9.45	9.02	8.70	8.35	7.91
4.D.2	Pasture Range and Paddock	N_2O	9.04	9.19	9.35	9.34	9.33	9.32	9.57	9.79	10.03	9.77	9.33	9.23	9.12	9.13	9.11	9.10	8.98	8.65
4.D.3	Indirect emissions	N_2O	4.34	4.35	4.34	4.43	4.54	4.64	4.69	4.60	4.88	4.90	4.63	4.38	4.31	4.39	4.27	4.22	4.16	3.97
4	Total Methane	CH_4	562.76	567.91	571.83	574.06	571.09	570.55	584.86	597.94	607.09	590.67	562.42	557.13	553.82	548.14	547.66	544.54	541.52	523.64
4	Total Nitrous oxide	N_2O	23.89	23.93	23.86	24.31	24.95	25.59	25.67	25.15	26.78	26.79	25.22	24.00	23.66	24.27	23.69	23.31	22.77	21.77
4	Total (CO_2 eq)	CO_2 eq	19,223.13	19,343.45	19,405.52	19,591.52	19,727.84	19,913.30	20,240.08	20,352.46	21,049.44	20,707.69	19,629.88	19,139.88	18,965.33	19,033.94	18,844.83	18,662.09	18,430.81	17,743.93
			Percentage Change in Total Emissions due to Recalculations																	
4.A	Enteric Fermentation	CH_4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.12	-0.19	-0.19	0.00	-0.01	0.00	0.00
4.B	Manure Management	CH_4	-0.17	-0.19	-0.21	-0.15	-0.12	-0.13	-0.19	-0.17	-0.16	-0.20	-0.16	-0.19	-0.15	-0.17	-0.15	-0.15	-0.13	-0.13
4.B	Manure Management	N_2O	-0.02	-0.02	-0.03	-0.02	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02
4.D.1	Direct Soil emissions	N_2O	-0.03	-0.03	-0.03	-0.02	-0.02	-0.02	-0.03	-0.03	-0.02	-0.03	-0.02	-0.02	-0.01	-0.01	-0.02	-0.04	-0.02	-0.02
4.D.2	Pasture Range and Paddock	N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.D.3	Indirect emissions	N_2O	-0.03	-0.04	-0.04	-0.03	-0.02	-0.02	-0.03	-0.03	-0.03	-0.04	-0.03	-0.04	-0.04	-0.05	-0.03	-0.03	-0.03	-0.03
4	Total Methane	CH_4	-0.04	-0.04	-0.04	-0.03	-0.03	-0.03	-0.04	-0.04	-0.03	-0.04	-0.03	-0.14	-0.18	-0.19	-0.03	-0.03	-0.03	-0.03
4	Total Nitrous oxide	N_2O	-0.02	-0.02	-0.02	-0.01	-0.01	-0.01	-0.02	-0.02	-0.01	-0.02	-0.01	-0.02	-0.01	-0.02	-0.01	-0.02	-0.01	-0.01
4	Total (CO_2 eq)	CO_2 eq	-0.03	-0.03	-0.03	-0.02	-0.02	-0.02	-0.03	-0.03	-0.03	-0.03	-0.03	-0.09	-0.12	-0.12	-0.02	-0.03	-0.02	-0.02

Chapter Seven

Land-Use, Land-Use Change and Forestry

7.1 Introduction

Following the publication of the IPCC Special Report on Land Use, Land-Use Change and Forestry (LULUCF) and adoption of the IPCC good practice guidance on Land Use, Land-Use Change and Forestry (IPCC, 2003), the source category classification for reporting on the LULUCF sector was revised by Decision 13/CP.9 to that given in Table 7.1. The six top-level categories are used to represent managed land areas and they are broadly defined to accommodate all land areas in most countries, taking into account possible differences in national classification systems. Each category is split into two sub-categories, which may be further sub-divided to reflect national circumstances and the level of detail considered most appropriate for the estimation of relevant emissions and removals. The conversion sub-categories allow for the tracking of land to the principal fixed categories by assuming that a unit of land subject to a change of use remains in the conversion sub-category for 20 years before it is reported in the top-level category to which it has been converted. The revised area-based approach is intended to make the best use of the various types of data likely to be available for the given categories of land and reduce possible overlaps and omissions in reporting for national total land areas.

The net emissions of CO_2 to, or removals of CO_2 from the atmosphere are to be reported with respect to overall carbon gain or loss for up to four relevant carbon pools for the defined land categories. These pools are above-ground biomass, below-ground biomass, dead organic matter (litter and dead wood) and soils. The IPCC good practice guidance on LULUCF provides basic methodologies for calculating changes in carbon pools where land areas form the basic activity data and carbon stock change is determined from a number of other parameters. Various levels of land sub-division may be used to capture differences due to climate, management system, vegetation type or other factors influencing carbon exchange. As for other sectors of the inventory, the IPCC good practice guidance for LULUCF also provides higher tier methods for estimating emissions and removals, which may be used if the necessary data are available. The liming of agricultural lands, which produces CO_2 emissions, is another important source included in the LULUCF sector. Emissions of N_2O in the LULUCF sector are reported for such activities as nitrogen fertilization of forest land, soil disturbance associated with land-use conversion to cropland and optionally for drainage of forest land and wetlands, while taking into account potential overlap with the *Agriculture* sector in some cases. Emissions of N_2O and CH_4 are also to be reported for biomass burning.

7.2 Overview of LULUCF Sector

7.2.1 Sector Coverage

The 2006 inventory submission included the results of Ireland's first attempts to comply with the reporting requirements of Decision 13/CP.9 for the LULUCF sector. Following the same approach, complete coverage of the relevant gases has been achieved for the years 1990-2008 in all IPCC land categories, as indicated by Table 7.1, whereas in submissions prior to 2006 Ireland reported CO_2 estimates only in respect of carbon stock change in forests and CO_2 emissions from the liming of agricultural soils. The reporting of estimates for all land-use categories in LULUCF represents a major improvement in terms of inventory completeness for Ireland. This chapter presents a broad description of data treatment and the methodologies used to estimate emissions and removals for the relevant land categories in the time-series 1990-2008. The estimates for 5.A Forest Land (except for the soils pool) are prepared under the responsibility of COFORD and submitted to the inventory agency in accordance with the MOU between COFORD and the Office of Climate Licensing and Resource Use of the EPA (section 1.3 of this report). All other emissions and removals estimates are prepared by a research fellow working directly to the inventory agency in OCLR. A more detailed report on the work undertaken to report on the LULUCF sector is available (O'Brien, 2007).

Table 7.1. Level 3 Source Category Coverage for Land Use, Land-Use Change and Forestry

5 Land Use Land-Use Change and Forestry	Carbon Stock Change Emissions of CO_2			CH_4	N_2O
	Biomass	DOM	Soils		
A. Forest Land					
1. Forest Land remaining Forest Land	All	All	NO*	All	Part, IE
2. Land converted to Forest Land	All	All	All	NA	IE
B. Cropland					
1. Cropland remaining Cropland	NO	NO	NO*	NA	NE
2. Land converted to Cropland	All	NO	All	NA	All
C. Grassland					
1. Grassland remaining Grassland	NO	NO	NO*	NO	NE
2. Land converted to Grassland	All	NO	All	NO	NE
D. Wetlands					
1. Wetlands remaining Wetlands	All	NO	All	NO	NE
2. Land converted to Wetlands	NO	NO	NO	NO	All
E. Settlements					
1. Settlements remaining Settlements	NO	NO	NA	NO	NE
2. Land converted to Settlements	All	NO	All	NO	NE
F. Other Land					
1. Other Land remaining Other Land	NO	NO	NO*	NO	NO
2. Land converted to Other Land	NO	NO	All	NO	NO
G. Other					
Agricultural Lime Application	NA	NA	All	NA	NA

DOM : dead organic matter
All : all emission sources covered; NE : emissions not estimated; NO : activity not occurring; NA : not applicable (no emissions of the gas occur in the pool/source category); IE : emissions included elsewhere.
** Under the Tier 1 method, there is no carbon stock change in soil for these land categories*

The 2008 inventory for LULUCF follows the same general approach and methodologies as those used for the 2008 and 2009 submissions. However, in the case of *5.A Forest Land*, there are some minor modifications in regard to the treatment of areas and other parameters in order to be as consistent as possible in reporting emissions and removals for forests under the Convention and under the Kyoto Protocol. Following recommendations of the 2007 in-country review of Ireland's national inventory, emissions of N_2O and CH_4 were reported by Ireland for the first time in the 2008 submission with the exception of N_2O emissions from the use of fertiliser in forests. The amount of nitrogen fertilizer used in forests is negligible compared to that used in agriculture and therefore all N_2O emissions from nitrogen fertilization are reported in the *Agriculture* sector and the notation IE is used in CRF Table 5(I). Information regarding the occurrence of forest wildfires in Ireland is available to facilitate the reporting of CH_4 and N_2O emissions from biomass burning in CRF Table 5(V).

The estimates of emissions and removals from LULUCF over the period 1990-2008 are presented in Table 7.2 for all land-use categories. The LULUCF sector was a significant net source of emissions up to 1997 and was a net sink of carbon in most years thereafter, with removals increasing substantially towards the end of the reported time-series. This result is determined mainly by the balance between the removals in category *5.A Forest Land* and the emissions from *5.C Grassland* and from lime applications. The most important individual emission categories over the time-series are the carbon release from soils in *5.A.2 Land Converted to Forest Land* and the CO_2 emissions from agricultural lime application on Grassland and Cropland. The increase in carbon stocks in living biomass in the category *5.A.1 Forest Land remaining Forest Land* is the dominant removal that offsets CO_2 emissions.

The Wetland, Settlements and Other Land categories are comparatively unimportant in terms of emissions or removals but Cropland constitutes a significant net source of carbon to the atmosphere towards the end of the time series. The inclusion of CH_4 and N_2O through the coverage of additional emission sources has a very minor effect on total emissions from LULUCF. The results contained in the 2010 submission for the years 1990-2008 for the LULUCF sector according to the requirements of Decision 13/CP.9 are not directly comparable with those provided in respect of land use change and forestry in submissions prior to 2006.

7.2.2 Land Use Definitions and Land Use Change Matrices

Table 7.3 summarises the definitions and coverage of the IPCC land-use categories in the LULUCF sector as they relate to Ireland along with the data sources that are used for estimating the respective areas remaining in the categories, the areas converted to the categories and their associated greenhouse gas emissions and removals. The IPCC *Wetlands* category has been split into natural unexploited wetlands (unmanaged), and peatlands, the latter being managed wetland areas that are drained for the purpose of commercial and domestic harvesting of peat for combustion or horticultural use.

Table 7.4 records the land-use changes among the various categories over the period 1990-2008 in the form of land-use change matrices for the individual years relative to the total national area of 7.11 million hectares, based on CORINE land-cover data. The matrices of land use are intended to show the dynamism of changes in Irish land use and to identify the conversions that are most significant in terms of their potential to contribute to either emissions or removals of greenhouse gases over the inventory time-series. The annual totals for individual years in the matrices do not necessarily correspond with the areas that appear as activity data for each year under the different land categories in the various sectoral background data tables in the CRF tables because the latter account for the rolling 20-year transition period that began in 1970. In addition, the area relevant to the biomass pool is not the same as that for the soils pool for *5.A.2 Land Converted to Forest Land* due to the combination of the three national forest area classes (young, mature and clear-felled) used in Ireland's approach to quantify carbon stock change in forest biomass. This is also the case for *5.D.1 Wetlands Remaining Wetlands* (peatland in Ireland) because different lengths of transition period apply to organic and mineral soils.

Grassland is the dominant land-use category in all years, accounting for 58.2 percent of total area in 1990, followed by *Wetland* accounting for 17.2 percent. The *Other Land* category is the next largest at 11.2 percent, followed by C*ropland* at 5.7 percent with *Forest Land* accounting for the remaining 5.2 percent of the total. The major land-use change since 1990 has been the conversion of grassland and peatland to forest land. The area of forests has increased by 67.3 percent between 1990 (370,126 ha) and 2008 (619,248 ha). However, the proportion of *Forest Land* to total land in the country is only 8.7 percent, which is low compared to many other Annex I Parties.

Table 7.2. Emissions[a] and Removals[a] from Land Use Land-Use Change and Forestry 1990-2008 (Gg CO_2 eq)

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
		Estimates in 2010 Submission (Gg CO_2eq.)																		
5.A	**Forest Land**	-339.82	-308.27	-108.46	-193.96	-132.41	-133.97	-126.65	-271.05	-449.12	-557.91	-444.80	-584.27	-778.70	-1044.47	-717.49	-906.73	-975.14	-1516.89	-2167.41
5.A.1	Forest Land remaining Forest Land	-999.06	-1151.18	-876.51	-863.00	-574.29	-395.39	-338.08	-235.83	-523.13	-572.63	-96.06	4.77	-374.72	-1210.56	-750.29	-898.98	-856.46	-1490.32	-2368.95
5.A.2	Land converted to Forest Land	659.24	842.91	768.05	669.05	441.88	261.42	211.43	-35.22	74.00	14.71	-348.74	-589.04	-403.97	166.09	32.81	-7.75	-118.68	-26.58	201.54
5.A	Biomass burning	13.48	8.62	5.53	11.15	12.72	17.16	18.91	10.37	5.48	4.47	11.15	22.10	5.05	31.21	18.18	6.60	6.63	7.49	9.22
5.A	Drainage of soils	10.47	11.08	11.40	11.81	12.06	12.83	13.28	13.26	13.47	13.67	14.05	14.49	14.74	14.92	15.21	15.56	15.75	15.85	16.04
5.B	**Cropland**	20.00	21.19	16.67	-26.66	-17.59	-35.01	48.20	53.24	5.77	-18.68	22.64	104.76	117.66	123.21	148.10	126.03	72.54	96.54	338.30
5.B.1	Cropland remaining Cropland	20.00	21.19	9.65	-58.90	-87.54	-62.86	-25.13	-20.09	-39.12	-63.57	-22.25	-28.22	-34.70	-35.32	-26.31	-0.14	-53.63	-29.63	-21.17
5.B.2	Land converted to Cropland	NE,NO	NE,NO	7.01	32.24	69.96	27.85	73.33	73.33	44.89	44.89	44.89	132.98	152.36	158.53	174.41	126.18	126.18	126.18	359.47
5.B	Agricultural Lime Application[b]	36.66	32.51	26.31	36.95	27.48	50.28	50.29	44.31	31.42	38.86	37.25	40.48	29.70	43.19	26.44	26.85	25.49	37.22	29.13
5.B.2	Emissions from soil disturbance	NA,NO	NA,NO	0.29	3.08	3.08	3.08	4.97	4.97	4.97	4.97	4.97	8.62	10.77	13.97	13.97	13.97	13.97	13.97	23.65
5.C	**Grassland**	493.47	556.83	431.52	344.93	174.67	379.01	414.97	496.96	310.43	398.80	468.81	452.81	457.96	553.37	334.93	197.11	299.50	333.44	290.28
5.C.1	Grassland remaining Grassland	621.96	583.23	529.88	618.43	523.23	718.45	707.74	648.56	543.55	613.75	598.52	614.19	512.98	611.73	480.36	505.90	494.31	604.49	493.91
5.C.2	Land converted to Grassland	-128.49	-26.39	-98.37	-273.51	-348.56	-339.44	-292.77	-151.60	-233.12	-214.96	-129.71	-161.38	-55.02	-58.36	-145.43	-308.79	-194.81	-271.05	-203.64
5.C	Agricultural Lime Application[b]	318.38	282.64	229.29	320.35	242.16	444.32	433.74	379.17	274.16	344.37	329.14	344.80	244.20	343.57	214.35	239.89	229.37	339.54	233.08
5.D	**Wetlands**	47.07	46.21	45.68	44.97	42.37	40.94	39.18	37.69	36.19	34.39	45.66	43.36	41.06	38.77	36.47	36.07	35.67	24.31	27.34
5.D.1	Wetlands remaining Wetlands	47.07	46.21	45.68	44.97	42.37	40.94	39.18	37.69	36.19	34.39	45.66	43.36	41.06	38.77	36.47	36.07	35.67	24.31	27.34
5.D.2	Land converted to Wetlands	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
5.D	Drainage of soils	3.59	3.54	3.52	3.48	3.46	3.42	3.35	3.31	3.27	3.20	3.15	3.11	3.07	3.03	2.99	2.95	2.91	2.81	2.74
5.E	**Settlements**	12.80	11.72	11.94	12.74	15.69	15.81	19.86	21.66	23.12	24.74	26.08	34.34	30.51	37.23	39.19	46.05	48.29	49.60	41.24
5.E.1	Settlements remaining Settlements	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
5.E.2	Land converted to Settlements	12.80	11.72	11.94	12.74	15.69	15.81	19.86	21.66	23.12	24.74	26.08	34.34	30.51	37.23	39.19	46.05	48.29	49.60	41.24
5.F	**Other Land**	-1.24	0.00	-13.26	-0.57	-2.31	0.00	-22.82	-6.75	-5.59	0.00	0.00	-14.01	-16.83	0.00	-35.60	-6.95	-12.17	0.00	-43.12
5.F.1	Other Land remaining Other Land	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.F.2	Land converted to Other Land	-1.24	NE,NO	-13.26	-0.57	-2.31	NE,NO	-22.82	-6.75	-5.59	NE,NO	NE,NO	-14.01	-16.83	NE,NO	-35.60	-6.95	-12.17	NE,NO	-43.12
5.G	**G. Other**	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5	TOTAL LULUCF CO_2 (net emissions/removals)	232.27	327.69	384.08	181.45	80.42	266.78	372.74	331.74	-79.20	-118.67	118.39	36.99	-148.33	-291.91	-194.39	-508.41	-531.30	-1,013.01	-1,513.37
5	TOTAL LULUCF GHGs (net emissions/removals)	247.56	343.09	399.80	200.83	100.18	287.67	396.05	354.22	-56.99	-96.43	141.58	65.22	-119.29	-257.17	-160.58	-475.34	-498.07	-979.69	-1470.10

[a] positive values indicate emissions and negative values indicate removals

[b] the emissions from lime application to grassland and cropland are reported in CRF Table 5(IV) rather than under Grassland in CRF Tables 5.B and 5.C, respectively. These emissions are not included in the totals for 5.C Grassland and 5.B Cropland

Table 7.3. Land Use Categories

Land Use Category	Definition and Coverage	Area 1990 (ha)	Area 2006 (ha)	Sources of Information	Principal Conversions	
					To	From
Forest Land	All public and private plantation forests. Forest land is an area of land where tree crown cover is greater than 20% of the total area occupied or 50% of conventional stocking and includes recently clearfelled areas. It has a minimum width of 20m and a minimum area of 0.1ha and includes all trees with a potential to reach 5m in height. Trees grown for fruit or flowers are excluded, as are woody species such as furze and rhododendron	370,126	612,190	FIPS (Forest Inventory and Planning System) 1995 COILLTE database Forest Service Premiums database LPIS (Land Parcels information System) CORINE Land Cover General Soil Map		Grassland
Cropland	Permanent crops and tillage areas (including setaside) recorded by the Central Statistics Office (CSO)	404,563	377,300	CSO, CORINE Land Cover LPIS (Land Parcels information System		Grassland
Grassland	Areas of improved grassland (pasture and areas used for the harvesting of hay and silage) and unimproved grassland (rough grazing) in use as recorded by CSO annual statistics	4,140,385	3,896,500	CSO, CORINE Land Cover LPIS (Land Parcels information System) CORINE Land Cover General Soil Map		Other Land
Wetlands	Natural unexploited wetlands	1,226,142	1,133,665	CORINE Land Cover General Soil Map	Peatlands	
Peatland	Wetland areas commercially exploited for public and private extraction of peat and areas used for domestic harvesting of peat	73,765	57,744	Bord na Mona (BNM) area statistics; Expert opinion		
Settlements	Urban areas, roads, airports and the footprint of industrial, commercial/institutional and residential buildings	98,152	112,574	CORINE Land Cover; National Roads Authority (NRA) road construction statistics; CSO housing stock, house completions and other construction floor area statistics; General Soil Map		Grassland
Other Land	Natural grasslands not in use for agricultural purposes, water bodies, bare rock	798,654	921,812	Natural grasslands not in use for agricultural purposes, water bodies, bare rock	Grassland	
Total Land	National territorial area (including inland water bodies and salt marshes and intertidal zones)	7,111,785	7,111,785	CORINE Land Cover		

Table 7.4 Land Use Matrices 1990-1997 (ha)

	Forest Land	Grassland	Cropland	Peatland	Wetland	Settlements	Other Land	Total
1990	**370,126**	**4,140,385**	**404,563**	**73,765**	**1,226,142**	**98,152**	**798,654**	**7,111,785**
Forest Land	370,094					31		370,126
Grassland	8,782	4,131,333				270		4,140,385
Cropland	356	2,489	401,694			24		404,563
Peatland	320	61		73,165	219			73,765
Wetland	9,689				1,216,453			1,226,142
Settlements						98,152		98,152
Other Land		16,370				18	782,266	798,654
1991	**389,241**	**4,150,253**	**401,694**	**72,763**	**1,216,671**	**98,495**	**782,668**	**7,111,785**
Forest Land	389,210					32		389,241
Grassland	7,264	4,119,655	1,216			274	21,844	4,150,253
Cropland	269		401,400			25		401,694
Peatland	320	61		72,164	219			72,763
Wetland	8,847				1,207,825			1,216,671
Settlements						98,495		98,495
Other Land						18	782,650	782,668
1992	**405,909**	**4,119,716**	**402,616**	**72,274**	**1,208,044**	**98,844**	**804,383**	**7,111,785**
Forest Land	405,875					34		405,909
Grassland	7,715	4,099,263	11,510			293	935	4,119,716
Cropland	314		402,275			26		402,616
Peatland	320	61		71,674	219			72,274
Wetland	7,649				1,200,395			1,208,044
Settlements						98,844		98,844
Other Land						19	804,364	804,383
1993	**421,873**	**4,099,324**	**413,785**	**71,515**	**1,200,614**	**99,216**	**805,459**	**7,111,785**
Forest Land	421,831					42		421,873
Grassland	9,275	4,085,878				361	3,811	4,099,324
Cropland	416	3,036	410,301			32		413,785
Peatland	320	61		70,915	219			71,515
Wetland	9,449				1,191,165			1,200,614
Settlements						99,216		99,216
Other Land						24	805,436	805,459
1994	**441,290**	**4,088,974**	**410,301**	**70,982**	**1,191,384**	**99,675**	**809,180**	**7,111,785**
Forest Land	441,247					42		441,290
Grassland	10,944	4,077,665				365		4,088,974
Cropland	525	467	409,277			33		410,301
Peatland	140	30		70,122	690			70,982
Wetland	12,100				1,179,283			1,191,384
Settlements						99,675		99,675
Other Land		9,685				24	799,470	809,180
1995	**464,957**	**4,087,847**	**409,277**	**70,183**	**1,179,973**	**100,138**	**799,409**	**7,111,785**
Forest Land	464,904					54		464,957
Grassland	9,710	4,032,277	7,812			461	37,587	4,087,847
Cropland	495		408,740			42		409,277
Peatland	140	30		69,323	690			70,183
Wetland	10,636				1,169,337			1,179,973
Settlements						100,138		100,138
Other Land						30	799,379	799,409
1996	485,885	4,032,307	416,552	68,859	1,170,027	100,725	837,430	7,111,785
Forest Land	485,826					59		485,885
Grassland	5,589	4,015,089				507	11,123	4,032,307
Cropland	326	2,081	414,100			46		416,552
Peatland	140	30		67,999	690			68,859
Wetland	5,380				1,164,648			1,170,027
Settlements						100,725		100,725
Other Land						33	837,397	837,430
1997	**497,260**	**4,017,200**	**414,100**	**67,967**	**1,165,338**	**101,369**	**848,552**	**7,111,785**

Table 7.4 (continued) Land Use Matrices 1997-2004 (ha)

	Forest Land	Grassland	Cropland	Peatland	Wetland	Settlements	Other Land	Total
1997	**497,260**	**4,017,200**	**414,100**	**67,967**	**1,165,338**	**101,369**	**848,552**	**7,111,785**
Forest Land	497,197					63		497,260
Grassland	6,396	4,001,045				546	9,214	4,017,200
Cropland	326	5,725	408,000			49		414,100
Peatland	140	30		67,107	690			67,967
Wetland	6,066				1,159,272			1,165,338
Settlements						101,369		101,369
Other Land						36	848,516	848,552
1998	**510,125**	**4,006,800**	**408,000**	**67,066**	**1,159,962**	**102,063**	**857,771**	**7,111,785**
Forest Land	510,057					68		510,125
Grassland	7,177	3,999,037				587		4,006,800
Cropland	423	6,624	400,900			53		408,000
Peatland	140	30		66,206	690			67,066
Wetland	4,929				1,155,033			1,159,962
Settlements						102,063		102,063
Other Land		11,709				38	846,024	857,771
1999	**522,725**	**4,017,400**	**400,900**	**65,670**	**1,155,723**	**102,809**	**846,559**	**7,111,785**
Forest Land	522,652					72		522,725
Grassland	8,489	4,008,290				621		4,017,400
Cropland	490	254	400,100			56		400,900
Peatland	327	75		63,724	1,544			65,670
Wetland	6,389				1,149,334			1,155,723
Settlements						102,809		102,809
Other Land		33,282				41	813,237	846,559
2000	**538,347**	**4,041,900**	**400,100**	**64,707**	**1,150,878**	**103,598**	**812,254**	**7,111,785**
Forest Land	538,252					96		538,347
Grassland	8,481	3,994,425	14,991			823	23,179	4,041,900
Cropland	517		399,509			74		400,100
Peatland	327	75		62,763	1,542			64,707
Wetland	6,139				1,144,740			1,150,878
Settlements						103,598		103,598
Other Land						54	812,200	812,254
2001	**553,716**	**3,994,500**	**414,500**	**63,866**	**1,146,282**	**104,645**	**834,277**	**7,111,785**
Forest Land	553,630					86		553,716
Grassland	8,624	3,948,525	8,793			738	27,821	3,994,500
Cropland	526		413,907			66		414,500
Peatland	327	75		61,922	1,542			63,866
Wetland	5,577				1,140,705			1,146,282
Settlements						104,645		104,645
Other Land						48	834,228	834,277
2002	**568,684**	**3,948,600**	**422,700**	**63,020**	**1,142,247**	**105,583**	**860,951**	**7,111,785**
Forest Land	568,579					105		568,684
Grassland	5,145	3,929,253	13,297			905		3,948,600
Cropland	315		422,303			81		422,700
Peatland	327	75		61,076	1,542			63,020
Wetland	3,310				1,138,937			1,142,247
Settlements						105,583		105,583
Other Land		4,572				59	856,320	860,951
2003	**577,676**	**3,933,900**	**435,600**	**62,175**	**1,140,479**	**106,734**	**855,220**	**7,111,785**
Forest Land	577,565					111		577,676
Grassland	5,831	3,868,569				954	58,546	3,933,900
Cropland	358	12,356	422,800			86		435,600
Peatland	327	75		60,231	1,542			62,175
Wetland	3,223				1,137,256			1,140,479
Settlements						106,734		106,734
Other Land						62	855,158	855,220
2004	**587,304**	**3,881,000**	**422,800**	**61,334**	**1,138,798**	**107,947**	**912,602**	**7,111,785**

Table 7.4 (continued) Land Use Matrices 2004-2008 (ha)

	Forest Land	Grassland	Cropland	Peatland	Wetland	Settlements	Other Land	Total
2004	**587,304**	**3,881,000**	**422,800**	**61,334**	**1,138,798**	**107,947**	**912,602**	**7,111,785**
Forest Land	587,174					130		587,304
Grassland	6,221	3,862,310				1,123	11,346	3,881,000
Cropland	384	38,415	383,900			101		422,800
Peatland	327	75		59,390	1,542			61,334
Wetland	3,164				1,135,634			1,138,798
Settlements						107,947		107,947
Other Land						73	912,529	912,602
2005	**597,270**	**3,900,800**	**383,900**	**60,516**	**1,137,176**	**109,374**	**922,749**	**7,111,785**
Forest Land	597,133					137		597,270
Grassland	4,753	3,874,724				1,178	20,145	3,900,800
Cropland	293	4,701	378,800			106		383,900
Peatland	327	75		58,572	1,542			60,516
Wetland	2,664				1,134,511			1,137,176
Settlements						109,374		109,374
Other Land						77	922,673	922,749
2006	**605,170**	**3,879,500**	**378,800**	**59,724**	**1,136,054**	**110,872**	**941,666**	**7,111,785**
Forest Land	605,015					155		605,170
Grassland	4,243	3,873,918				1,339		3,879,500
Cropland	262	1,118	377,300			120		378,800
Peatland	80	53		59,388	202			59,724
Wetland	2,591				1,133,463			1,136,054
Settlements						110,872		110,872
Other Land		21,411				87	920,168	941,666
2007	**612,190**	**3,896,500**	**377,300**	**59,388**	**1,133,665**	**112,574**	**920,168**	**7,111,785**
Forest Land	612,073					117		612,190
Grassland	4,243	3,780,947	39,852			1,008	70,450	3,896,500
Cropland	262		376,948			91		377,300
Peatland	80	53		57,470	141			57,744
Wetland	2,591				1,131,075			1,133,665
Settlements						112,413		112,413
Other Land						66	921,907	921,973
2008	**619,248**	**3,781,000**	**416,800**	**57,470**	**1,131,216**	**113,695**	**992,357**	**7,111,785**

7.2.3 Soil Type and Soil Organic Carbon

Soil organic carbon (SOC) is the basic parameter in the IPCC estimation methods for determining carbon stock changes in soils, which is the dominant source of carbon emissions in land conversion categories in LULUCF. The organic carbon status of Irish soils under native vegetation is established from the soil type and the default reference soil organic carbon stocks (SOC_{ref}) for cold, temperate moist regions (Tables 3.2.4, 3.3.3 and 3.4.4 of the IPCC good practice guidance on LULUCF). The General Soil Map of Ireland (Gardiner and Radford, 1980) is the basic data source for soil type information in Ireland. Mineral soils as identified from the general soil map are allocated to the HAC (high activity clay), LAC (low activity clay), sandy and humic soil classes used by the IPCC, while peats are allocated to the IPCC wetlands class as shown in Table 7.5, based on detailed national assessment of soil carbon stocks in Ireland (Tomlinson, 2003). The values of SOC_{ref} appropriate to each soil association may then be assigned using the correspondence to IPCC classes given in Table 7.5. The distribution of CORINE Land Use over IPCC soil classes was established in the same way to facilitate complete correspondence between land use, soil and SOC_{ref}.

Table 7.5. Soil Class Coverage and Soil Organic Carbon

General Soil Map Soil Association	IPCC Soil Class					Proportion of Soil Association in Area of Ireland
	HAC	LAC	Peaty/ Humic	Sandy Soil	Wetlands Soil	
basin peat					0.34	0.06
brown earth		0.19				0.13
brown podzolic		0.21				0.15
gley		0.30			0.02	0.22
grey brown podzolic		0.30				0.21
lithosol			0.22	1.00		0.04
lowland blanket peat					0.31	0.05
podzol			0.78			0.08
Renzinas	1.00					0.01
upland blanket peat					0.33	0.06
Proportion of IPCC Soil Class in Area of Ireland	0.01	0.71	0.10	0.01	0.17	
SOC_{ref} (t C/ha)	95	85	115	71	87	

7.2.4 Estimation of Emissions from Soils

Mineral Soils

The annual change in SOC in mineral soils over the appropriate transition period determines the carbon emissions or removals for the various land-use conversion categories as follows:

$$\Delta C = A * (SOC_0 – SOC_{0\text{-}T}) / T \qquad (7.1)$$

$$SOC = SOC_{ref} * F_{LU} * F_{MG} * F_I$$

where

- ΔC = annual change in carbon stocks
- A = area of land converted from a former land use
- SOC_0 = soil organic carbon stock for current land use
- $SOC_{0\text{-}T}$ = soil organic carbon stock for former land use
- SOC_{ref} = reference soil organic carbon under native vegetation for a given soil type in area A
- T = transition period
- F_{LU} = stock change factor for land use or land-use change type
- F_{MG} = stock change factor for management regime
- F_I = stock change factor for organic matter input

The factors F_{LU}, F_{MG} and F_I account for changes in SOC due to management practices that impact on soil carbon. Table 7.6 shows the adjustment factors derived from the product of F_{LU}, F_{MG} and F_I taken from Table 3.3.4 of the IPCC good practice guidance on LULUCF for the land uses defined for Ireland (Table 7.3). Equation 7.1 is the basic Tier 1 methodology used for estimating emissions from mineral soils for all land-use categories as described in the following sections. The default transition period of 20 years is applied for all mineral soils. The estimation procedure is performed following a simple approach that provides estimates of emissions from soils for the defined land uses in accordance with the IPCC good practice guidance for LULUCF and the available information for the country. It involves the identification and quantification of the land areas subject to a change of use, the application of the data in Table 7.5 to assign SOC_{ref} for the soil types in those land areas and the calculation of carbon stock change on the basis of the factors given in Table 7.6.

Table 7.6. Adjustment Factors for SOC

Land Use	F_{LU}	F_{MG}	F_I	Adjustment factor, AF
Cropland	0.71	1.09	1.11	0.86
Improved grassland	1.0	1.0	1.14	1.14
Unimproved grassland	1.0	1.0	NA	1.0
Rough grazing	1.0	0.95	NA	0.95
Other agricultural land (Native grassland)	1.0	1.0	NA	1.0

Organic Soils
The basic methodology for estimating emissions from organic soils is to assign a direct annual carbon loss rate that accounts for the oxidation of organic matter due to drainage, tillage or disturbance of the land area concerned. The default emission factors of 0.25 t C/ha per year for managed grassland soils and 1 t C/ha per year for cultivated cropland soils in cold temperate climatic regions given in the IPCC good practice guidance for LULUCF are adopted for Ireland. Some information is available to suggest that a transition period shorter than the default duration of 20 years is appropriate for some land-use conversions on organic soil, which is taken into account in the analysis described in the following sections.

7.3 Forest Land (Category 5.A)

7.3.1 Carbon Stock Change in Living Biomass

Previous NIRs have described Ireland's well-established Tier 2 methodology used to estimate the annual increase in forest carbon stocks in Ireland's expanding forests. A detailed account of the model used (CARBWARE version 4) is available (Gallagher et al, 2004). The output from the model has been updated to include 2008 forestry data. This is a static model, which has been used to calculate the total standing carbon content of forests year-on-year using Irish forest yield models and appropriate values of biomass expansion factor, wood density and carbon content for the various tree species to be found in Irish forests. Wood harvest is determined separately from national statistics and converted to carbon using the same values of biomass expansion factor and carbon content. In the submissions up to 2005, the value of carbon removals reported for a particular year in LUCF Table 5.A of the former CRF is the difference between standing carbon stock at the end of that year and carbon stock at the end of the previous year. This value represents the total for the above-ground biomass and below-ground biomass pools in both *5.A.1 Forest Land Remaining Forest Land* and *5.A.2 Land Converted to Forest Land* under the present reporting scheme.

Given that it fully quantifies annual change in forest biomass, the CARBWARE version 4 model is retained as the basic methodological tool for estimating carbon stock increment in LULUCF categories 5.A.1 and 5.A.2 by making the appropriate split between their respective contributing areas on the basis of the age of forests. The model as used to date accounts for total forest area in the following classes

(i) Areas of young forest from 7 to 25 years of age;

(ii) Areas of mature forests greater than 25 years old and

(iii) Cleared and unclassified areas, which are assumed not to store carbon. This area class represents total identified forest area by the Forest Service less covered forest as located by remote sensing and classified in the Forestry Inventory and Planning System (FIPS) (Fogarty, 1999).

The area representing category *5.A.2 Land Converted to Forest Land* may be readily determined from the area of young forests in class (i) above. The area for category *5.A.1 Land Remaining Forest Land* is then the total productive area less that for category 5.A.2. The allocation of carbon uptake to above-ground biomass and below-ground biomass is achieved by partitioning between these two carbon pools in the ratio 0.8:0.2. Carbon storage in this approach is attributed only to forests old enough to have biomass (i.e. more than six years old), rather than to all planted areas. The CARBWARE model does not cover deforestation and therefore cannot provide information on forest lands converted to other land categories. The following paragraphs summarise the carbon accounting methodology applied for carbon stock change in living biomass in the CARBWARE model. The activity data (forest areas, afforestation rates, harvest, etc) and the estimated carbon stock changes in biomass for *5.A Forest Land* are compiled in Table F.1 of Annex F for the years 1990-2008.

Forest Area and Species

A time series of forest strata by area and age was constructed for the years 1990-2008 using information from the FIPS base year of 1995 and the total forest area as given by the Forest Service. The FIPS survey data comprise recorded and interpreted information on areas and species for identified state forests and private forests. The young crop (7 to 25 years of age inclusive) and mature crop (greater than 25 years) classes in FIPS were broken down by species to provide nine individual strata. A third broad class covering cleared/unclassified areas (age up to 7 years) was included so that the total Forest Service area was accounted for in all years. This area class includes felled areas in which forest cover had not been re-established, recent plantings less than 7 years old, which are assumed to have no measurable biomass, and other productive un-forested areas.

Having established the basic area-species matrix for 1995, the corresponding data for the years 1996 to 2008 were obtained by accounting for annual changes in area per species, using annual data on planting and clear felling rates (Annex F), while also taking into account the progression of forested areas between the cleared, young and mature categories on the basis of age. The process was worked in reverse for the years 1994 to 1990 to obtain consistent time-series data for this period, as shown in Annex F.

The total forest areas shown in column G in table F.1 of Appendix F have been slightly revised up to 2008 to be consistent with areas reported under Article 3.3 of the Kyoto Protocol described in Chapter 11 of this NIR. The areas presented in the Convention CRF tables, i.e. corresponding to columns E and F of Table F.1, Annex F, are now equivalent to the sum of the afforestation, reforestation and deforestation and forest management areas shown in the supplementary reporting related to the Kyoto Protocol (Table 11.1 of Chapter 11). The area adjustment was applied to unclassified forest areas in column E of Table F.1, which is assumed to have a zero net emission. Therefore, this does not influence the emission or removals estimates for forest land and does not warrant a recalculation for this land use category.

Volume

The FIPS survey results do not contain wood volume or increment data. Therefore, the volume of stemwood was determined from Irish yield models (Hamilton *et al*, 1971; Forest Service, 2000) and is based on periodic current annual increment. The Coillte average weighted yield class (wood production model) was applied to all public and private sector forests for each of the FIPS categories. Main crop volume *after* thinning was used for conifers. The ages assumed for young and mature conifers were 15 and 35 years, respectively. Young broadleaved crops were allocated a nominal standing volume of 10 m^3/ha.

The volume in mature broadleaved forests was determined from the total timber plus firewood volume recorded in the inventory of private woodlands (Purcell, 1979), divided by area. Mixed mature forest volume was based on an average for the mature other conifers and broadleaves strata. The standing volume is reduced by 15 percent to allow for forest roads and rides. The reduced volumes are multiplied by biomass expansion factors (BEF) of 2 for young forests and 1.4 for mature forests (which give a weighted BEF of 1.64 for all forests) and by dry density in the range 0.35-0.55, depending on species and age, to obtain whole-tree wood volume (m^3/ha).

Harvest

Coillte records are the main source of data for wood harvesting. These data (Table F.1 of Annex F) are compiled through the company's timber sales reporting system. The annual wood harvest volumes for the main species (broadleaves, spruce, pine and other conifers) are converted to carbon using the average carbon content of 0.5 and weighted biomass expansion factor of 1.64, as in the case of volume increment. Harvest volumes include firewood, which is estimated to be in the region of 30,000 m^3/year.

Carbon Stock Increment

The carbon uptake of each FIPS category is calculated by multiplying whole-tree volume by a carbon content of 0.5 and by area. In the original version of the CRF, increment values were used to determine annual increments in carbon stocks and from these the harvest was subtracted to find the net changes in carbon stocks. In the current approach, reduced actual standing volumes (standing volumes less thinnings) on *a net areas basis* are used to estimate standing volume. Annual increment in the latest year is then calculated by subtracting the carbon stock in the previous year from the estimated carbon stock in the latest year. This is the increment less the harvest, as the thinning volumes have already been deducted in the data used and the areas are net of clear-felled volumes. The carbon stock change estimates for living biomass in forests are slightly revised on those given in the 2007 submission due to the effect of some updated information for afforestation in 2004 provided by the National Council for Forest Research and Development (COFORD).

7.3.2 Carbon Stock Change in Dead Organic Matter

Dead organic matter consists of the dead wood and litter pools. For dead wood the Tier 1 approach is used, which assumes that input is equal to output and therefore the net carbon stock change is zero (Section 3.2.1.2 of the good practice guidance for LULUCF). In the case of litter, the litter pool carbon stock changes submitted in 2009 have been recalculated using country specific data. Litterfall for broadleaf (based on sycamore ask, birch, yield class 6) and conifer crops (based on Sitka spruce yield class 16) was calculated using the Tier 3 methodology. The annual litterfall was determined as a function of leaf biomass using algorithms based on diameter at breast height (DBH) and height (H) for broadleaves (Johansson, 1992) and conifers (Tobin et al., 2006). Litterfall was then calculated using a mean leaf lifetime of 5 years for conifers, i.e. 20 percent of leaf biomass per year (Tobin et al., 2006), and 1 year for broadleaves assuming all leaves are lost each year. Additional litter inputs from harvesting activities are also taken into account. The decay constant for litter was assumed to be 0.14 t C/ha/yr based on experimental data taken from published Irish research (Saiz et al., 2007). Based on these analyses the mean net litter stock change for broadleaves was 0.31 t C/ha/yr young crops (< 20 years old) and 1.49 t C/ha/yr for old crops (>20 years old). The net litter stock change in conifer crops based on Sitka spruce yield class 16 was 0.5 t C/ha/yr for young crops (< 20 years old). This value is consistent with recently published values of 0.43 t C/ha/yr for a Sitka spruce chronosequence (Black et al., 2009). The net accumulation of litter in mature conifer crops varied from 0.7 t C/ha/yr for thinned plantations to 1.2 t C/ha/yr for unthinned areas. It is assumed that 74 percent of all conifer crops are thinned, based on National Forest inventory statistics (NFI, 2007). Therefore a weighted mean of 0.67 ha/yr^{-} was used for old conifer crops (>20 years old). Modification of the litter pool emission factors based on new research information has prompted a recalculation of the time series 1990-2007 (see recalculations). This methodology is also consistent with the method used for reporting on Article 3.3 activities (Chapter 11).

It is assumed that afforested and reforested areas less than 7 years old do not contribute to the dead organic matter pool, which is consistent with the approach above for estimating the carbon stock change in living biomass. Young forest areas, computed for rolling 20-year periods (e.g. 1971-1990, 1972-1991 etc), are split as 7 percent broadleaf and 93 percent conifer based on the species distribution in the 1995 FIPS baseline year. The area of mature forests is calculated as total forest area less young forest area and reforested area for the preceding seven years. This represents the litter producing area assuming there is no litter input in the first 7 years following reforestation. It is also assumed that the reforested area equals the harvested area. The broad leaf and conifer proportions for old forests are 31 percent and 69 percent, respectively, again chosen on the basis of the 1995 FIPS baseline year species distribution.

7.3.3 Net Carbon Stock Change in Soils

Forest Land Remaining Forest Land (5.A.1)

Under the Tier 1 approach it is assumed that the carbon stock in soil organic matter for category *5.A.1 Forest Land remaining Forest Land* remains constant, regardless of changes in forest management, forest type and disturbance. The notation key NO is therefore used under this land category in CRF Table 5.A.

Land Converted to Forest Land (5.A.2)

There has been an annual increase in the national forest area since 1970. Initially, the lands converted to forestry were of relatively poor quality, with marginal potential for economic returns under agricultural practices. In more recent years, and especially with the increase in private afforestation, land of higher quality has been converted to forestry, reflecting improved grant-aid under the afforestation programme, the decline in economic returns for conventional farming practices and a preference for less labour-intensive land usage. In order to maintain consistency, the land areas used for estimating carbon stock changes in soil are those used by COFORD in the estimation of carbon stock changes in forest biomass and in dead organic matter. The same split of the total for *5.A.2.Land Converted to Forest Land* is applied for all years (Table F.1 of Annex F) with *5.A.2.3 Wetlands Converted to Forest Land* accounting for 57 percent of the total area.

Using GIS analysis, land areas were allocated to the conversion categories 5.A.2.1 through 5.A.2.5 and to soil classes using Table 7.5. The agricultural lands converted to forest land were determined from the LPIS (Land Parcel Information Systems) database, supplied by the Forest Service, which records the areas converted as spatially defined areas. The Forest Service GIS database is a comprehensive description of all existing holdings and activities dating back to 1920. This database system provides detailed information on individual land conversion areas and plantation date from 1990 for private afforestation under grant-aided schemes. Prior to 1990, total annual afforestation area was used. It was assumed that planting practice was consistent with the practices in the early 1990's, and therefore forest areas were allocated to the various soil types in the same proportions as prevailed in the early 1990's.

The afforested areas were superimposed on the general soil map and the CORINE 1990 Land Cover Map of Ireland (level 6). This overlay combination delineated the individual areas and underlying soil type of afforested lands. It also revealed the plantation date and gave an indication of the previous land use. The previous land use given by CORINE was used as a general guidance. Where the previous land use was clearly anomalous, for example where it was indicated by CORINE that the afforested area was a water body, it was assumed that the trees were actually planted on a sub-area of unimproved grassland, which is included in the category 5.F Other Land. Although there is evidence that afforestation on mineral soils has little or no impact on the carbon stock within mineral soils under Irish conditions, there is not sufficient published data to apply a country-specific or region-specific emissions scheme. Therefore the Tier 1 IPCC defaults in the good practice guidelines were used. Accordingly, afforestation on mineral soils has been assigned the default transition period of 20 years, requiring evaluation of new forests on mineral soils from 1970 onwards. Carbon stock changes for afforested areas on mineral soils were estimated using Equation 7.1.

Previously, it was assumed that afforestation occurs on mineral and organic soils in the proportions 60 percent and 40 percent, respectively. The allocation to mineral and organic soils is now determined separately for each year using LPIS data. Recent forest research in the UK (Hargreaves et al, 2003) under climatic and organic soil conditions similar to those in Ireland suggests that following plantation, organic soils emit carbon at an elevated rate of approximately 16 t C/ha over a typical period of 4-5 years. This implies an emission rate of 4 t C/ha annually over a transition period of 4 years. Thereafter the emission from afforested organic soils reduces to zero, or indeed the soil may become a modest sink of carbon. While the emission rate is large compared to the default rate of 0.68 t C/ha/year for organic soils in cold wet temperate conditions, the transition period is much shorter than the 20-year default period. The accumulated default emission of 13.6 t C/ha over 20 years is only 15 percent less than total emissions according to the UK findings (Hargreaves et al, 2003). A country specific transition period of four years is therefore considered appropriate to afforested areas on organic soils.

7.3.4 Emissions from Biomass Burning

Estimates of emissions from forest biomass burning in Ireland relate to forest wildfires. The estimates are improved in this submission following some amendments to areas based on new information form the Forest Service. In order to incorporate the effect of forest fires into CARBWARE, the following assumptions were made:

1) All fires occur in the young forest land class under *5.A.1 Forest Land Remaining Forest Land* and *5.A.2 Land Converted to Forest Land*. The allocation of biomass burned in the two categories is based on the representative areas of land converted to forests and forests remaining forests. Wildfires normally occur in stands prior to canopy closure due to existence of non-forest vegetation in the under story. Fires are generally carried over by heather or furze vegetation in adjacent lands;
2) Forest land subject to wildfires in the young forest land class under *5.A.1 Forest Land Remaining Forest Land* is equally distributed among all species cohorts;

3) Emissions from the burning of forest biomass are calculated using equation 3.2.19 of the IPCC good practice guidance for LULUCF. A carbon release factor of 0.4 is used for wildfires (GPG Table 3A 1.12), with emission ratios for methane and nitrous oxide of 0.012 and 0.007, respectively (GPG Table 3 A 1.15). For nitrous oxide a C;N ratio of 0.01 is assumed;

4) Emissions directly resulting from fire (i.e. combustion) are included for all years from 1990. Where area data were not available (1990 through 1992) a mean value of 200 ha per year for the period 1993-2008 was assumed;

5) The indirect effect of fires on carbon stock changes include those associated with loss of productivity of the area after fire and re-growth following re-planting, which is assumed to occur in the following year. It is assumed that changes in the area of forest remaining forest due to fire before 1995 were already captured by the FIPS 1995 data underlying the CARBWARE model. Therefore, the indirect effects of fires and replanting on carbon stock changes, excluding the direct emission due to combustion, were only applied for the years from 1995 onwards;

6) The direct effect of wildfires on litter and soil carbon stocks is assumed to be negligible.

7.3.5 Emissions of N_2O from Fertilization

Ireland does not report emissions of N_2O due to fertilizer use for *5.A Forest Land*. The amount of synthetic fertilizer used in forests is negligible compared to that used in agriculture and therefore all N_2O emissions from fertilizer applications are reported under agriculture. The notation key IE is therefore used in CRF Table 5(I).

7.3.6 Emissions of N_2O from Drainage

Tier 1 estimates of N_2O emissions due to the drainage of organic soils and mineral soils in forest lands were first reported in 2009. Nitrous oxide emission estimates for drained forest soils are now improved in the present submission. This is due to the availability of National Forest Inventory (NFI) data released in 2007 (NFI 2007a and 2007b). The NFI results are based on randomised systematic grid sample design, at a grid resolution of 2 x 2 km to provide the number of plots needed to estimate total standing volume with a precision of ±5 percent at the 95 percent confidence level. The grid generated 17,423 intersections, each representing 400 ha. A land use classification of each intersection point was undertaken to identify afforested areas using photo-interpretation of OSI aerial photographs, aided by supplementary databases such as the Coillte and the afforestation grant and premiums datasets. This resulted in the classification of 1,742 points as forest land. At each intersection point permanent sample plots, representing 400 ha, were set up. Each plot was visited and a wide range of growth, carbon stock, forest type, soil and other variables were assessed and electronically stored. Data collection began in November 2004 and was completed in November 2006. Data were quality controlled by independently assessing a sub-sample of the plots, and by inbuilt checks in the data collection software.

The NFI data was used to derive a breakdown of areas for drained mineral, rich organic and poor organic soils over the time-series 1969 to 2005, based on planting year, soil type and cultivation type. Soils were assumed not to be drained if there was no cultivation or if pit planting was employed during forest establishment. The proportion of the three tier 1 soil types subjected to drainage for the young and mature time-series are determined from this soil/drainage matrix. The default emission factors were used for mineral, poor organic and rich organic soils (IPCC GPG, LULUCF Appendix 3a.2; Table 3a.2.1 pp 3.275.). The inclusion of N_2O emissions from forest soils contributes emissions of 10.5 to 16.0 Gg CO_2 equivalents in the years 1990 and 2008, respectively. This represents an annual reduction in the forest sink of 0.0016 to 0.0026 percent over these years.

7.3.7 Deforestation Areas

In previous submissions, deforestation was reported only in respect of forest land converted to settlements, derived from CORINE data. New data from the Forest Service shows that some forest land is converted to land categories other than settlements and this information is used to derive carbon stock changes for the relevant land categories for the 2010 submission. These activity data come from felling licence applications and are limited to the years 2006, 2007 and 2008. The Forestry Act legally requires a formal application to the Forest Service to fell trees under either a limited or a general felling license. General felling licences cover forestry activities associated with silvicultural management, such as thinnings or clearfell and replanting. Limited felling licences now capture areas and volumes felled and land use transitions for all forest land converted to other land uses.

All activities carried out under a general felling licence are not considered to represent deforestation. However, the NFI programme will continue to monitor whether clear felled forest land is replanted. The NFI performs land use transition analysis based on a 2 x 2 km grid using aerial photography every 5 years. The first NFI was completed in 2006 with a follow up due in 2010. A unit of land is defined as deforested land if there is a clear indication of land use change, either from limited felling licences or aerial photography and a permanent sample point, which was recorded as unplanted previously clearfelled land in the previous inventory, is still unplanted at the time of the subsequent inventory. Based on experience and expert judgement, it is considered that all forest land uncertified for replanting is restocked within three years following clear fell. The breakdown of land-use conversion from forest land into other categories for the years 2006 to 2008 is shown in Table 7.7. The areas subject to deforestation for the 1990-2005 period are as given in previous submissions and it is assumed that all such forest land in those years was converted to settlements. The estimation of emissions associated with conversion of forest land to other land use categories is described under the relevant categories below.

Table 7.7. Transition of Forest Land to other Land Categories in 2006, 2007 and 2008.

% land use transition from forests into					
	Grasslands	**Cropland**	**Wetlands**	**Settlements**	**Other**
2006	4.59	0.00	89.88	5.53	0.00
2007	4.46	0.00	87.74	2.75	5.05
2008	28.12	0.00	16.01	16.20	39.67
Areas (ha)					
2006	11.12	0.00	217.82	13.40	0.00
2007	7.80	0.00	153.40	4.80	8.83
2008	7.43	0.00	4.23	4.28	10.48

7.4 Cropland (Category 5.B)

7.4.1 Cropland Areas

Cropland areas are based on CSO annual statistics for tillage crops, revised by the inventory agency to account for inconsistencies due to the impact of changes in total farmed area reported in 1997, as described in the 2007 NIR. In submissions prior to 2008, it was maintained that approximately 3,000ha of peatland was subject to inversion tillage. This was based on a GIS analysis, which superimposed high resolution Land Parcel Information on lower resolution soil distribution maps and contradicted the general acceptance that there was negligible cultivation of organic soils in Ireland. Following the in-country review in 2007 and discussion with the respective experts in agricultural practices and GIS analysis, it was agreed, pending the results of proposed research, that no cultivation of peat occurs, and the GIS result can be regarded as indicating zero cultivation within the error margins associated with this type of analysis. Therefore, the organic soil area designated as being under cropland in submissions prior to 2008 has been reallocated to mineral soils and cropland organic soils are designated as "not occurring", i.e. "NO" in the CRF tables. This action has a knock-on effect in other land use categories, as new cropland areas on organic soils are no longer required to transfer to, or from, grasslands, with an equivalent change in the dynamics of transfer of mineral soils between classes.

Croplands are assumed to revert to natural grassland status during set-aside (the temporary exclusion of tillage areas from production) but stay within the category *5.B Croplands Remaining Croplands*, as a land parcel that is given over to set-aside in one year will usually be tilled in subsequent years. The Central Statistics Office data includes set-aside areas within what is termed "Other Crops". This area of Other Crops is used as the upper limit to give a conservative estimate of set-aside area. In order for the net change in cropland to correspond to that indicated by the CSO statistics, the cropland areas lost to *5.A Forest Land* and *5.E Settlements* must be offset by new lands converted from *5.C Grassland*. This is achieved by adding those areas of cropland in transition to either forest lands or settlements to the area of land in transition to cropland, and deducting an equal amount from the area under *5.B.1 Croplands Remaining Croplands*. The relevant emissions and removals are determined by net carbon stock changes in living biomass and soils for *5.B.2 Lands Converted to Cropland*.

7.4.2 Carbon Stock Change in Biomass

The stock change relates only to above-ground biomass and its estimation is based on the difference between initial and final carbon content of biomass for the lands converted. In the conversion of land to cropland, it is assumed under the Tier 1 approach that the dominant vegetation from the initial land use is removed entirely. The carbon stock change is then quantified as the net sum of carbon lost on conversion and the carbon added by the first year's growth of crops. Grassland is the only relevant land-use type undergoing conversion to cropland in Ireland. The dry matter content of grassland is taken as 13.6 tonnes/ha and the carbon content of dry matter is 0.5 percent. The default value of 5 t C/ha from Table 3.3.8 of the IPCC good practice guidance for LULUCF is adopted for the carbon stock in crop biomass after one year. The carbon stock change in biomass on the area (A) converted to cropland is then calculated from Equation 3.3.8 of the IPCC good practice guidance as follows:

$$\Delta C = A * [(C_{after} - C_{before}) + \Delta C_{growth}] \qquad (7.2)$$

$$\Delta C = A * [(13.6 * 0.5 - 0.0) + 5.0]$$

7.4.3 Carbon Stock Change in Soils

The spatial distribution of cropland areas over IPCC soil class is derived from GIS analysis of the LPIS 2004 dataset provided by the Department of Agriculture, superimposed on the General Soil Association Map of Ireland (Gardiner and Radford, 1980). The GIS analysis shows that a very high proportion (98 percent) of croplands are located on Low Activity Clay (LAC) soils. It is assumed that only grasslands on LAC soils are suitable for direct conversion to croplands, which is consistent with the requirement for cropland productivity. It is therefore reasonable to assume that all grassland areas converted to croplands are also on LAC soils and that no other land categories are converted to croplands.

Carbon stock changes in mineral soils are estimated using Equation 7.1. Farm management and input practices are assumed to have been constant over the inventory period for established croplands. Therefore the SOC will not have changed for mineral soils, with the exception of those lands going to set-aside for short periods within the transition period of 20 years. In line with expert option it is assumed that no cultivation occurs on organic soils, as discussed in 7.4.1.

7.4.4 N_2O Emissions in Cropland

Soil disturbance associated with land-use conversions to cropland result in minor emissions of N_2O. Emissions from this category were reported in the 2008 submission for the first time following recommendations from the in-country review conducted in 2007. Such emissions are estimated for mineral soils in category 5.B.2.2 Grassland Converted to Cropland and the estimates are included in CRF Table 5(III). The estimates are calculated from the change in soil organic carbon over the 20 year transition period, obtained using Equation 7.1 for the land-use and soil type converted to cropland, and the soil C: N ratio as follows:

$$N_2O = (\Delta C \;/\; R_{C:N}) * 44/28 \qquad (7.3)$$

where ΔC is the annual change in carbon stocks given by Equation 7.1 and $R_{C:N}$ is the C:N mass ratio in soil organic matter for which a default value of 15 is given in the IPCC good practice guidance.

7.5 Grassland (Category 5.C)

7.5.1 Grassland Areas

Grassland is the dominant land-use category in Ireland. Area estimates are based principally on CSO annual statistics for improved grassland (pastures and areas harvested for silage and hay) and unimproved grassland, which refers to rough grazing. The methodology for estimating Grassland area has not changed from the previous submission. Any revisions are due to the knock-on effects of changes in other land classes.

It is important to note that both improved and unimproved grassland areas are estimates of grasslands *in use* for agricultural purposes. Rough grazing areas *in use* are native grasslands that are unmanaged with regard to drainage or other factors, such as fertilizer application, but which may be quite intensively grazed by cattle or sheep. The CSO annual statistics for rough grazing exclude other areas of grassland not reported to be in use for agricultural purposes. These grasslands are assumed to be unmanaged natural grasslands, in a carbon-stable state, with no associated emission or sink activity. However, they do represent a reserve of lands available for conversion to other land uses. Given the uncertainty of the area of unused grassland, it was decided to include this type of grassland in the category *5.F Other Land*. When there is a demand for new grassland for use as rough grazing, it is met by a conversion from *5.F Other Land* to unimproved grassland. Overall, the area of improved pasture has been increasing slightly and the area of rough grazing, or unimproved grassland has been decreasing. This is probably in response to sheep farming policy, which in recent years has sought to decrease over grazing on vulnerable commonage and mountain areas. The grazing of unimproved grasslands leads to degradation of the soil, with consequent emission of carbon.

From the data available, it is difficult to estimate the changes in area within the category *5.C.1 Grassland Remaining Grassland*. The annual CSO figures refer to the areas of land that farmers have declared to be "in use" under the specified types of use. Given the economic investment required to maintain "improved" grassland, it is probable that the declared "in use" areas are a good indicator of the actual extent of well-maintained managed grasslands. Therefore, significant changes in the improved grassland areas do represent changes in land use, with lands either being neglected, or actively managed, depending on the potential for good economic return. The neglect of improved grasslands will cause the land to revert to the nominally managed or native grassland state over time. The transition to rough grazing causes a degradation of the soil, leading to an emission of carbon. However, it is assumed that the average biomass remains constant. This is an underestimate of the effect of grazing, but insufficient data exists to quantify the impact.

There is a strong dynamic of lands moving between grassland and cropland (with a knock effect on the area assigned to other land). This is because of the nature of the CSO statistics, which record only the areas of grassland and cropland in a particular year. Under Irish conditions, conversion of grassland to cropland leads to a net loss of carbon from the soil, and also a loss of living biomass when the Tier 1 default methods are applied.

7.5.2 Carbon Stock Changes in Grassland

The relevant carbon stock changes are for living biomass under *5.C.2 Land Converted to Grassland* and for soils under both *5.C.1 Grassland Remaining Grassland* and *5.C.2 Land Converted to Grassland.*

Carbon Stock Changes in Living Biomass

The Tier 1 methodology assumes that grassland remaining grassland has zero biomass carbon stock change under static management practices. This approach is adopted here and the notation NO is entered in CRF Table 5.C. The category *5.C.2.5 Other Land Converted to Grassland* is the most important conversion category in most years while some conversions from cropland and exhausted peatlands also occur. Carbon stock changes are estimated using the Tier 1 methodology in the same way as for land converted to cropland using Equation 7.2 above. The biomass value of cropland converted to grassland is taken to be 10 t/ha and the carbon stock increase due to growth in grasslands (ΔC growth) in the first year is 6 t C/ha from GPG Tables 3.4.2 and 3.4.3. In the case of peatlands there is no initial biomass at the time of conversion to grassland and therefore the carbon stock change is due only to the first year's growth at 6.0 t C/ha. The category *5.C.2.5 Other Land converted to Grassland* is in effect the transition of unmanaged native grassland to improved or unimproved pasture, as indicated in section 7.5.1 above. There is a change in carbon stock associated with conversion to improved grassland, as the land is invariably subject to ploughing and reseeding. This is accounted for through Equation 7.2 as a loss of 6 t C/ha for standing biomass followed by a gain of 6.0 t C/ha through growth in the first year, using the default values[1].

Table 7.7 in section 7.3.7 above gives the area of forest land converted to grassland for the years 2006, 2007 and 2008. The estimated clearfelled biomass volume, as given by the general license applications for such lands, was converted into total biomass carbon using a BEF of 1.4 and a carbon content of 50 percent. Where volume estimates were not supplied, the volume of timber removed was estimated based crop age and species using yield tables (Edwards and Christie, 1981).

Carbon Stock Changes in Soils

The distribution of grassland areas converted from other land uses over the IPCC soil classes is determined from GIS analysis of CORINE 1990 land cover data superimposed on the General Soil Association Map of Ireland (Gardiner and Radford, 1980). Mineral soils as identified from the general soil map were allocated to the five IPCC soil groups and their organic carbon status is established from the soil type and the default reference soil organic carbon stocks (Table 7.5). Table 7.6 shows the adjustment factors applied to the default SOC_{ref} to correct for land use and farming practice. The principal conversion affecting carbon stock change in soils is that from native grassland to rough grazing, which causes a decrease in soil carbon. Conversely, it can be seen from Table 7.6 that conversion from cropland to improved grassland implies an increase in the soil carbon. A significant secondary source of carbon emission is the use of wetland soil types as pasture. It is assumed here that the wetlands soils under pasture are to some extent artificially drained, and so encourages the emission of carbon from this organic soil type. The default emission rate of 0.25 t C/ha for drained organic soils under grassland have been applied.

7.5.3 Agricultural Lime Application

Much of the total emission of carbon for productive agricultural land derives from the use of lime applied to control soil acidity. Data on the annual amounts of lime applied to land are currently obtained from the Irish Business and Employers Federation. Limestone is the standard form of the application. The CO_2 emissions are calculated using the default emission factor of 120 kg C/tonne lime. Estimates are calculated for both grassland and cropland areas. The estimates are reported in CRF Table 5(IV) rather than in CRF Tables 5.B and 5.C, the carbon stock change tables for cropland and grassland, respectively.

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[1] There appears to be some inconsistency between default biomass carbon stocks given in Table 3.4.9 and those derived from Tables 3.4.2 and 3.4.3 of the IPCC good practice guidance on LULUCF. The inventory agency believes that the value of 13.6 tonnes DM/ha for the cold wet temperate climate zone should be 12 tonnes DM/ha.

7.6 Wetlands (Category 5.D)

7.6.1 Wetland Areas

Wetlands as applied to Ireland refer to natural unexploited wetlands while peatlands are those wetland areas drained for the purpose of commercial exploitation and harvesting of peat. The national wetland area is therefore split into two types, unmanaged wetland and managed peatland (Table 7.3). This split is necessary to account for the conversion of wetlands to peatland, which is an internal change under the IPCC definition of wetlands. The activity data areas that appear under category *5.D.1 Wetlands Remaining Wetlands* in CRF Table 5.C therefore refer to managed peatlands in the Irish context and conversion to wetland is not applicable.

The commercial exploitation of wetlands as peatlands by Bord na Mona (the Irish Peat Board) according to the land-use definition in Table 7.3 proceeds is three separate stages, all of which may lead to changes in carbon stocks. Drainage is the first management activity, followed after several years by removal of the top layers of plant growth in the first season of peat extraction and then by the industrial extraction and harvesting of a layer of 10 to 15 cm of peat annually. The average working life of commercially developed Irish peatland is of the order of 30-50 years. Conversion to grasslands or forest land has been the historically favoured use of cutaway peatland. However, in recent years wetland reclamation has been investigated, and achieved with some success. The areas reported under category *5.D.1 Wetlands Remaining Wetlands* refer to all lands drained, whether the peat remains covered by vegetation or is exposed. Bord na Mona manages its peat reserves to meet present demand and is therefore progressing to extract peat from new sites only when an older field is exhausted. It is assumed that the decrease in reserves of peatland indicate new extraction areas, and therefore they are an estimate of the area from which biomass has been removed. Until recently, Bord na Mona held a small area of un-drained wetlands in reserve. However, these lands have been transferred to the National Parks and Wildlife Service for conservation.

Table 7.8 Area Statistics for Peatlands (ha)

	1985-1990	1991-1995	1996-2000	2001-2005	Vegetation Cover
Peatland Category					
Active Production Bog	49,715	48,961	46,319	43,761	None
Production Reserve (Drained)	16,250	14,100	12,772	5,930	Heather
Fringe Bog (Undrained)	8,300	8,300	8,300	8,300	Heather dominated Bog Vegetation
Partially Drained	3,090	3,090	3,090	3,090	Typical Bog vegetation
Undrained Intact Bog	4,150	2,508	-	-	Intact Bog vegetation
Cutaway Areas					
Forestry (Plantation)	2,500	4,000	4,000	4,200	Conifers
Forestry (Natural)	-	100	800	2,235	Birch / Willow
Wetland (Acidic)	483	483	2,703	9,044	Eriophorum, Carex, Sphagnum
Wetland (Alkaline)	250	1,250	2,150	3,200	Typha, Phragmites, Open water
Lands Sold/Transferred	2,541	1,946	2,658	374	
Total owned (at end of period)	84,738	82,792	80,134	79,760	

Bord na Mona supplies the area estimates for the company's commercial peat harvesting activities. The data for Bord na Mona commercial peat extraction areas are given as totals for consecutive five-year periods for a variety of peatland categories (Table 7.8). The annual average value obtained from this total is used for each of the five years to obtain the full time series. Domestic harvesting of peat bogs by private landowners for their own household use is a strong tradition in many parts of Ireland, and although well documented in a social and cultural context, the amount of such peat extraction is poorly quantified. Previously estimates of the land area devoted to private harvesting of peat was estimated to be in the region of 400 ha per year based on the assumption that the area under private commercial and domestic use was of the order of one eighth that of Bord na Mona lands. In the 2009 submission a refined estimate was made using the value of residential peat use in the national energy balance and a bulk density estimate of 0.25 t/m^3 for peat m^{-3} (McGoff et al. 2007). This new approach is also used in this submission and ensures consistency between the quantities of peat combusted in *1.A.3.b Residential* and the area of private peat exploitation in LULUCF.

7.6.2 Carbon Stock Changes in Wetland

Biomass

Carbon stock changes in biomass are determined by the balance between carbon loss due to the removal of vegetation on preparation for peat harvesting and gain on areas of restored peatland. These changes have been estimated on the basis that the entire cover of vegetation is removed to prepare for peat harvesting and that an equivalent amount of biomass is returned on restoration of cutaway areas. In the 2006 NIR, it was assumed that the restoration of biomass occurred in the year of conversion. However, discussions with experts from Bord na Mona suggest a more appropriate biomass transition period of 5 years.

The area from which vegetation is removed is taken to be the amount of peatland reserve that is drained to come under production annually and the restoration area is taken as the annual increase in cutaway wetland given by Table 7.7. The vegetation is typically heather-dominated bog or heathland cover for which a biomass carbon content of 3 t C/ha is adopted (Cruickshank et al, 2000).

Table 7.7 in section 7.3.7 above gives the area of forest land converted to wetland for the years 2006, 2007 and 2008. The estimated clearfelled biomass volume, as given by the general license applications for such lands, was converted into total biomass carbon using a BEF of 1.4 and a carbon content of 50 percent. Where volume estimates were not supplied, the volume of timber removed was estimated based crop age and species using yield tables (Edwards and Christie, 1981).

Soils

The CO_2 emissions associated with the combustion of peat are accounted for in the *Energy* sector. An additional loss of carbon is associated with drainage and the exposure of the new peat surface annually after harvesting takes place. The annual activity data are the active production areas of Bord na Mona bog (Table 7.7), together with the areas of peatland in use by private commercial enterprises and by domestic users. All such peatlands are nutrient-poor raised bogs or rain-fed blanket bogs for which the appropriate carbon emission factor is 0.2 t C/ha, given for boreal and temperate climatic regions in the IPCC good practice guidance. The activity land area in respect of the soils carbon pool is the value that appears in CRF Table 5.D. This area is significantly larger than that relevant to the estimation of carbon stock change in biomass above.

7.6.3 Emissions of Non-CO_2 Gases

In the submissions prior to 2008, no estimate was reported for N_2O emissions associated with the drainage of peatlands for commercial exploitation, as this is an optional reporting category in the LULUCF sector, therefore the notation key NA was used in CRF Table 5 (II). This position was reviewed following the in-country review of Irelands GHG inventory in 2007. Emissions of N_2O due to the drainage of peatlands are now reported and utilise the IPCC Tier 1 approach.

7.7 Settlements (Category 5.E)

7.7.1 Areas of Settlements

The area of settlements in 1990 is that given by CORINE 1990. Land converted to settlements is the area taken up by new road building, available from the National Roads Authority, and the area covered by new residential, commercial and industrial construction based on CSO annual statistics, which are extracted from floor area records for permitted development. An incomplete time series of housing types (for the years 1995-2000) was used to estimate the residential building footprint from floor area. It was assumed that approximately 50 percent of the planning permits granted for construction were for green-field sites previously not part of the urban fabric.

The identification of the land use from which settlement areas are converted is based on an analysis of the distribution of land use classes given by CORINE 1990, with the exclusion of wetland, water bodies, existing continuous urban fabric and other marginal unsuitable land types. Conversions of the different types of land area to settlement areas are assumed to occur in the proportions under which the respective categories existed in 1990. For example, as 80 percent of the land is grassland, it is reasonable to assume that 80 percent of new buildings and road construction takes place on grasslands.

7.7.2 Carbon Stock Changes in Settlements

The assumption is made of complete removal of biomass in the year of the planning permission for buildings constructed or in the year of completion of road projects. The biomass loss from grassland and cropland is as per guidelines using the Tier 1 approach. The relative loss of biomass from forest per hectare is large. Based on the carbon estimates in Section 7.3, the average biomass of forested lands in Ireland is of the order of 42 t C/ha. No account has been made of the potential increased carbon stock in biomass in urban areas. This may be a significant carbon sink, especially under the policy of actively encouraging urban tree planting along new roads and in new housing developments, but no data is available.

Table 7.7 in section 7.3.7 above gives the area of forest land converted to settlements for the years 2006, 2007 and 2008. The estimated clearfelled biomass volume, as given by the general license applications for such lands, was converted into total biomass carbon using a BEF of 1.4 and a carbon content of 50 percent. Where volume estimates were not supplied, the volume of timber removed was estimated based crop age and species using yield tables (Edwards and Christie, 1981).

7.8 Other Land (Category 5.F)

7.8.1 Areas of Other Land

The category *5.F Other Land* includes all lands not classified under the categories 5.A through 5.E. It represents the difference between the sum of categories 5.A through 5.E and the total land area of Ireland. A large part of *5.F Other Land* is not relevant in terms of its potential for emissions or removals but for Ireland this category includes areas of natural grassland which are an available reserve for rough grazing but which are not grazed in the inventory year. As indicated above in section 7.5.1, when the demand for areas of pasture in a particular year is less than in the previous year, surplus areas of improved or unimproved pasture are allowed to revert to rough grazing, which are then not recorded as "in use" as grassland by CSO statistics. For area accounting purposes, such lands are assumed to be in transition and are assigned to category *5.F.2.3 Grassland Converted to Other Land* in a manner that maximises the area in *5.F.1 Other Land Remaining Other Land*.

7.8.2 Carbon Stock Changes in Other Land

The degradation of lands reverting to rough grazing not in use results in carbon losses from the soil. The soil classes are identified for *5.F.2.3 Grassland Converted to Other Land* in the same way as for other land-use categories. For mineral soils, SOC_{ref} is assigned according to Table 7.5 while Table 7.6 is used to apply the SOC adjustment factors and the carbon stock change is calculated using Equation 7.1. The default emission factor of 0.25 t C/ha is used to calculate carbon loss from organic soils.

Table 7.7 in section 7.3.7 above gives the area of forest land converted to Other Land for the years 2006, 2007 and 2008. The estimated clearfelled biomass volume, as given by the general license applications for such lands, was converted into total biomass carbon using a BEF of 1.4 and a carbon content of 50 percent. Where volume estimates were not supplied, the volume of timber removed was estimated based crop age and species using yield tables (Edwards and Christie, 1981).

7.9 Uncertainties in *LULUCF*

Detailed land-use datasets extending over a considerable time period are required in order to apply even the most basic Tier 1 methods of the IPCC good practice guidance to estimate emissions and removals of greenhouse gases in the land-based approach for the LULUCF sector. The analysis for the several land-use categories invariably means that datasets differing in terms of format, spatial resolution, reference years and other attributes need to be combined for national coverage of sources and sinks. It follows that a high degree of uncertainty is associated with the land area activity data in general. This is especially true of the conversion categories, which are in many cases the land-use categories having the greatest impact on carbon pools. Large uncertainties are also inherent in the parameters that determine carbon stock change factors and in the emission factors for N_2O as indicated by the wide error ranges given in the good practice guidance. It is also difficult to assess to what extent the given values for broad climatic regions are relevant to Irish circumstances. It may be concluded that the uncertainties in reported emissions and removals are large for the sector overall and their full evaluation in quantitative terms has not been possible for the current submission.

7.10 Recalculations in *LULUCF*

The recalculations for LULUCF include a number of methodological refinements resulting mainly from wider use of the NFI data in the CARBWARE model for forest land and its development to ensure consistency between the LULUCF submissions under the Convention and the Kyoto Protocol. The following are the principal items leading to recalculations for the years 1990-2008.

a) Revised estimates of forest biomass due to biomass loss from young forests as a result of biomass burning/forest fires in *5.A. Forest Land*;

b) Adjustment to total forest area shown in Table F.1 of Appendix F to be consistent with areas reported under Article 3.3 of the Kyoto Protocol in chapter 11 (KP_LULUCF);

c) Upgrade from tier 1 method to tier 3 method for estimating carbon stock change in the litter pool in forest land;

d) Inclusion of N_2O emissions in drained forest soils;

e) Minor revisions for biomass burning;

f) Revised area estimates for deforestation in 2006 and 2007 which are accounted for in carbon stock change estimates for forest land conversions to cropland, wetland and other lands;

The net effect of the recalculations outlined are shown in Table 7.9.

7.11 Improvements in *LULUCF*

The coverage of sources of emissions and removals by Ireland in the LULUCF sector under the Convention is complete for the years 1990-2008. The present submission also contains estimates for 2008 in respect of activities under Article 3.3 of the Kyoto Protocol (Chapter 11), which are fully consistent with Convention reporting for LULUCF. Even though a rather simplified approach has had to be followed for many land-use categories due to the level of information available, the assessment of emissions and removals according to the reporting requirements of Decision 13/CP.9 has identified a number of important CO_2 emission sources, in addition to the well known carbon sink in forests. Extensive further work has been conducted to improve completeness, methodologies and data treatment for this submission and to apply some refinements due to approaches taken for estimating emissions and removals for Article 3.3 activities. The inventory agency is continuing to collaborate with the bodies from which the key land-use and forestry datasets are obtained and has established formal arrangements for the provision of the data within the national system, in the same way as for other sectors. The agency's capacity on GIS continues to be developed, which facilitates the assessment and integration of available datasets. It is intended to apply this capacity in a more detailed treatment of soils for future submissions.

The results of the national forest inventory are now being applied more extensively in the LULUCF inventory and this submission reflects further improvements given by this data source and by supporting research projects on climate change and forestry being undertaken over the period from 2007 to 2012. The CARBWARE development project has improved forest carbon stock change reporting tools and software to make available an integrated system that meets the reporting needs of the Convention and the Kyoto Protocol with respect to forest land. It also draws on data from the ongoing CARBiFOR II project and other related research projects, to continually refine estimates of carbon stock change for reporting purposes and for projecting carbon sinks into the future.

Table 7.9 Percentage Change in Emissions and Removals from LULUCF due to Recalculations

a) 2009 Submission (Gg CO_2 eq)

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
									Estimates in 2009 Submission (Gg CO_2eq.)										
5.A	**Forest Land**	-336.49	-300.80	-96.69	-188.82	-124.83	-128.05	-124.52	-266.66	-455.65	-561.51	-437.97	-566.27	-773.54	-1,033.20	-692.67	-908.59	-958.11	-1,517.69
5.A.1	Forest Land remaining Forest Land	-995.72	-1,143.71	-864.72	-857.87	-566.70	-389.48	-335.96	-231.46	-529.68	-576.24	-89.25	22.74	-369.61	-1,199.32	-725.49	-900.86	-839.45	-1,491.13
5.A.2	Land converted to Forest Land	659.23	842.91	768.04	669.04	441.88	261.43	211.44	-35.21	74.03	14.73	-348.72	-589.01	-403.93	166.12	32.82	-7.73	-118.66	-26.56
5.A	Biomass burning	21.64	21.64	21.64	20.43	22.84	24.93	23.99	15.33	3.16	2.97	15.27	38.57	14.13	51.61	39.83	7.87	22.63	11.30
5.A	Drainage of soils	11.36	11.76	12.14	12.45	12.85	13.36	13.80	14.03	14.28	14.44	14.72	14.97	15.19	15.33	15.45	15.56	15.69	15.79
5.B	**Cropland**	20.00	21.19	16.78	11.26	-59.59	-34.90	48.63	25.03	6.00	-18.46	22.87	104.79	94.89	140.00	100.27	126.44	72.94	96.94
5.B.1	Cropland remaining Cropland	20.00	21.19	9.65	-58.90	-87.54	-62.86	-25.13	-20.09	-39.12	-63.57	-22.25	-28.23	-34.71	-35.33	-26.31	-0.13	-53.63	-29.63
5.B.2	Land converted to Cropland	NE,NO	NE,NO	7.13	70.16	27.96	27.96	73.76	45.12	45.12	45.12	45.12	133.02	129.61	175.33	126.58	126.58	126.58	126.58
5.B	Agricultural Lime Application[b]	36.66	32.51	26.31	36.95	27.48	50.28	50.29	44.31	31.42	38.86	37.25	40.47	29.69	43.18	26.44	26.85	25.49	37.22
5.B.2	Emissions from soil disturbance	NA,NO	NA,NO	0.30	3.10	3.10	3.10	5.00	5.00	5.00	5.00	5.00	8.64	10.78	14.01	14.01	14.01	14.01	14.01
5.C	**Grassland**	493.53	556.98	431.63	345.04	174.92	379.40	415.29	497.42	310.97	399.48	469.64	453.57	458.72	554.13	336.55	199.06	300.56	334.87
5.C.1	Grassland remaining Grassland	621.96	583.23	529.88	618.43	523.23	718.45	707.74	648.56	543.55	613.75	598.52	614.19	512.99	611.74	480.36	505.89	494.31	604.49
5.C.2	Land converted to Grassland	-128.42	-26.25	-98.26	-273.40	-348.31	-339.05	-292.45	-151.13	-232.57	-214.27	-128.88	-160.62	-54.27	-57.61	-143.81	-306.83	-193.76	-269.62
5.C	Agricultural Lime Application[b]	318.38	282.64	229.29	320.35	242.16	444.32	433.74	379.17	274.16	344.37	329.14	344.81	244.21	343.58	214.35	239.88	229.37	339.54
5.D	**Wetlands**	46.47	45.62	45.08	44.38	42.01	39.60	36.86	34.39	31.92	29.14	37.08	32.97	28.86	24.75	20.64	20.23	19.84	12.50
5.D.1	Wetlands remaining Wetlands	46.47	45.62	45.08	44.38	42.01	39.60	36.86	34.39	31.92	29.14	37.08	32.97	28.86	24.75	20.64	20.23	19.84	12.50
5.D.2	Land converted to Wetlands	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
5.D	Drainage of soils	3.59	3.54	3.52	3.48	3.46	3.42	3.35	3.31	3.27	3.20	3.15	3.11	3.07	3.03	2.99	2.95	2.91	2.81
5.E	**Settlements**	12.80	11.72	11.94	12.74	15.69	15.81	19.86	21.66	23.12	24.74	26.08	34.34	30.51	37.23	39.19	46.06	48.30	54.80
5.E.1	Settlements remaining Settlements	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
5.E.2	Land converted to Settlements	12.80	11.72	11.94	12.74	15.69	15.81	19.86	21.66	23.12	24.74	26.08	34.34	30.51	37.23	39.19	46.06	48.30	54.80
5.F	**Other Land**	-1.24	0.00	-13.26	-0.57	-2.31	0.00	-22.82	-6.75	-5.59	0.00	0.00	-14.07	-16.89	0.00	-35.54	-6.89	-12.23	0.00
5.F.1	Other Land remaining Other Land	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.F.2	Land converted to Other Land	-1.24	NO	-13.26	-0.57	-2.31	NO	-22.82	-6.75	-5.59	NO	NO	-14.07	-16.89	NO	-35.54	-6.89	-12.23	NO
5.G	**G. Other**	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5	TOTAL LULUCF CO_2 (net emissions/removals)	235.08	334.72	395.49	224.02	45.89	271.85	373.31	305.09	-89.23	-126.61	117.70	45.33	-177.44	-277.09	-231.56	-523.68	-528.70	-1,018.57
5	TOTAL LULUCF GHGs (net emissions/removals)	251.99	351.98	413.41	244.90	67.36	293.98	397.63	328.81	-66.41	-103.70	141.95	75.55	-147.12	-240.05	-195.51	-490.45	-494.04	-984.93

b) 2010 Submission (Gg CO_2 eq)

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
		Estimates in 2010 Submission (Gg CO_2eq.)																	
5.A	**Forest Land**	-339.82	-308.27	-108.46	-193.96	-132.41	-133.97	-126.65	-271.05	-449.12	-557.91	-444.80	-584.27	-778.70	-1,044.47	-717.49	-906.73	-975.14	-1,516.89
5.A.1	Forest Land remaining Forest Land	-999.06	-1151.2	-876.51	-863	-574.29	-395.39	-338.08	-235.83	-523.13	-572.63	-96.061	4.77201	-374.72	-1210.6	-750.29	-898.98	-856.46	-1490.3
5.A.2	Land converted to Forest Land	659.24	842.91	768.05	669.05	441.88	261.42	211.43	-35.22	74.00	14.71	-348.74	-589.04	-403.97	166.09	32.81	-7.75	-118.68	-26.58
5.A	Biomass burning	13.48	8.62	5.53	11.15	12.72	17.16	18.91	10.37	5.48	4.47	11.15	22.10	5.05	31.21	18.18	6.60	6.63	7.49
5.A	Drainage of soils	10.47	11.08	11.40	11.81	12.06	12.83	13.28	13.26	13.47	13.67	14.05	14.49	14.74	14.92	15.21	15.56	15.75	15.85
5.B	**Cropland**	20.00	21.19	16.67	-26.66	-17.59	-35.01	48.20	53.24	5.77	-18.68	22.64	104.76	117.66	123.21	148.10	126.03	72.54	96.54
5.B.1	Cropland remaining Cropland	20.00	21.19	9.65	-58.90	-87.54	-62.86	-25.13	-20.09	-39.12	-63.57	-22.25	-28.22	-34.70	-35.32	-26.31	-0.14	-53.63	-29.63
5.B.2	Land converted to Cropland	NE,NO	NE,NO	7.01	32.24	69.96	27.85	73.33	73.33	44.89	44.89	44.89	132.98	152.36	158.53	174.41	126.18	126.18	126.18
5.B	Agricultural Lime Application[b]	36.66	32.51	26.31	36.95	27.48	50.28	50.29	44.31	31.42	38.86	37.25	40.48	29.70	43.19	26.44	26.85	25.49	37.22
5.B.2	Emissions from soil disturbance	NA,NO	NA,NO	0.29	3.08	3.08	3.08	4.97	4.97	4.97	4.97	4.97	8.62	10.77	13.97	13.97	13.97	13.97	13.97
5.C	**Grassland**	493.47	556.83	431.52	344.93	174.67	379.01	414.97	496.96	310.43	398.80	468.81	452.81	457.96	553.37	334.93	197.11	299.50	333.44
5.C.1	Grassland remaining Grassland	621.96	583.23	529.88	618.43	523.23	718.45	707.74	648.56	543.55	613.75	598.52	614.19	512.98	611.73	480.36	505.90	494.31	604.49
5.C.2	Land converted to Grassland	-128.49	-26.39	-98.37	-273.51	-348.56	-339.44	-292.77	-151.60	-233.12	-214.96	-129.71	-161.38	-55.02	-58.36	-145.43	-308.79	-194.81	-271.05
5.C	Agricultural Lime Application[b]	318.38	282.637	229.293	320.348	242.164	444.319	433.743	379.173	274.163	344.369	329.135	344.801	244.197	343.569	214.354	239.886	229.366	339.544
5.D	**Wetlands**	47.07	46.21	45.68	44.97	42.37	40.94	39.18	37.69	36.19	34.39	45.66	43.36	41.06	38.77	36.47	36.07	35.67	24.31
5.D.1	Wetlands remaining Wetlands	47.07	46.21	45.68	44.97	42.37	40.94	39.18	37.69	36.19	34.39	45.66	43.36	41.06	38.77	36.47	36.07	35.67	24.31
5.D.2	Land converted to Wetlands	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
5.D	Drainage of soils	3.59	3.54	3.52	3.48	3.46	3.42	3.35	3.31	3.27	3.20	3.15	3.11	3.07	3.03	2.99	2.95	2.91	2.81
5.E	**Settlements**	12.80	11.72	11.94	12.74	15.69	15.81	19.86	21.66	23.12	24.74	26.08	34.34	30.51	37.23	39.19	46.05	48.29	49.60
5.E.1	Settlements remaining Settlements	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
5.E.2	Land converted to Settlements	12.80	11.72	11.94	12.74	15.69	15.81	19.86	21.66	23.12	24.74	26.08	34.34	30.51	37.23	39.19	46.05	48.29	49.60
5.F	**Other Land**	-1.24	0.00	-13.26	-0.57	-2.31	0.00	-22.82	-6.75	-5.59	0.00	0.00	-14.01	-16.83	0.00	-35.60	-6.95	-12.17	0.00
5.F.1	Other Land remaining Other Land	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5.F.2	Land converted to Other Land	-1.24	NE,NO	-13.26	-0.57	-2.31	NE,NO	-22.82	-6.75	-5.59	NE,NO	NE,NO	-14.01	-16.83	NE,NO	-35.60	-6.95	-12.17	NE,NO
5.G	**G. Other**	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5	TOTAL LULUCF CO_2 (net emissions/removals)	232.27	327.69	384.08	181.45	80.42	266.78	372.74	331.74	-79.20	-118.67	118.39	36.99	-148.33	-291.91	-194.39	-508.41	-531.30	-1,013.01
5	TOTAL LULUCF GHGs (net emissions/removals)	247.56	343.09	399.80	200.83	100.18	287.67	396.05	354.22	-56.99	-96.43	141.58	65.22	-119.29	-257.17	-160.58	-475.34	-498.07	-979.69

c) Percentage Change

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
		Percentage Change in Total Emissions due to Recalculations																	
5.A	**Forest Land**	0.99	2.48	12.18	2.72	6.08	4.62	1.71	1.65	-1.43	-0.64	1.56	3.18	0.67	1.09	3.58	-0.21	1.78	-0.05
5.A.1	Forest Land remaining Forest Land	0.34	0.65	1.36	0.60	1.34	1.52	0.63	1.89	-1.24	-0.63	7.63	-79.01	1.38	0.94	3.42	-0.21	2.03	-0.05
5.A.2	Land converted to Forest Land	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.05	-0.03	-0.13	0.01	0.01	0.01	-0.02	-0.04	0.21	0.01	0.07
5.A	Biomass burning	-37.68	-60.15	-74.42	-45.43	-44.33	-31.19	-21.20	-32.34	73.10	50.30	-27.01	-42.69	-64.24	-39.53	-54.36	-16.10	-70.72	-33.68
5.A	Drainage of soils	-7.80	-5.83	-6.11	-5.18	-6.13	-3.94	-3.82	-5.43	-5.61	-5.33	-4.52	-3.22	-2.96	-2.72	-1.54	-0.01	0.34	0.39
5.B	**Cropland**	0.00	0.00	-0.67	-336.78	-70.49	0.29	-0.89	112.72	-3.76	1.22	-0.99	-0.03	23.99	-12.00	47.71	-0.32	-0.55	-0.41
5.B.1	Cropland remaining Cropland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.03	-0.04	-0.02	0.00	4.68	0.00	0.00
5.B.2	Land converted to Cropland	NA	NA	-1.59	-54.05	150.25	-0.36	-0.59	62.53	-0.50	-0.50	-0.50	-0.03	17.56	-9.58	37.79	-0.32	-0.32	-0.32
5.B	Agricultural Lime Application[b]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.04	0.02	0.00	-0.02	0.00	0.00
5.B.2	Emissions from soil disturbance	NA	NA	-1.59	-0.36	-0.36	-0.36	-0.50	-0.50	-0.50	-0.50	-0.50	-0.20	-0.09	-0.32	-0.32	-0.32	-0.32	-0.32
5.C	**Grassland**	-0.01	-0.03	-0.03	-0.03	-0.14	-0.10	-0.08	-0.09	-0.17	-0.17	-0.18	-0.17	-0.17	-0.14	-0.48	-0.98	-0.35	-0.43
5.C.1	Grassland remaining Grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.C.2	Land converted to Grassland	0.05	0.56	0.11	0.04	0.07	0.12	0.11	0.31	0.23	0.32	0.64	0.47	1.39	1.31	1.13	0.64	0.54	0.53
5.C	Agricultural Lime Application[b]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00
5.D	**Wetlands**	1.27	1.30	1.31	1.33	0.87	3.39	6.29	9.58	13.39	18.01	23.13	31.52	42.29	56.65	76.71	78.24	79.79	94.43
5.D.1	Wetlands remaining Wetlands	1.27	1.30	1.31	1.33	0.87	3.39	6.29	9.58	13.39	18.01	23.13	31.52	42.29	56.65	76.71	78.24	79.79	94.43
5.D.2	Land converted to Wetlands	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.D	Drainage of soils	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.E	**Settlements**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-9.49
5.E.1	Settlements remaining Settlements	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.E.2	Land converted to Settlements	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-9.49
5.F	**Other Land**	0.00	NA	0.00	0.00	0.00	NA	0.00	0.00	0.00	NA	NA	-0.43	-0.36	NA	0.17	0.88	-0.50	NA
5.F.1	Other Land remaining Other Land	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.F.2	Land converted to Other Land	0.00	NA	0.00	0.00	0.00	NA	0.00	0.00	0.00	NA	NA	-0.43	-0.36	NA	0.17	0.88	-0.50	NA
5.G	**G. Other**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	TOTAL LULUCF CO_2 (net emissions/removals)	-1.19	-2.10	-2.88	-19.00	75.25	-1.87	-0.15	8.74	-11.24	-6.26	0.59	-18.39	-16.41	5.35	-16.05	-2.92	0.49	-0.55
5	TOTAL LULUCF GHGs (net emissions/removals)	-1.76	-2.53	-3.29	-17.99	48.72	-2.15	-0.40	7.73	-14.18	-7.01	-0.26	-13.67	-18.92	7.13	-17.87	-3.08	0.82	-0.53

Chapter Eight

Waste

8.1 Overview of Waste Sector

The main activities normally giving rise to greenhouse gas emissions in the *Waste* sector are solid waste disposal in landfill sites, wastewater treatment and waste incineration (Table 8.1). The most important of these sources is usually solid waste disposal where CH_4 is the gas concerned. Landfills represent a key emission category in Ireland (Chapter Three) and the emission estimates are reasonably well quantified in Ireland's inventories. The treatment of wastewaters and sludge in anaerobic systems may also be an important source of CH_4. All wastewater treatment in Ireland is aerobic and consequently this is not a source of CH_4 emissions. However, there are some CH_4 emissions from sludge treatment, which are included. The N_2O emissions arising from the production of human sewage continue to be reported following the inclusion of first estimates for this source as part of the recalculations undertaken for the 2002 submission. The 2010 submission shows total GHG emissions of 1,094.9 Gg CO_2 equivalent in the *Waste* sector in 2008, of which 85.5 percent came from 6.A Solid Waste and the remainder was due to wastewater treatment. The latest estimates show that emissions in this sector decreased by 16 percent from 1990 to 2008.

Unlike many other developed countries, Ireland has not used waste incineration as a waste management option to any significant extent to date. No incineration of municipal waste currently takes place and the incineration of clinical wastes was discontinued around 1995. The practice is now mainly confined to the destruction of liquid vapours by a small number of chemical and pharmaceutical companies. The quantities of both greenhouse gases and indirect gases concerned are considered negligible. The incineration of municipal waste will become an additional source of emissions for inclusion in annual inventories in the coming years as two waste incinerators are now under construction. This source of emissions will be included when the incinerators are commissioned.

Table 8.1. Level 3 Source Category and Gas Coverage for Waste

Waste	**CO_2**	**CH_4**	**N_2O**
A. Solid Waste Disposal on Land			
1. Managed Waste Disposal on Land	NA	All	NA
2. Unmanaged Waste Disposal Sites	NA	All	NA
3. Other	NO	NO	NO
B. Wastewater Handling			
1. Industrial Wastewater	NA	NO	NO
2. Domestic and Commercial Wastewater	NA	NO	All
3. Other	NO	NO	NO
C. Waste Incineration	NO	NO	NO
D. Other	NO	NO	NO

All : all emission sources covered; NE : emissions not estimated; NO : activity not occurring; NA : not applicable (no emissions of the gas occur in the source category); IE : emissions included elsewhere

8.2 Solid Waste Disposal (6.A)

8.2.1 Methodological Issues

The development of a national waste management strategy for Ireland (DELG, 1998) recognised the need for comprehensive analysis of the CH_4 production potential of landfills, particularly in view of the need to reduce the amount of municipal waste being placed in landfills. A modified form of the IPCC Tier 2 First Order Decay (FOD) method was therefore adopted as the most appropriate basis on which to assess annual CH_4 emissions where reasonable predictions could be made for decreasing waste quantities into the future. The method was used up to the 2009 submission with only minor updating of the underlying activity data and inclusion of sewage sludge placed in landfills as an additional source of degradable organic matter for the estimation of emissions from 2004. The analysis of CH_4 production was based on all municipal solid waste landfilled taken together in a single hypothetical landfill while taking account of a variable allocation of wastes between well-managed landfills, where the full CH_4 potential is realised, and shallow unmanaged landfills for which the potential CH_4 could be as low as 40 percent. To estimate annual emissions for the years 1990 to 2007 as submitted in 2009, the CH_4 potential of wastes landfilled in each year from 1969 (21 years prior to 1990) was first determined. These annual CH_4 potentials were assigned as emissions over 20 subsequent years (with an initial lag of 1 year) according to a first-order decay curve for the 20-year period to give the total emissions for the end year in that period.

The primary data on waste quantities and composition were taken from national waste statistics and the values of other parameters needed for the calculation of annual CH_4 generation were taken from the IPCC Good Practice Guidance. The amounts of CH_4 flared in landfills together with that utilized for energy purposes were deducted from CH_4 production to determine actual emissions into the atmosphere. The quantity of CH_4 utilized was obtained by back calculation of the electricity produced in engines as recorded in Sustainable Energy Ireland (SEI) annual energy balance sheets. The European Pollution Emissions Register (EPER) compilation for landfills for 2001 and 2004 and supporting data obtained from landfill operator’s Annual Environmental Reports (AERs) was used to provide estimates of methane flared.

8.2.2 Methodology for CH_4 Generation from Solid Waste Disposal

While the method previously used to estimate and report Ireland’s CH_4 emissions from landfills has stood up to scrutiny in the UNFCCC review process, the inventories team is aware that the simple approach used to estimate CH_4 generation does not adequately reflect the major changes in landfill operation and management after 1998 (introduction of licences for landfill operation) and better use could be made of the information now available for landfills in general. More detailed analysis was needed to address the inadequate representation of the cumulative time-dependent production of CH_4 resulting from estimation on the basis of total waste disposal – effectively as a single hypothetical landfill. Therefore the OCLR in its capacity as the national entity responsible for compiling GHG inventories has adopted the methodology for estimating CH_4 production given in the 2006 IPCC Guidelines for use in the 2010 submission.

The 2006 IPCC guidelines provide an improved methodology and an associated model for estimating CH_4 emissions from landfills. It is a simple first order decay spreadsheet model that keeps a running total of the amount of decomposable DOC available in the landfill as the basis for calculating the amount of DOC converted to CH_4 and CO_2 annually. In the present analysis the model is applied on a multi-phase basis, where data on waste composition from the national waste statistics are used directly to quantify the amount of the various constituents that produce DOC. The model contains ranges of default values for DOC content and methane generation rate constant of the waste constituents from which values appropriate to national circumstances may be selected. A methane correction factor (MCF) is used to account for the effect of landfill type and level of management on CH_4 generation. In the 2006 IPCC guidelines the MCF varies from 0.4 for shallow unmanaged landfills to 1.0 for fully anaerobic deep and managed landfills. In the present model analyses undertaken for both individual sites and groups of landfills, annual MCF values show an increase over time to reflect the change from generally shallow, poorly-managed landfills before 1998 to well controlled and engineered landfills in subsequent years.

The model was applied for the five largest landfills individually and to all other landfills by assigning them to seven separate groups according to annual waste amount and life cycle. Two additional runs were used to account for sewage sludge and street cleanings (Table G.1 of Annex G). The application of the model to individual landfills and to groups of landfills with similar characteristics accounts for the known life cycle of landfills and captures the time dependency of methane generation in a more representative manner than the previous approach based on all waste taken together in one hypothetical landfill. This revised approach adequately accounts for the closure of approximately 250 largely uncontrolled landfills of various sizes around 1998 as waste licensing came into effect under Directive 1999/31/EC (CEU, 1999). One of the five largest landfills and all landfills in four of the landfill groups selected for analysis are closed sites. The five largest landfills account for approximately 40 percent of the municipal waste disposal in Ireland over the period to which the analysis relates, which means that assumptions regarding the numerous landfills taken in groups, which are largely closed sites, have a significant bearing on the estimates of CH_4 generation, particularly for the early years of the 1990-2008 time-series. Table G.1 of Annex G provides a compilation of the input data for the IPCC model runs.

Waste Quantity and Composition

The EPA commenced the development of the National Waste Database (NWD) in the early 1990s to address a severe lack of information on waste production and waste management practices in Ireland. The database was needed to support radical reform of national policy and legislation on waste pursuant to the Waste Management Act of 1996 and subsequent Government strategies on sustainable development (DELG, 1997) and waste management (DELG, 1998). National statistics generated from this database published on a three-year cycle, and interim reports published on a yearly basis since 2001 by the EPA (Carey et al, 1996; Crowe et al, 2000; Meaney et al, 2003; Collins et al, 2004a; Collins et al, 2004b; Collins et al, 2005; Le Bolloch et al, 2006; Le Bolloch et al, 2007; Le Bolloch et al, 2009; McCoole et al, 2009) are the primary basis for establishing the historical time-series of municipal solid waste (MSW) placed in landfills from 1995 onwards. Identification and risk assessment of historical landfills under S.I. No. 524 of 2008 (DEHLG, 2008) serves as the main source of information on landfilling of waste prior to 1995. The results of other surveys undertaken in previous years (Boyle, 1987, ERL, 1993, MCOS, 1994 and DOE, 1994) have also been used to some extent in compiling the MSW time-series.

The NWD reports published since 1995 provide a good starting point for assigning waste quantities to individual landfills, which is supplemented by the other sources indicated which provide a representation of waste composition. However, assumptions on waste quantities and composition are still needed to establish the basic information historically, given the extended time-frame that must be taken into account for a number of the models. The waste quantities for each of the 12 IPCC spreadsheet model analyses are determined by adding up the amounts of household and commercial waste for the relevant landfills for each year where this is given by the NWD and the quantities for other years are estimated by interpolation and from various published reports for the larger landfills in Ireland. Paper products are the key determinant of degradable carbon in landfills. The NWD shows a significant decline in the proportion of paper products in waste going to landfills from 31 percent in 1995 to 21 percent in 2008, which reflects the increase in recycling of paper. In the analysis for historical years, the paper content was fixed at 40 percent for 1980 and previous years and decreases linearly from 40 percent in 1980 to 31 percent in 1995. The NWD is used to give the values for all years in the period 1995 to 2008. The proportion of organics, the other principal constituent of waste, was estimated in the same way for each year.

Degradable Organic Carbon (DOC)
The waste constituents of MSW that contribute to DOC are food waste, paper, wood, textiles and disposable nappies are identified in the available NWD breakdown for 1995, 1998, and 2001 through 2008. The IPCC default proportions of DOC content are used for all these constituents (Annex G). In addition, DOC contents of 20 percent and 10 percent have been assumed for street cleansings and sewage sludge, respectively.

Decay Rate Constant k
The 2006 IPCC Guidelines provide narrow ranges for the value of decay rate constant appropriate to the individual waste components under different climatic zones. Ireland has chosen the highest values given for the Western Europe wet temperate conditions for all waste constituents, as the value of the ratio MAP:PET (Mean Annual Precipitation: Potential Evapotranspiration) is greater than 2 in Ireland.

Degradable Carbon Fraction DOC_f
A value of 0.6 is considered appropriate for the fraction of organic carbon that ultimately decomposes in solid waste landfills in general in Ireland, given that decomposition is not significantly inhibited by lignin. A higher value of 0.75 has been applied in the models for two major landfills that are less than 10 years old (Annex G), which accept baled municipal waste and where site conditions and management are conducive to the enhanced degradation of organic carbon.

Methane Correction Factor MCF
The choice of MCF in each of the model runs is made by assigning the individual landfill or group of landfills to the IPCC management category considered to reflect the applicable level of management for each year of their lifetime. The licensing of landfill sites came into effect around 1998, which ultimately resulted in the closure of approximately 250 sites. All landfills that continued in operation under licence after 1998, together with all new sites, are assumed to come within the IPCC description of a managed site and the MCF of 1.0 applies. The larger landfills that were in existence prior to the introduction of waste licensing were subject to some level of management but not to the extent of fully managed licensed sites after 1998. These large sites are assigned to the IPCC category of unmanaged deep sites for the years up to 1998 with MCF of 0.8 and to the managed category with MCF of 1.0 for the remainder of their lifetime. The 250 sites that operated primarily as small open town dumps and shallow uncontrolled disposal sites with significant aerobic conditions up to the introduction of waste licensing are assigned to the IPCC category of unmanaged shallow sites up to 1998, for which the appropriate MCF is 0.4. A transition from unmanaged shallow classification in 1960 to one-third unmanaged shallow and two-thirds unmanaged deep sites in 1998 is applied to the remainder of sites, giving an increasing MCF from 0.4 to 0.67 over this period.

8.2.3 Methane Recovery at Solid Waste Disposal Sites

In 2008 the EPA commissioned a detailed study with Fehily Timony Consultants (FTC) to quantify methane recovered through landfill gas flaring for all years since the practice was introduced in Ireland and to validate the methane utilization amounts recorded in the SEI annual energy balances. Survey data were obtained in respect of 64 landfill sites (27 open and 37 closed), which indicated a survey response rate of over 90 percent. Information on the number of flares in use, together with data relating to flare capacity, run time and performance was used to estimate the volume of landfill gas flared at each site. The tonnage of CH_4 flared was calculated from landfill gas volume by accounting for gas temperature (assumed to be ambient air temperature) and pressure (provided in survey questionnaire returns) and by using methane destruction efficiencies of 50 percent for open flares and 98 percent for closed flares. The study found that there were six methane utilisation plants at landfills in Ireland in 2008 with a total of 24 engines operated by Bioverda Power Systems. The amount of methane input to landfill gas utilization plants is calculated from their known electricity outputs as obtained by SEI from EIRGRID (Electricity Transmission System Operator) using an overall efficiency of 36.6 percent for the engines, which is considered typical of the engine types in general use.

The FTC study on landfill gas flaring is the most detailed ever undertaken in the country and the consultants have considerable experience and expertise in landfill design and landfill gas management practices. A high response rate was achieved in the survey of flare use and the results may be accepted as reasonably robust for the purpose of quantifying the amount of CH_4 captured in this way. The estimates of CH_4 for landfill gas utilized in electricity generation are considered to be reliable in that they reflect metered electrical output from gas engines for which efficiency is well established and which can be readily used to estimate CH_4 input.

Table 8.2. Methane Emissions from Solid Waste Disposal 1990-2008

	Methane Generation (Tonnes)	Methane Flaring (Tonnes)	Methane Utilisation (Tonnes)	Methane Recovery (Tonnes)	Percent Methane Recovery	Methane Emissions (Tonnes)	Methane Emissions (Gg CO_2eq)
1990	55,859	0	0	0	0.00	55,859	1,173.05
1991	59,607	0	0	0	0.00	59,607	1,251.74
1992	62,499	0	0	0	0.00	62,499	1,312.47
1993	64,862	0	0	0	0.00	64,862	1,362.09
1994	67,141	0	0	0	0.00	67,141	1,409.97
1995	69,031	0	0	0	0.00	69,031	1,449.66
1996	70,895	1,514	5,877	7,391	0.10	63,504	1,333.58
1997	73,167	3,219	18,354	21,573	0.29	51,594	1,083.48
1998	75,358	3,404	17,632	21,036	0.28	54,322	1,140.76
1999	77,930	4,238	19,317	23,555	0.30	54,376	1,141.89
2000	82,542	6,524	19,818	26,342	0.32	56,200	1,180.19
2001	88,205	6,570	20,159	26,729	0.30	61,476	1,290.99
2002	93,505	11,456	16,108	27,564	0.29	65,942	1,384.77
2003	98,277	15,859	13,781	29,640	0.30	68,637	1,441.38
2004	102,439	28,599	16,749	45,348	0.44	57,091	1,198.91
2005	107,220	35,358	20,947	56,305	0.53	50,915	1,069.21
2006	112,284	34,558	21,346	55,904	0.50	56,380	1,183.98
2007	116,977	47,695	20,072	67,767	0.58	49,209	1,033.40
2008	121,057	54,726	21,768	76,494	0.63	44,563	935.83

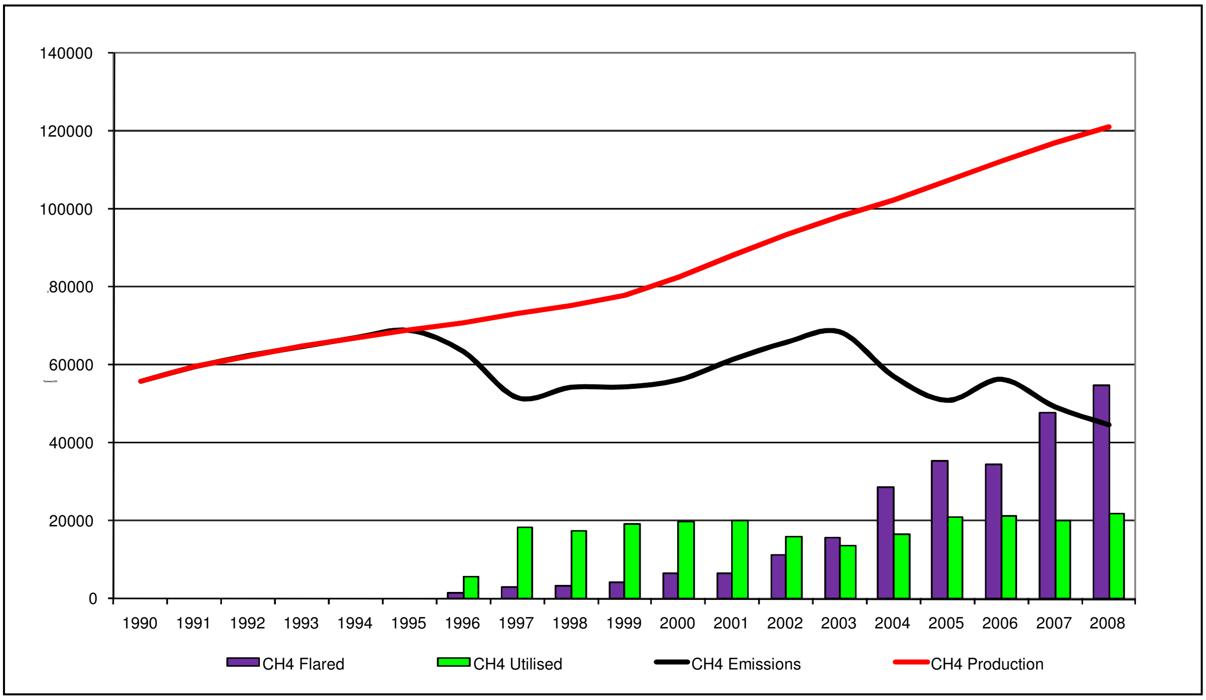


Figure 8.1. Methane Emissions from Solid Waste Disposal 1990-2008

Table 8.2 and Figure 8.1 present the results of the revised approach and the new estimates of emissions from category 6.A Solid Waste Disposal. The new estimates of CH_4 generation obtained using the model in the IPCC 2006 Guidelines are considered more robust than previous estimates, and they show a steady increase in CH_4 production over the period 1990-2008, reflecting Ireland's strong dependence on solid waste disposal to landfills. The utilization of CH_4 has remained generally constant since becoming established in 1997, with no additional sites being used for this purpose for a number of years. In contrast, the amount of flared methane increased sharply after 2003. This reflects the proliferation in the use of enclosed flares as a means of odour control at landfills generally throughout the country, which all operate under EPA licence and stringent environmental controls.

The amounts of CH_4 flared are substantially higher than the previous available estimates based on EPER returns for 2001 and 2004, which were incomplete. These latest results show that CH_4 recovery through flaring and utilisation reached the level of 63 percent in 2008, which is to be expected from the very extensive use of flaring infrastructure now in place at landfills in Ireland. The flaring study also indicated significant potential for viable electricity production at several landfill sites in addition to those already in operation but the costs associated with grid connection remains a barrier to their development. The recovery of CH_4 for energy purposes was the principal offset to production over the period 1996-2002 causing a sharp initial reduction, but emissions increased from 1997 to reach the 1995 level again in 2003. Due to the rapidly increasing level of CH_4 flared after 2003, the emissions show a steady decline from the 2003 level of 1,441.38 Gg CO_2eq o 935.8 Gg CO_2eq in 2008. The emissions in 2008 are approximately 20 percent lower than in 1990.

8.3 Emissions from Wastewater Handling (6.B)

8.3.1. CH_4 Emissions from Wastewater and Sludge (6.B.2.1)

Approximately one-third of the population in Ireland is served by urban wastewater treatment plants, which are based on aerobic systems with no emissions of CH_4. The other one-third of the population uses septic tanks to treat wastewater mainly for individual houses in non-urban areas (Smith et al., 2004). The prevailing temperature in septic tanks is less than $15^{O}C$ in Ireland, which is too low for the occurrence of methanogenesis and it is reasonable to assume that no appreciable emissions of CH_4 occur. Consequently the notation key "NO" is reported for CH_4 under wastewater in sub-categories 6.B.1 and 6.B.2 of the CRF tables.

The anaerobic stabilisation of sludge is a source of CH_4 in Ireland. The amounts of industrial wastewater sludge produced are available from biennial reports on urban wastewater treatment and approximately three percent of this sludge is treated anaerobically (O' Leary et al. 1997, 2000; O'Leary and Carty, 1998; Smith et al. 2003; 2004, 2007; Monaghan et al. 2009). The average BOD of industrial wastewater sludge is 60 kg/t (40 percent of the typical BOD content of treated industrial wastewater) and DOC is estimated as the product of average BOD content and tonnes of dry solids of sludge. The emission factor for CH_4 is derived from equation 11 on page 6.21 of the Revised 1996 IPCC Guidelines using the IPCC default value of 0.6 for B_O, 0.3 for the fraction of sludge treated and 1.0 for MCF. The sludge arising from secondary treatment of urban wastewater for the Dublin agglomeration, which accounts for approximately half of the population equivalent served by urban wastewater treatment systems, is thermally dried and pastuerised for use as an organic fertilizer. The CH_4 produced is used for electricity generation for use on site since 2005. For the remainder of domestic/commercial wastewater sludge, the DOC is calculated using 60g BOD/capita/day population equivalent[2] and SBF (the fraction of BOD that readily settles) of 0.395, which is a combination of 0.35 for conventional primary sedimentation and 0.045 for secondary sedimentation tanks. The emission factor for CH_4 is derived as for industrial sludge.

The sludge from wastewater treatment is disposed of in landfills or used as organic fertilizer on agricultural lands or in composting. The quantity of sludge that is disposed of in landfills contributes to CH_4 emissions from SWDS and is accounted for in emission estimates for CRF category *6.A.1 Solid Waste Disposal on Land*. The proportion of sludge disposed of in SWDS has reduced significantly from 42 percent of sludge produced (tonnes of dry solids) in 1990 to 17 percent in 2005 (data for 2006 and 2007 is currently not available, therefore assumed the same as 2005). The sludge applied to agricultural land contributes to N_2O emissions from soils and is included in emission estimates for CRF category *4.D.1 Direct soil emissions* as discussed in section 6.5.1 of this report. The proportion of sludge applied to agricultural lands has increased from 12 percent in 1990 to 70 percent in 2007.

8.3.2 N_2O Emissions from Human Sewage (6.B.2.2)

Human consumption of food results in the production of sewage, which is processed in septic tanks or in wastewater treatment facilities and is then disposed of directly onto land, into the soil through percolation areas or discharged to a water body. Nitrous oxide can be produced during these processes through nitrification and denitrification. Estimates of emissions of N_2O from human sewage discharges are made using the IPCC methodology.

[2] Population Equivalent is the BOD associated with the wastewater produced by one person and is established as 60g per day by Directive 91/271/EEC

This source of emissions was first included as part of the recalculation exercise undertaken for the 2002 submission.

In submissions prior to 2002, the body weight and average protein intake of the population were taken as 80 kg and 0.75 g/kg body weight per day, respectively, to estimate annual protein consumption based on information provided by the Food Safety Authority of Ireland (FSAI, 1999). The 2003 in-country review of Ireland's 2001 submission identified that FAO statistics indicate a typical protein intake of about 114 g/capita/day for the population of Ireland, compared to the 60 g/capita/day suggested by the FSAI recommendations. Ireland adopted the FAO estimate of protein intake in the estimates for 2003 and the corresponding emissions in other years were recalculated on this basis for the purpose for the 2005 submission. The emissions in 2007 are estimated using the same approach. The N_2O emissions are computed by taking the IPCC default value of 0.16 for the nitrogen content in protein and applying the default emission factor of 0.01 to obtain the quantity of nitrogen in sewage ultimately entering the atmosphere as N_2O. Emission estimates are provided in Table 8.3.

Table 8.3 Estimates of N_2O emissions from human sewage 1990-2008

Year	Protein (g/day)	Days	Pop (million)	N fraction (IPCC default)	EF (IPCC default)	N_2O Gg*
	A	B	C	D	E	
1990	114.3	365	3.506	0.16	0.01	0.368
1991	115.2	365	3.526	0.16	0.01	0.373
1992	118.5	366	3.555	0.16	0.01	0.388
1993	115.5	365	3.574	0.16	0.01	0.379
1994	112.5	365	3.586	0.16	0.01	0.370
1995	108.6	365	3.601	0.16	0.01	0.359
1996	108.7	366	3.626	0.16	0.01	0.363
1997	111.1	365	3.664	0.16	0.01	0.374
1998	112.2	365	3.703	0.16	0.01	0.381
1999	114.2	365	3.742	0.16	0.01	0.392
2000	117.2	366	3.790	0.16	0.01	0.409
2001	114.8	365	3.847	0.16	0.01	0.405
2002	114.2	365	3.917	0.16	0.01	0.411
2003	114.2	365	3.979	0.16	0.01	0.417
2004	114.2	365	4.044	0.16	0.01	0.424
2005	114.2	365	4.131	0.16	0.01	0.433
2006	114.2	365	4.240	0.16	0.01	0.444
2007	114.2	365	4.339	0.16	0.01	0.455
2008	114.2	365	4.221	0.16	0.01	0.463

*emissions calculated as A * B * C * D * E * 44 / 28000

8.4 Uncertainties and Time-Series Consistency

The methodologies used in the derivation of emissions estimates from the waste sector are consistent over the time-series. In the case of category 6.A, this consistency applies to all three components that determine the ultimate emissions, i.e. CH_4 generation, CH_4 flared and CH_4 utilised. Adoption of the model in the 2006 IPCC Guidelines is justified by the information available for its detailed application and brings Ireland into line with other Parties using this methodology well in advance of the expected mandatory use of these guidelines for inventory reporting post-2012.

While the work undertaken for the 2010 submission improves the robustness of emissions estimates, it is recognised that the overall uncertainty associated with estimating CH_4 emissions from source category 6.A are likely to remain very high, even under detailed analysis of national data as described above, mainly because of the lengthy historical period that must be taken into account. Uncertainty estimates for the source category are calculated using equations 6.3 and 6.4 of the IPCC Good Practice Guidance. Uncertainties of 20 percent are assumed in relation to the quantity of MSW, its composition and DOC contents, giving a combined uncertainty of 34.6 percent for activity data using equation 6.4. This is also the emission factor uncertainty when 20 percent is taken as the uncertainty for the fraction of DOC dissimilated, MCF and decay rate constant. This gives an uncertainty of 48.9 percent for CH_4 generation again using equation 6.4, which is combined with uncertainties of 30 percent and 10 percent for CH_4 flaring and CH_4 utilisation, respectively equation 6.3 to give an uncertainty of 31.1 percent for emissions.

Uncertainties in estimates of emissions from the source category 6.B arise due to the quality of source data, wastewater production estimates, its chemical parameters in terms of COD or BOD, the methane producing capacity and its treatment. The only source of emissions from wastewater handling in Ireland is the anaerobic treatment of sludge, for which uncertainty estimates of 10 percent and 30 percent are assigned to the activity data and emission factor used, respectively.

8.5 Quality Assurance and Quality Control

As part of ongoing QA/QC by the inventory team, emission estimates are reviewed on a round-robin basis so that the person who develops the estimates of emissions is not also the person undertaking the QC procedures. Activity data are drawn from various reports prepared in other EPA offices as outlined in the previous sections. Quality control procedures are undertaken by the teams involved through yearly reviews of data collection methods and through agreed collation and aggregation methodologies required to meet the relevant reporting requirements under the applicable legislation. In addition, where any anomalies exist in data compiled in such reports, revised data are published in the reports in following years and thus forms a basis for recalculations in emission estimates by the EPA inventory team in the Climate Change Unit. The calculated estimates of CH_4 for all flares in the survey results obtained from the consultants engaged to carry out the study on CH_4 recovery were replicated by the inventory team from the survey data as a specific QA/QC activity to support the revised emissions estimates described above. The inventory team also maintains close collaboration with specialists and license inspectors in the waste sector who are in a position to give advice or guidance on the use of the NWD or on methane recovery at landfill sites.

8.6 Recalculations for Waste

Previous NIRs refer to a number of shortcomings that the inventory agency had identified with the approach used to estimate emissions from category 6.A and to the need for better data on the amount of CH_4 flared in landfills. These issues have been addressed in the manner proposed in the 2009 NIR and the emissions estimates for the waste sector are substantially revised in the 2010 submission, reflecting the following changes

(a). Application of the model in the 2006 IPCC Guidelines to estimate CH_4 generation in 6.A Solid Waste Disposal on the basis of 12 individual model applications;

(b). More in-depth analysis of the available information on waste quantities, waste composition and waste recycling, as well as landfill management to develop appropriate choices for DOC_f, MCF and decay rate constant for all model applications;

(c). The use of the results of a comprehensive study that gives estimates of CH_4 flared in landfills for all years since the practice was introduced in Ireland;

(d). Reduction of CH_4 emissions from sludge treatment for urban wastewater to account for the use of the CH_4 produced from this activity in respect of the Dublin agglomeration.

Table 8.4 sets out the quantitative changes in the emissions estimates for the waste sector for the years 1990-2007, which are dominated by those for 6.A Solid Waste Disposal. The effect is highly variable over the period as both CH_4 generation and recovery rates are revised substantially but recovery applies only after 1996. The decrease in total emissions for the sector varies from 10.9 percent in 1990 to 19.8 percent in 2007.

8.7 Improvements in Waste

Ireland's refined approach to the estimation of CH_4 emissions from solid waste disposal and the delivery of recalculated estimates for the waste sector is an important improvement for the GHG inventory that has been pending for a number of years. The inventory agency believes that the use of the model provided by the 2006 IPCC Guidelines is justified as a robust estimation methodology where its flexibility in accommodating changes to input parameters to suit national circumstances is fully exploited. In the present analysis, the application of the model to individual landfills and to groups of landfills with similar characteristics accounts for the known management and life cycle of landfills in Ireland as well as the quantity and composition of waste and captures the time dependency of methane generation in a more representative manner than the previous approach based on one hypothetical landfill. The adoption of this methodology simplifies the task of the inventories team with regard to inventory preparation and its response to the UNFCCC review process. It provides a convenient basis on which to incorporate further modifications in respect of particular data items or model parameters and gives an efficient and improved mechanism for undertaking emissions projections in relation to landfills, which is an issue of increasing importance.

Following the outcome of the 2009 annual review, Ireland has re-stated its position regarding the non-applicability of a number of minor sources of emissions in wastewater handling and has made a revision to account for some utilisation of the CH_4 derived from the treatment of sewage sludge. Similarly, it has been re-iterated in this chapter that waste incineration has not yet come into effect in Ireland.

Table 8.4 Recalculated Estimates for Waste 1990-2007

			1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
	Estimates in 2009 Submission (Gg CO_2 eq.)																			
6.A.1	Managed Waste Disposal on Land	CH_4	980.329	1,015.507	1,056.690	1,103.583	1,152.119	1,201.772	1,131.137	919.328	985.183	1,009.759	1,080.731	900.135	1,045.863	1,171.996	1,174.972	1,190.103	1,287.701	1,434.120
6.A.2	Unmanaged Waste Disposal Sites	CH_4	351.940	350.149	349.517	350.866	354.571	360.862	368.888	376.821	385.496	397.196	413.806	432.963	455.325	471.260	462.221	425.334	381.706	336.525
6.B.1.b	Industrial Wastewater	CH_4	1.964	1.976	1.992	2.003	2.009	1.956	1.970	3.801	3.841	4.084	4.231	4.389	4.469	4.265	5.105	5.187	5.269	5.351
6.B.2.b	Domestic and Commercial Wastewater	CH_4	12.764	12.836	12.941	13.013	13.056	12.710	12.797	16.505	16.680	17.736	17.963	18.634	18.973	18.106	18.401	18.696	18.992	19.287
6.B.2	Human Sewage	N_2O	113.999	115.549	120.158	117.440	114.768	111.265	112.442	115.818	118.203	121.561	126.697	125.648	127.266	129.270	131.379	134.202	137.748	140.969
6	Total	CO_2 eq.	1,460.997	1,496.017	1,541.298	1,586.905	1,636.523	1,688.565	1,627.233	1,432.272	1,509.403	1,550.336	1,643.428	1,481.770	1,651.896	1,794.897	1,792.078	1,773.522	1,831.417	1,936.254
	Recalculated Estimates in 2010 Submission (Gg CO_2 eq.)																			
6.A.1	Managed Waste Disposal on Land	CH_4	NO	NO	NO	NO	NO	NO	NO	NO	NO	808.784	865.267	993.962	1,104.961	1,180.912	959.141	848.097	979.592	844.080
6.A.2	Unmanaged Waste Disposal Sites	CH_4	1,173.049	1,251.744	1,312.469	1,362.095	1,409.965	1,449.659	1,333.585	1,083.482	1,140.764	333.107	314.926	297.032	279.812	260.470	239.770	221.118	204.385	189.315
6.B.1.b	Industrial Wastewater	CH_4	1.964	1.976	1.992	2.003	2.009	1.956	1.970	3.801	3.841	4.084	4.231	4.389	4.469	4.265	5.105	5.187	5.294	5.401
6.B.2.b	Domestic and Commercial Wastewater	CH_4	12.764	12.836	12.941	13.013	13.056	12.710	12.797	16.505	16.680	17.736	17.963	18.634	18.973	18.106	18.401	9.348	9.541	9.733
6.B.2	Human Sewage	N_2O	113.999	115.549	120.158	117.440	114.768	111.265	112.442	115.818	118.203	121.561	126.697	125.648	127.266	129.270	131.379	134.202	137.748	140.969
6	Total	CO_2 eq.	1,301.777	1,382.105	1,447.560	1,494.551	1,539.798	1,575.590	1,460.793	1,219.606	1,279.488	1,285.272	1,329.084	1,439.665	1,535.482	1,593.023	1,353.796	1,217.952	1,336.560	1,189.499
	Percentage Change in Total Emissions due to Recalculations																			
6.A.1	Managed Waste Disposal on Land	CH_4	NA	NA	NA	NA	NA	NA	NA	NA	NA	-19.90	-19.94	10.42	5.65	0.76	-18.37	-28.74	-23.93	-41.14
6.A.2	Unmanaged Waste Disposal Sites	CH_4	233.31	257.49	275.51	288.21	297.65	301.72	261.51	187.53	195.92	-16.14	-23.90	-31.40	-38.55	-44.73	-48.13	-48.01	-46.45	-43.74
6.B.1.b	Industrial Wastewater	CH_4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.93
6.B.2.b	Domestic and Commercial Wastewater	CH_4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-50.00	-49.76	-49.54
6.B.2	Human Sewage	N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Total	CO_2 eq.	-10.90	-7.61	-6.08	-5.82	-5.91	-6.69	-10.23	-14.85	-15.23	-17.10	-19.13	-2.84	-7.05	-11.25	-24.46	-31.33	-27.02	-38.57

Chapter Nine

Other Sources

The sector *Other* in the IPCC source sector classification (Table A.2, Annex A) that is the basis for the CRF reporting tables provides for the inclusion of greenhouse gas emissions sources that may be particular to individual Parties. There are no such sources to report in Ireland.

Chapter Ten

Recalculations and Improvements

10.1 Introduction

Ongoing demands for more complete and more accurate estimates of greenhouse gas emissions means that the methodologies being used are subject to regular revision and refinement as inventory capacity is increased and better data become available. The general improvement in inventories over time may therefore introduce inconsistencies between the emissions estimates for recent years and those for years much earlier in the time-series. Recalculated estimates are often needed to eliminate these inconsistencies and to ensure that the inventories for all years in a time-series are directly comparable with respect to the sources and gases covered and that the methods, activity data and emission factors are applied in a transparent and consistent manner. In this way, the results can be used with greater confidence in identifying trends and in monitoring progress towards the commitments that have been defined with reference to emissions in the base year. The UNFCCC reporting guidelines provide for the reporting of recalculations as part of the annual submissions from Annex I Parties. Justification for the recalculations should be provided, as well as explanations of the changes that have been made and the numerical values of the original and revised estimates must be compared to show the impact of the changes.

10.2 Explanations and Justifications for Recalculations

The foregoing chapters describe recalculations and improvements for the individual Level 1 source sectors of the inventory undertaken for the 2010 submission and they present the corresponding quantitative changes in emissions and removals within the individual sectors. The recalculations in all cases are due to methodological refinement rather than major methodological change, as defined by the IPCC good practice guidance. Table 10.1 records the major changes and where they are described in the 2010 NIR. This section summarises the recalculations and assesses their effect in relation to total national emissions to record the updates and the most recent emissions estimates as they appear in the 2010 submission CRF tables. The original and revised numerical values of the emissions estimates for the years 1990-2007, along with the changes related to methods, activity data and emission factors are detailed in the respective CRF Tables 8(a) and 8(b). The principal changes that that give rise to recalculated estimates for the years 1990-2007 included in the 2010 submission are as follows:

1.A.1 Energy Industries

- Revision of CH_4 and N_2O emission factors for all stationary combustion sub-categories to the best available IPCC values, as detailed in Annex C;
- Revised estimate for CH4 and N2O due to bimass co firing in peat power plants for 2006 and 2007.

1.A.2 Manufacturing Industries and Construction

- Revision of CH_4 and N_2O emission factors for all stationary combustion sub-categories to the best available IPCC values, as detailed in Annex C;

- Use of a country-specific CO_2 emission factor for petroleum coke in all sub-categories where this fuel is used;
- Minor revisions of energy data in the national energy balance.

1.A.3 Transport

- Minor revisions to emission factors for CH_4 and N_2O from 1.A.3(b) Road Transportation (Gasoline) introduced by the application of COPERT 4 version 6.1;
- Revision of CH_4 and N_2O emission factors for 1.A.3(c) Railways (Diesel), as detailed in Annex C;
- Revision of N_2O emission factors for 1.A.3(d) Navigation (Liquid fuels), as detailed in Annex C.

1.A.4 Other Sectors

- Revision of CH_4 and N_2O emission factors for all stationary combustion sub-categories to the best available IPCC values, as detailed in Annex C;
- Use of a country-specific CO_2 emission factor for petroleum coke in 1.A.4(b) Residential, as detailed in Annex C;
- Revision of CH_4 and N_2O emission factors for all mobile combustion in 1.A.4(c) Agriculture to the best available IPCC values, as detailed in Annex C;
- Minor revisions of energy data in the national energy balance.

2.A Mineral Products

- Minor revision to activity data in 2.A.3 Limestone and Dolomite Use for all years from 1990-1999;
- Reallocation of process CO_2 emissions from Soda Ash use (in Glass production facilities) previously reported in 2.A.4 to sub category 2.A.7.1 Glass production;
- Estimates of process CO_2 emissions from 2.A.7.1 Glass Production provided for the first time for all years from 1990-2008;
- Minor revision to process CO_2 emission factor in sub category 2.A.7 Bricks and Tiles for all years from 1990-2004.

3. Solvent and Other Product Use

- Minor revision of activity data for sub categories 3.A. Paint Application, 3.B. Degreasing, dry cleaning and electronics and 3. D. Other Use of Solvents.

4.A Enteric Fermentation

- Minor revisions in CH_4 emission factors based on revised animal weight classifications for pigs using national data for all years 1990-2007;
- Revised population statistics for sheep for 2001-2003 and 2005.

4.B Manure Management

- Minor revisions in CH_4 and N_2O emission factors for pigs using national data;

- Revised population statistics for sheep for 2001-2003 and 2005.

4.D.1.2 Animal Manure Applied to Soil

- Revised pig weight and manure production classification for all years 1990-2007.

4.D.3.1 Atmospheric Deposition

- Minor revisions to NH_3 emissions from pigs due to the adoption of country specific emission factors for PRTR reporting.

5.A Forest Land

- Minor modifications in regard to the treatment of areas and other parameters in order to be as consistent as possible in reporting emissions and removals for forests under the Convention and under Article 3.3 of the Kyoto Protocol;
- Revision of the litter pool carbon stock changes using country specific data;
- Revised estimates of CO_2 and CH_4 emissions from forest biomass burning following some amendments to areas based on new information from the Forest Service.

5.B Cropland

- Revised crop area for all years 1990-2007.

5.C Grassland

- Revised cropland areas and therefore lands in transition under sub category 5.C.2.2 Cropland converted to Grassland.

5.D Wetlands

- Revision to correct a double count of biomass restoration on acidic peatland for all years 1990-2007.

5.E Settlements

- Revised land area in sub category 5.E.2 Land converted to Settlements for 2007.

6.A Solid Waste Disposal on Land

- Application of the model provided in the 2006 IPCC Guidelines to estimate CH_4 generation on the basis of 12 individual model applications for MSW disposal to landfills;
- Analysis of the available information on waste quantities, waste composition and waste recycling, as well as landfill management to develop appropriate choices for DOC_f, MCF and decay rate constant for all model applications;
- The use of the results of a comprehensive study that gives estimates of CH_4 flared in landfills for all years since the practice was introduced in Ireland;
- Reduction of CH_4 emissions from sludge treatment for urban wastewater to account for the use of the CH_4 produced from this activity in respect of the Dublin agglomeration for the years after 2004 being utilised for electricity generation.

Table 10.1 Changes in Methodological Descriptions compared to 2009 NIR

METHODS	RECALCULATIONS	REFERENCE
IPCC categories where the 2010 NIR includes changes in methodological descriptions compared to the 2009 NIR	**Sub-categories where changes are reflected in recalculations of estimates for previous years**	**Reference to sub-category, gas, pages in the NIR, Annex**
1.A 1 Energy Industries	1.A.1(a), 1.A.1(b), 1.A.1(c)	Use of ETS CO_2 data in 1.A.1 and revised EF for CH_4 and N_2O; NIR section 3.2.1.1; Annex C
1.A.2 Manufacturing Industries and Construction	1.A.2	Use of ETS energy data in 1.A.2; country specific CO_2 EF for petroleum coke and revised EF for CH_4 and N_2O; NIR section 3.2.1.2; Annex C
1.A.4 Other Sectors	1.A.4(b); 1.A.4(c)	Country specific CO_2 EF for petroleum coke and revised EF for CH_4 and N_2O; NIR section 3.2.1.4; Annex C
2.A Mineral Products	2.A.3, 2.A.7	Reallocation as appropriate from 2.A.3 to 2.A.7 and separate treatment for glass production; NIR section 4.2.5
6.A Solid Waste Disposal on Land	6.A	Use of 2006 IPCC GLs model for CH_4 generation and use of new survey results on CH_4 recovery; NIR section 8.2.2

10.3 Effects on Emission Levels, Trends and Time-Series Consistency

Tables 10.2 and 10.3 outline the effect of recalculations for the years 1990-2007 according to greenhouse gas and the IPCC sectors, respectively. The overall effect on total emissions excluding LULUCF is a reduction that varies from 1.04 percent in 1990 to 2.28 percent in 2007 (Table 10.2(c)). The change is greatest for the latter years of the time-series due to higher impact of the revisions for category 6.A Solid Waste in these years. The effects of other revisions are much smaller and they are similar in all years. There is no significant impact on the trend in total emissions (Chapter Two). The recalculations improve time-series consistency and comparability and they take account of the inventory review process by implementing the major outstanding inventory-specific recommendations of the latest annual review reports. It may be said that fully consistent greenhouse gas inventories are available for the years 1990-2008 and that these annual inventories are complete with respect to the coverage of the six greenhouse gases and all IPCC source categories. The range of really important greenhouse gas emission sources in Ireland is quite small and the important elements of good practice are taken into account in the current approaches to estimating their emissions.

10.4 Response to the Review Process and Planned Improvements

Ireland recognises the need to deliver annual submissions in close conformity with the UNFCCC reporting guidelines on annual inventories to facilitate the work of expert review teams in conducting productive and efficient technical reviews of greenhouse gas inventories. Every attempt is made to participate in the UNFCCC review process and to facilitate the work of the UNFCCC secretariat, especially insofar as it impacts on the quality and transparency of the Irish estimates of emissions. The in-country review of Ireland's 2006 submission (UNFCCC, 2007) was an important development in this regard. The majority of the recommendations in the 2007 review report were implemented in the 2008 submission while further recommendations from the 2008 and 2009 centralized reviews of Ireland's inventory have also been addressed where feasible in the present submission. This involved greater application of country-specific information in a number of areas of the inventory and improved explanations and clarifications have been included in the 2010 NIR relating to the use of ETS data, which are used extensively in the *Energy* and *Industrial Processes* sectors. Annex H summarises the issues raised in the UNFCCC 2009 review and Ireland's response to those issues through the present submission. It may be stated therefore that the inventory material being submitted in 2010 broadly meets the principles of transparency, completeness, consistency, comparability and accuracy laid down in the UNFCCC reporting guidelines.

Further general improvements to greenhouse gas inventories are taking place through consolidation and implementation of the national system, which has been fully operational since 2007, and through application of formal QA/QC procedures that have been put into effect as an integral part of the national system. Memoranda of Understanding which define the data inputs between the inventory agency and all key data providers and which outline the responsibilities that are conferred to the data providers under the national system (Table 1.1) underpin the national system in Ireland and have improved the quality and timely delivery of the activity data. Their application has identified where additional MOUs may be useful, including some secondary MOUs incorporated in 2009. An updated national climate change strategy was published in 2007 providing a framework in which internal review of annual inventories will take place among all stakeholders to monitor progress on the strategy, thereby fulfilling another important requirement of national system implementation.

The implementation of comprehensive QA/QC procedures in this reporting cycle according to the plan supporting the national inventory system maintains and enhances the general improvement in quality of Irish greenhouse gas inventories. The QA/QC elements include a plan and procedures for QA/QC in data selection and acquisition, data processing and reporting to comply with international requirements under Decision 280/2004/EC and the Kyoto Protocol. The plan provides guidance on and templates for appropriate quality checking, documentation and traceability, the selection of appropriate source data and calculation methodologies. It extends to peer review and expert review of inventory data and outlines the annual requirements of a continuous improvement programme for the inventory. Participation in the internal review mechanisms within the EU as part of the QA/QC plan developed for the EU inventory under Decision 280/2004/EC provides an opportunity to engage with other Member States in the examination and assessment of individual IPCC sectors and particular issues relating to methodologies and country-specific approaches that could bring mutual benefits to their greenhouse gas inventories. The revisions relating to categories 2.A.3 and 2.A.7 mentioned above result from efforts by EU Member States to harmonise reporting in these categories for their 2010 submissions.

Table 10.2 Recalculations by Gas 1990-2007

(a) Emissions by Gas 1990 –2007 reported in 2009 Submission (Gg CO_2eq)

GAS	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
CO_2 (inc net CO_2 from LULUCF)	32,635.18	33,562.04	33,505.98	33,460.59	34,529.13	35,541.29	37,305.35	38,731.29	40,433.37	42,084.72	44,866.14	47,244.85	45,596.08	44,764.03	45,660.04	47,114.28	46,714.10	46,480.15
CO_2 (exc net CO_2 from LULUCF)	32,400.10	33,227.32	33,110.49	33,236.58	34,483.24	35,269.44	36,932.04	38,426.20	40,522.61	42,211.33	44,748.44	47,199.52	45,773.52	45,041.13	45,891.61	47,637.96	47,242.80	47,498.72
CH_4 emissions (inc CH_4 from LULUCF)	13,470.40	13,613.59	13,706.31	13,794.64	13,761.79	13,800.53	14,045.83	14,107.11	14,363.67	14,042.02	13,537.05	13,287.46	13,358.99	13,941.49	13,346.24	13,250.06	13,279.74	12,962.89
CH_4 emissions (exc CH_4 from LULUCF)	13,468.59	13,611.78	13,704.50	13,792.94	13,759.89	13,798.45	14,043.83	14,105.84	14,363.40	14,041.77	13,535.77	13,284.25	13,357.81	13,937.19	13,342.92	13,249.40	13,277.85	12,961.95
N_2O emissions (inc N_2O from LULUCF)	9,493.37	9,338.18	9,327.94	9,476.83	9,742.09	9,951.61	10,008.92	9,911.40	10,516.23	10,567.58	10,097.83	9,576.31	9,099.36	8,932.03	8,765.85	8,704.31	8,470.57	8,075.79
N_2O emissions (exc N_2O from LULUCF)	9,478.26	9,322.72	9,311.83	9,457.65	9,722.52	9,931.56	9,986.60	9,888.96	10,493.67	10,544.92	10,074.85	9,549.31	9,070.22	8,899.29	8,733.12	8,671.73	8,437.79	8,043.09
HFCs	0.69	5.27	6.17	9.44	19.97	44.85	76.11	132.28	190.71	197.13	230.22	251.49	276.52	349.98	386.44	435.06	506.96	497.62
PFCs	0.09	7.62	15.15	30.21	45.27	75.38	103.09	130.82	61.87	195.93	305.41	295.98	212.40	228.79	182.43	168.34	148.32	130.58
SF_6	35.40	40.64	45.87	55.35	64.83	82.83	102.06	132.10	94.28	69.01	55.96	69.49	70.31	118.69	67.09	95.96	68.60	73.20
Total including LULUCF	**55,635.13**	**56,567.34**	**56,607.41**	**56,827.07**	**58,163.09**	**59,496.48**	**61,641.36**	**63,145.00**	**65,660.14**	**67,156.39**	**69,092.61**	**70,725.58**	**68,613.66**	**68,335.01**	**68,408.10**	**69,768.00**	**69,188.27**	**68,220.23**
Total excluding LULUCF	**55,383.14**	**56,215.36**	**56,194.00**	**56,582.17**	**58,095.73**	**59,202.51**	**61,243.73**	**62,816.20**	**65,726.55**	**67,260.09**	**68,950.66**	**70,650.03**	**68,760.78**	**68,575.06**	**68,603.61**	**70,258.44**	**69,682.31**	**69,205.15**

(b) Recalculated Emissions by Gas 1990 –2007 reported in 2010 Submission (Gg CO_2eq)

GAS	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
CO_2 (inc net CO_2 from LULUCF)	32,609.46	33,511.74	33,467.67	33,396.28	34,522.01	35,486.98	37,285.02	38,689.66	40,390.92	42,037.48	44,769.27	47,094.98	45,500.21	44,605.75	45,568.19	47,011.21	46,578.91	46,292.19
CO_2 (exc net CO_2 from LULUCF)	32,377.19	33,184.05	33,083.59	33,214.83	34,441.59	35,220.20	36,912.28	38,357.92	40,470.12	42,156.16	44,650.87	47,057.98	45,648.54	44,897.65	45,762.58	47,519.62	47,110.21	47,305.20
CH_4 emissions (inc CH_4 from LULUCF)	13,575.75	13,751.62	13,838.10	13,921.48	13,866.33	13,869.34	14,052.46	14,046.12	14,296.23	13,898.05	13,336.56	13,335.54	13,328.36	13,812.63	12,994.45	12,786.16	12,821.27	12,302.83
CH_4 emissions (exc CH_4 from LULUCF)	13,574.62	13,750.91	13,837.63	13,920.55	13,865.27	13,867.91	14,050.88	14,045.26	14,295.77	13,897.68	13,335.63	13,333.70	13,327.94	13,810.03	12,992.94	12,785.61	12,820.72	12,302.21
N_2O emissions (inc N_2O from LULUCF)	8,837.35	8,634.56	8,619.84	8,773.59	8,994.94	9,206.80	9,242.75	9,107.66	9,645.77	9,660.36	9,200.71	8,616.88	8,231.11	8,138.26	7,941.30	7,848.16	7,682.49	7,373.28
N_2O emissions (exc N_2O from LULUCF)	8,823.19	8,619.88	8,604.59	8,755.14	8,976.24	9,187.34	9,221.02	9,086.04	9,624.02	9,638.49	9,178.45	8,590.49	8,202.50	8,106.12	7,909.00	7,815.64	7,649.82	7,340.59
HFCs	0.69	5.27	6.17	9.44	19.97	44.85	76.11	133.35	191.95	198.25	231.23	253.05	278.14	351.44	387.31	436.72	509.17	500.49
PFCs	0.09	7.62	15.15	30.21	45.27	75.38	103.09	130.82	61.87	195.93	305.41	295.98	212.40	228.79	182.43	168.34	148.32	130.58
SF_6	35.40	40.64	45.87	55.35	64.83	82.83	102.06	132.10	94.19	68.87	55.81	69.30	69.95	118.18	66.64	95.46	67.46	68.75
Total including LULUCF	**55,058.75**	**55,951.46**	**55,992.79**	**56,186.35**	**57,513.35**	**58,766.17**	**60,861.48**	**62,239.71**	**64,680.92**	**66,058.95**	**67,898.98**	**69,665.73**	**67,620.18**	**67,255.06**	**67,140.33**	**68,346.05**	**67,807.63**	**66,668.13**
Total excluding LULUCF	**54,811.19**	**55,608.37**	**55,593.00**	**55,985.52**	**57,413.18**	**58,478.51**	**60,465.43**	**61,885.49**	**64,737.91**	**66,155.38**	**67,757.40**	**69,600.51**	**67,739.48**	**67,512.22**	**67,300.90**	**68,821.39**	**68,305.70**	**67,647.82**

(c) Percentage Change in Emissions by Gas 1990-2007

GAS	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
CO_2 (inc net CO_2 from LULUCF)	-0.08	-0.15	-0.11	-0.19	-0.02	-0.15	-0.05	-0.11	-0.10	-0.11	-0.22	-0.32	-0.21	-0.35	-0.20	-0.22	-0.29	-0.40
CO_2 (exc net CO_2 from LULUCF)	-0.07	-0.13	-0.08	-0.07	-0.12	-0.14	-0.05	-0.18	-0.13	-0.13	-0.22	-0.30	-0.27	-0.32	-0.28	-0.25	-0.28	-0.41
CH_4 emissions (inc CH_4 from LULUCF)	0.78	1.01	0.96	0.92	0.76	0.50	0.05	-0.43	-0.47	-1.03	-1.48	0.36	-0.23	-0.92	-2.64	-3.50	-3.45	-5.09
CH_4 emissions (exc CH_4 from LULUCF)	0.79	1.02	0.97	0.93	0.77	0.50	0.05	-0.43	-0.47	-1.03	-1.48	0.37	-0.22	-0.91	-2.62	-3.50	-3.44	-5.09
N_2O emissions (inc N_2O from LULUCF)	-6.91	-7.53	-7.59	-7.42	-7.67	-7.48	-7.65	-8.11	-8.28	-8.58	-8.88	-10.02	-9.54	-8.89	-9.41	-9.84	-9.30	-8.70
N_2O emissions (exc N_2O from LULUCF)	-6.91	-7.54	-7.60	-7.43	-7.68	-7.49	-7.67	-8.12	-8.29	-8.60	-8.90	-10.04	-9.57	-8.91	-9.44	-9.87	-9.34	-8.73
HFCs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.81	0.65	0.57	0.44	0.62	0.59	0.42	0.23	0.38	0.44	0.58
PFCs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SF_6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.10	-0.21	-0.28	-0.27	-0.50	-0.43	-0.66	-0.52	-1.66	-6.08
Total including LULUCF	**-1.04**	**-1.09**	**-1.09**	**-1.13**	**-1.12**	**-1.23**	**-1.27**	**-1.43**	**-1.49**	**-1.63**	**-1.73**	**-1.50**	**-1.45**	**-1.58**	**-1.85**	**-2.04**	**-2.00**	**-2.28**
Total excluding LULUCF	**-1.03**	**-1.08**	**-1.07**	**-1.05**	**-1.17**	**-1.22**	**-1.27**	**-1.48**	**-1.50**	**-1.64**	**-1.73**	**-1.49**	**-1.49**	**-1.55**	**-1.90**	**-2.05**	**-1.98**	**-2.25**

Table 10.3 Recalculations by IPCC Sector 1990-2007

(a) Emissions by IPCC Sector 1990 –2007 reported in 2009 Submission (Gg CO_2eq)

SOURCE AND SINK CATEGORIES	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1. Energy	31,448.58	32,412.54	32,354.91	32,524.51	33,575.63	34,450.37	36,081.96	37,285.86	39,581.33	41,352.97	43,408.46	45,639.02	44,324.34	44,607.28	44,742.37	46,486.66	46,072.48	46,156.18
2. Industrial Processes	3,165.57	2,875.97	2,803.91	2,792.58	3,068.88	3,061.50	3,203.66	3,654.60	3,495.13	3,560.13	4,184.88	4,293.51	3,720.42	3,039.91	3,142.84	3,251.94	3,262.44	3,281.68
3. Solvent and Other Product Use	79.43	81.13	81.62	81.91	82.92	84.58	84.55	85.11	85.76	82.12	78.96	78.61	76.97	76.53	76.78	78.65	81.33	83.19
4. Agriculture	19,228.57	19,349.71	19,412.26	19,596.26	19,731.77	19,917.49	20,246.33	20,358.36	21,054.92	20,714.54	19,634.93	19,157.13	18,987.17	19,056.44	18,849.54	18,667.67	18,434.64	17,747.86
5. LULUCF	251.99	351.98	413.41	244.90	67.36	293.98	397.63	328.81	-66.41	-103.70	141.95	75.55	-147.12	-240.05	-195.51	-490.45	-494.04	-984.93
6. Waste	1,461.00	1,496.02	1,541.30	1,586.91	1,636.52	1,688.56	1,627.23	1,432.27	1,509.40	1,550.34	1,643.43	1,481.77	1,651.90	1,794.90	1,792.08	1,773.52	1,831.42	1,936.25
7. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total exc LULUCF	**55,383.14**	**56,215.36**	**56,194.00**	**56,582.17**	**58,095.73**	**59,202.51**	**61,243.73**	**62,816.20**	**65,726.55**	**67,260.09**	**68,950.66**	**70,650.03**	**68,760.78**	**68,575.06**	**68,603.61**	**70,258.44**	**69,682.31**	**69,205.15**

(b) Recalculated Emissions by IPCC Sector 1990 –2007 reported in 2010 Submission (Gg CO_2eq)

SOURCE AND SINK CATEGORIES	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1. Energy	31,028.31	31,913.00	31,842.14	32,012.77	32,981.77	33,831.92	35,465.07	36,561.54	38,816.08	40,507.68	42,523.67	44,637.96	43,435.36	43,767.69	43,882.01	45,609.32	45,193.07	45,350.17
2. Industrial Processes	3,178.55	2,888.68	2,816.16	2,804.76	3,080.85	3,073.12	3,214.94	3,666.77	3,507.14	3,571.78	4,195.80	4,304.40	3,726.33	3,041.03	3,143.45	3,253.32	3,263.69	3,280.25
3. Solvent and Other Product Use	79.43	81.13	81.62	81.91	82.92	84.58	84.55	85.11	85.76	82.97	78.96	78.61	76.97	76.54	76.82	78.70	81.57	83.97
4. Agriculture	19,223.13	19,343.45	19,405.52	19,591.52	19,727.84	19,913.30	20,240.08	20,352.46	21,049.44	20,707.69	19,629.88	19,139.88	18,965.33	19,033.94	18,844.83	18,662.09	18,430.81	17,743.93
5. LULUCF	247.56	343.09	399.80	200.83	100.18	287.67	396.05	354.22	-56.99	-96.43	141.58	65.22	-119.29	-257.17	-160.58	-475.34	-498.07	-979.69
6. Waste	1,301.78	1,382.10	1,447.56	1,494.55	1,539.80	1,575.59	1,460.79	1,219.61	1,279.49	1,285.27	1,329.08	1,439.67	1,535.48	1,593.02	1,353.80	1,217.95	1,336.56	1,189.50
7. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total exc LULUCF	**54,811.19**	**55,608.37**	**55,593.00**	**55,985.52**	**57,413.18**	**58,478.51**	**60,465.43**	**61,885.49**	**64,737.91**	**66,155.38**	**67,757.40**	**69,600.51**	**67,739.48**	**67,512.22**	**67,300.90**	**68,821.39**	**68,305.70**	**67,647.82**

(c) Percentage Change in Emissions by Sector 1990-2007

SOURCE AND SINK CATEGORIES	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1. Energy	-1.34	-1.54	-1.58	-1.57	-1.77	-1.80	-1.71	-1.94	-1.93	-2.04	-2.04	-2.19	-2.01	-1.88	-1.92	-1.89	-1.91	-1.75
2. Industrial Processes	0.41	0.44	0.44	0.44	0.39	0.38	0.35	0.33	0.34	0.33	0.26	0.25	0.16	0.04	0.02	0.04	0.04	-0.04
3. Solvent and Other Product Use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04	0.00	0.00	0.01	0.01	0.06	0.06	0.29	0.94
4. Agriculture	-0.03	-0.03	-0.03	-0.02	-0.02	-0.02	-0.03	-0.03	-0.03	-0.03	-0.03	-0.09	-0.12	-0.12	-0.02	-0.03	-0.02	-0.02
5. LULUCF	-1.76	-2.53	-3.29	-17.99	48.72	-2.15	-0.40	7.73	-14.18	-7.01	-0.26	-13.67	-18.92	7.13	-17.87	-3.08	0.82	-0.53
6. Waste	-10.90	-7.61	-6.08	-5.82	-5.91	-6.69	-10.23	-14.85	-15.23	-17.10	-19.13	-2.84	-7.05	-11.25	-24.46	-31.33	-27.02	-38.57
7. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total exc LULUCF	-1.03	-1.08	-1.07	-1.05	-1.17	-1.22	-1.27	-1.48	-1.50	-1.64	-1.73	-1.49	-1.49	-1.55	-1.90	-2.05	-1.98	-2.25

PART II

SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7.1 OF THE KYOTO PROTOCOL

Chapter 11

Emissions and Removals from LULUCF Activities under Article 3.3 of the Kyoto Protocol

11.1 General Information

11.1.1 Introduction

The major item of supplementary information required under Article 7.1 of the Kyoto Protocol is the estimates of anthropogenic emissions by sources and removals by sinks from land use land-use change and forestry activities under Article 3 paragraph 3 and any activities that a Party has elected under Article 3 paragraph 4 of the Kyoto Protocol. These estimates must be reported for afforestation, reforestation and deforestation activities since 1990 under Article 3.3 and in respect of any of those activities from forest management, cropland management, grazing land management and revegetation under Article 3.4 for which a Party has elected to account in the Kyoto Protocol commitment period 2008-2012. Ireland has not elected to account for any activity under Article 3.4 of the Protocol in this period and therefore the information provided in this chapter relates to emissions and removals in 2008 associated with afforestation, reforestation and deforestation in Ireland since 1990 (Table 11.1). The estimates of emissions and removals for the applicable land areas under these activities (Table 11.2) are compiled in supplementary CRF tables similar to those used for submitting the GHG inventory under the Convention as described in Part I of this NIR. The net removals of CO_2 in 2008 on 265.45 ha of lands subject to afforestation since 1990 is estimated at 2,653.24 Gg, a major additional key category (Table 11.3), while there were net emissions of 10.98 Gg CO_2 on a deforested area of 1.38 ha. The approach to data collection and the methodologies used to derive the estimates for Article 3.3 activities are described below.

11.1.2 Institutional Arrangements

The inventory for Article 3.3 activities is prepared by FERS Ltd, a consultant working to COFORD (Council for Forest Research and Development) which in turn delivers the information to the inventory agency under an agreed Memorandum of Understanding (Table 1.1). The reporting system adopts an activity based approach using the tier 3 CARBWARE national model that is applied specifically to report on Article 3.3 actvities. A different system is used to report for *Forest Land* in the LULUCF inventory under the Convention (Chapter 7) due to a lack of suitable historic activity data, such as forest inventory information. However, it is envisaged that a new time series will be reported for both *Forest Land Remaining Forest Land* and *Land Converted to Forest Land* once there is sufficient data derived using the new methods to enable back extrapolation to 1990.

The newly developed tier 3 CARBWARE system is based on a land transition matrix and detailed forest activity information (See Figure 11.1). The forest **activity data** sources for the Article 3.3 inventory are the National Forest Inventory (NFI) and felling license records compiled by the Forest Service. Memoranda of Understanding have been established between COFORD and these key data providers (Table 1.1) to facilitate timely annual reporting by FERS. Additional information is supplied by the semi-private forestry company (Coillte). The state Forest Information Planning System (FIPS), the Grants Payment Administration Scheme (GPAS) and limited felling licence records are used to derive **spatial data**. The reporting system includes an ongoing QA/QC system, whereby model outputs are validated against repeated NFI measurements on a 5 year rolling basis. Additional, external data checks on activity data are carried out by the data suppliers. The first repeat forest inventory on one-fifth of the forest area is due for completion in 2011.

Table 11.1 Reported Activities and Pools (CRF Table NIR 1)

Activity		Change in carbon pool reported[1]					Greenhouse gas sources reported[2]						
		Above-ground biomass	Below-ground biomass	Litter	Dead wood	Soil	Fertilization[3]	Drainage of soils under forest management	Disturbance associated with land-use conversion to croplands	Liming	Biomass burning[4]		
							N_2O	N_2O	N_2O	CO_2	CO_2	CH_4	N_2O
Article 3.3 activities	Afforestation and Reforestation	R	R	R	R	R	IE			NO	R	R	R
	Deforestation	R	R	R	R	R			NO	NO	NO	NO	NO
Article 3.4 activities	Forest Management	NA	NA	NA	NA	NA	NA	NA		NA	NA	NA	NA
	Cropland Management	NA	NA	NA	NA	NA			NA	NA	NA	NA	NA
	Grazing Land Management	NA	NA	NA	NA	NA				NA	NA	NA	NA
	Revegetation	NA	NA	NA	NA	NA				NA	NA	NA	NA

R indicates the reported carbon pools and emissions from biomass burning;
IE (included elsewhere) is used to show that emissions from fertilization of soils are included under agriculture

Table 11.2 Land Transition Matrix (CRF Table NIR 2)

From previous inventory year / To current inventory		Article 3.3 activities		Article 3.4 activities				Other [5]	Total area at the beginning of the current inventory year[6]
		Afforestation and Reforestation	Deforestation	Forest Management (if elected)	Cropland Management (if elected)	Grazing Land Management (if elected)	Revegetation (if elected)		
		(kha)							
Article 3.3 activities	Afforestation and Reforestation	259.198	0.026						259.224
	Deforestation		1.354						1.354
Article 3.4 activities	Forest Management (if elected)		NA	NA					NA
	Cropland Management[4] (if elected)	NA	NA		NA	NA	NA		NA
	Grazing Land Management[4] (if elected)	NA	NA		NA	NA	NA		NA
	Revegetation[4] (if elected)	NA			NA	NA	NA		NA
Other [5]		6.249	0.000	NA	NA	NA	NA	6,844.958	6,851.207
Total area at the end of the current inventory year		265.447	1.380	NA	NA	NA	NA	6,844.958	7,111.785

Table 11.3 Key Categories for Article 3.3 Activities (CRF Table NIR 3)

KEY CATEGORIES OF EMISSIONS AND REMOVALS	GAS	CRITERIA USED FOR KEY CATEGORY IDENTIFICATION			COMMENTS [3]
		Associated category in UNFCCC inventory[1] is key (indicate which category)	Category contribution is greater than the smallest category considered key in the UNFCCC inventory [1], [4] (including LULUCF)	Other [2]	
Specify key categories according to the national level of disaggregation used[1]					
Afforestation and Reforestation	CO2	Forest land remaining forest land	Yes	No	Level assessment

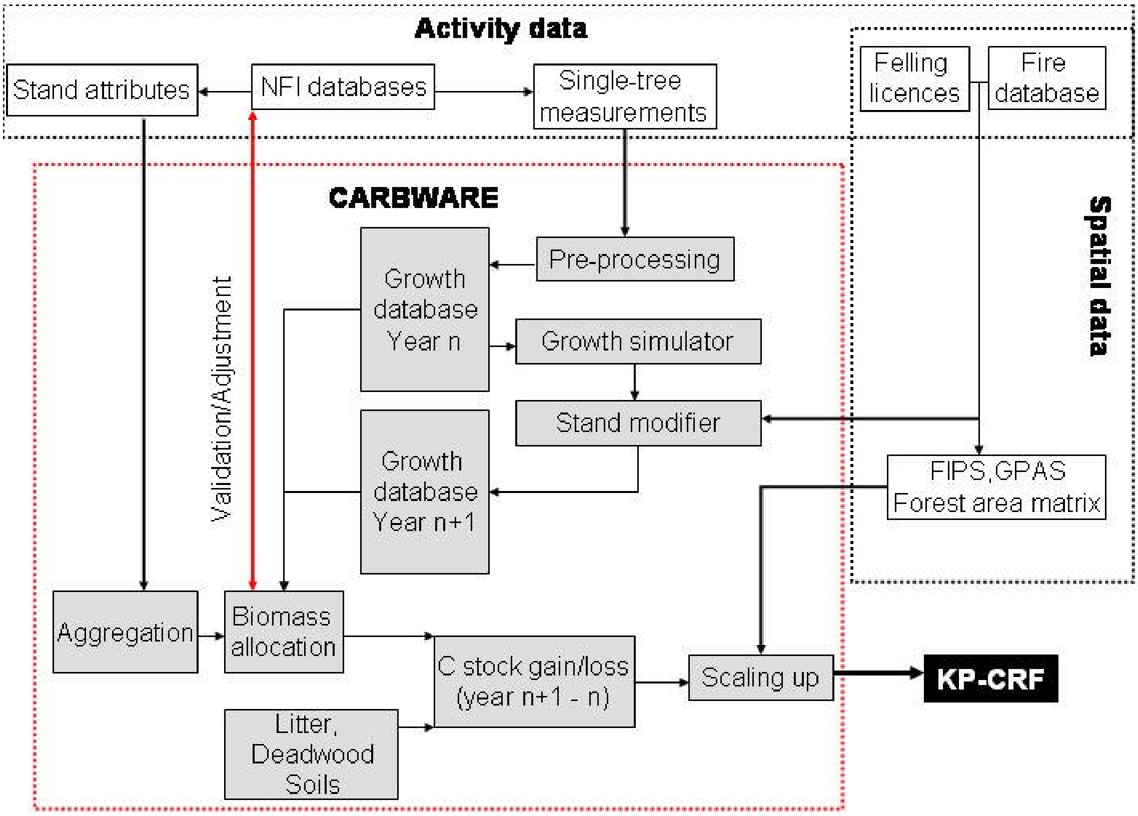


Figure 11.1: Schematic Overview of Reporting System and CARBWARE Functionality

11.1.3 Forest Definition and Application

The definition of forest is the same as that adopted for the LULUCF inventory under the Convention. Forest land has a minimum area of 0.1 hectare, a minimum width of 20 m, trees higher than 5 m and a canopy cover of more than 20 percent within the forest boundary, or trees able to reach these thresholds in situ. The following attributes are also relevant to the definition

- A tree is a woody perennial of a species forming a single main stem or several stems, and having a definitive crown;
- A forest includes windbreaks, shelterbelts and corridors of trees with an area of more than 0.1 ha and minimum width of 20 m;
- Forest is determined both by the presence of trees/stumps and the absence of other predominant land-uses. Areas under re-establishment (following clearfell) that have not yet reached but are expected to reach a canopy cover of 20 percent and a minimum tree height of 5 m are included, as are temporarily un-stocked areas, resulting from human intervention, which are expected to be restocked (see section 11.4.2);
- The forest area is determined by the forest boundary. The term forest boundary is defined by any man-made boundary enclosing the forest area or, in the absence of such boundary feature, the boundary of the forest is determined by extending out 1 m from the position of the pith-line of the outermost trees (NFI, 2007a);
- The forest area includes forest roads, firebreaks and other small open areas on forest land; forest in national parks, nature reserves and other protected areas such as those of specific scientific, historical, cultural or spiritual interest;

- The forest area excludes tree stands in agricultural production systems, for example in fruit plantations and Christmas tree plantations;
- The term forest also includes trees in urban parks and gardens, provided these areas satisfy the forest definition.

Reforestation activities do not occur in Ireland and the relevant activities under Article 3.3 are limited to afforestation and deforestation. All afforested areas are the result of planting and establishment of forest areas of 5 ha or greater under guidelines of the Forest Service Grant and Premiums Scheme (Forest Service, 2003). All of these forest areas are consistent with the forest definition. The scheme was introduced under European Commission Council Regulation 2080/92 to support afforestation of agricultural land as part of accompanying measures to reform the Common Agricultural Policy. The afforestation grant and premiums dataset captures all areas afforested following successful grant application. Afforestation areas recorded by the Forest Service are verified using a strict control and referrals process, following a post-establishment site visit by a forestry inspector (Forest Service, 2003). All deforestation areas are derived from legally-binding licence applications under the Forestry Act. These provisions fulfil the requirement to demonstrate that afforestation and deforestation began on or after1 January 1990 and are directly human-induced, which is necessary for the accounting of emissions and removals for activities under Article 3.3. These datasets were primarily digitised using the 1:12560 and 1:2500 Ordnance Survey Ireland (OSI) raster maps (see section 11.2).

A forest area is classified as deforested when there is clear indication of a specific land use change for that area. Whilst different methodologies have been used to detect deforestation over time (Chapter 7), this definition of deforestation has been applied consistently in developing the 1990 to 2008 area time-series. In addition, a consistent time series has been recalculated for deforested areas, based on new activity data obtained for the years 2006, 2007 and 2008 (Chapter 7).

11.1.4 Comparison of Forest Areas under Convention and Article 3.3 Reporting

There are marked differences in the areas reported under the Convention (See Chapter 7 and Annex E) and those subject to reporting for. Article 3.3 activities. Under Convention reporting, forest areas undergo transitions between categories, whereby areas in *Land Converted to Forest Land (F-L)* move to the *Forest Land Remaining Forest Land (F-F)* category after a transtion period of 20 years. For example, an afforested area in 1980 remains in the F-L category until 1999 and is then transferred to the F-F category in 2000. In reporting under the Protocol, Article 3.3 areas can not move to Article 3.4 areas and deforestation areas can not move to any other category (thus the area can only increase in time). Article 3.4 forest management areas are initially determined at 1990 levels and can, therefore, only decrease in time due to deforestation events. Table 11.4 shows the relationship between areas for Article 3.3 and 3.4 activities and Convention forest areas reported for Ireland. The forest management area is much larger than the afforestation area but Ireland has elected not to account for this activity in the 2008-2012 commitment period.

Table 11.4 Forest Areas Comparison

Year	Forest category areas (kHa)						
	KP areas			Convention areas			Total area
	FM	AR	D	F-L	F-F	UNCL	
1990	465.81	15.82	0.03	175.43	194.73	111.46	481.62
1991	465.75	34.96	0.06	184.46	189.26	126.98	500.71
1992	465.68	51.66	0.09	191.21	185.02	141.11	517.35
1993	465.62	67.66	0.13	197.39	183.55	152.34	533.28
1994	465.54	87.12	0.17	207.57	179.03	166.06	552.66
1995	465.46	110.83	0.21	222.08	172.75	181.45	576.29
1996	465.36	131.81	0.26	234.46	172.06	190.65	597.17
1997	465.25	143.25	0.31	237.54	181.67	189.29	608.49
1998	465.14	156.17	0.37	242.19	192.68	186.43	621.31
1999	465.01	168.84	0.43	247.00	200.90	185.96	633.85
2000	464.89	184.54	0.49	256.51	203.09	189.83	649.42
2001	464.72	200.00	0.58	265.60	209.14	189.99	664.72
2002	464.58	215.05	0.65	274.14	220.51	184.98	679.63
2003	464.40	224.15	0.74	277.21	235.62	175.72	688.55
2004	464.21	233.89	0.83	281.28	241.46	175.37	698.10
2005	464.00	243.99	0.94	286.14	248.27	173.58	707.98
2006	463.51	252.02	1.18	287.21	258.29	170.04	715.54
2007	463.16	259.20	1.35	286.03	276.45	159.87	722.36
2008	463.11	265.45	1.38	286.14	294.95	147.47	728.56

FM, Forest management, AR and D are afforested reforested and deforested areas under article 3.3 (see ***KP CRF Table NIR2****). F-L is lands converted to forests and F-F forest remaining forests (20 year transitions) UNCL, are unclassified forest areas in the F_F category that are not reported under convention reporting (see Chapter 7, CRF Tables). For comparison to Convention reporting, KP (3.4)* ***FM = F-F + UNCL+ F-L - AR***

11.2 Land Area Information

11.2.1 Spatial Assessment Unit

Ireland uses a combination of approaches 2 and 3 defined in Chapter 2, section 2.3.2 of the IPPC good practice guidance for LULUCF for the representation of land areas for Article 3.3 activities. Afforestation and deforestation areas are reported within the entire territory of Ireland, with no further sub division within internal national boundaries. Afforestation areas are tracked on a spatially explicit basis (IPCC Approach 3) while deforestation areas are identifiable but not spatially explicit (IPCC Approach 2). Both approaches can detect a land use change at a resolution consistent with the forest definition area of 0.1 ha. Forest areas under Article 3.3 shown in CRF table NIR2 are sub categorised into forest categories in order to transparently report and compare implied carbon stock change factors for different forest and soil types (Tables 5(KP-I)A.1.1 and 5(KP-I)A.1.2).

11.2.2 Methodology for Land Transition Matrix

The main drivers for producing reliable and up-to-date forest cover statistics and related spatial data in Ireland are carbon accounting under the Kyoto Protocol and the need for spatial data related to environmental modelling and monitoring under the Water Framework Directive. A number of data sources were used to derive land use change statistics for afforestation and deforestation areas for input into the CARBWARE system (see Figure 11.1).

11.2.2.1 Afforestation Areas (Approach 3)

Spatially explicit GIS polygons, representing all afforestation areas, were derived from the available FIPS98 spatial layer (NIR Chapter 7), which represents all forested land in 1998 (621.31 kha in Table 11.1 and Table E.1 Annex E) and digitised maps of afforested areas since 1990 using the Grants and Premiums Administration System (**GPAS**), archived in the **iFORIS** database (Figure 11.2). After attributing the species information with the unique ID from the **Species Data** table, the spatial and attribute data were joined in the **Premiums** layer. The data was quality controlled and the reasons for records not meeting the data validation criteria were recorded by the Forest Service. There were four separate stages in the data validation process, which occurred in successive iterations. The validated data were appended together and then reformatted and quality controlled. The **FIPS98** afforested areas was then erased from the resulting **Premiums** table to produce the **Forestry07** layer. These data sources are being updated for the new grant aided afforestation scheme areas. The **Forestry08** layer is derived from the **GPAS08** data and the **Forestry07** layer (Figure 11.2). Some spatial and attribute data (approximately 2 percent of the afforested areas in iFORIS) has not been captured on a small number of occasions because no spatial or species information was available for the **Premiums** dataset component. Therefore, the official total afforestation area is derived directly from the GPAS and IFORIS database

11.2.2.2 Deforestation Areas (Approach 2)

The Irish Forestry Act provides a legal obligation for land owners to apply for limited felling licences before trees can be felled for non-silvicultural reasons. These licences may only be granted if certain criteria are met and the land owner provides information on the area and volume of timber felled and an indication of future land use. Although the system does identify the areas of forested land that is deforested, the data is not spatially explicit. In addition, this system was only implemented in 2006. Estimates of deforestation for the years 1990-2005 have been reported in previous submissions under the Convention in the category *Forest Land Converted to Settlements*. These estimates were derived from CORINE data (approach 3) using the assumption that all deforested land was converted to settlements. By adopting the assumption that immediate oxidation of all carbon pools takes place on deforested land in the year the felling licence is granted, this does not introduce any carbon sink/source bias within the time frame of the commitment period and reference period.

11.2.2.3 Forest Fire Areas (Approach 2)

Areas of forest subjected to wild fires were obtained from Forest Service statistics (See Chapter 7, NIR). These areas were assumed to be proportionally distributed between the Kyoto Protocol forestry categories afforestation/reforestation and forest management. For example, in 2008 the AR area in Table 11.1 represented 36 percent of the total forest area, so it was assumed that 36 percent of areas experiencing wild fires in 2008 are in the AR category. This determines the area for estimating biomass burned, reported in CRF Table 5(KP II)5.

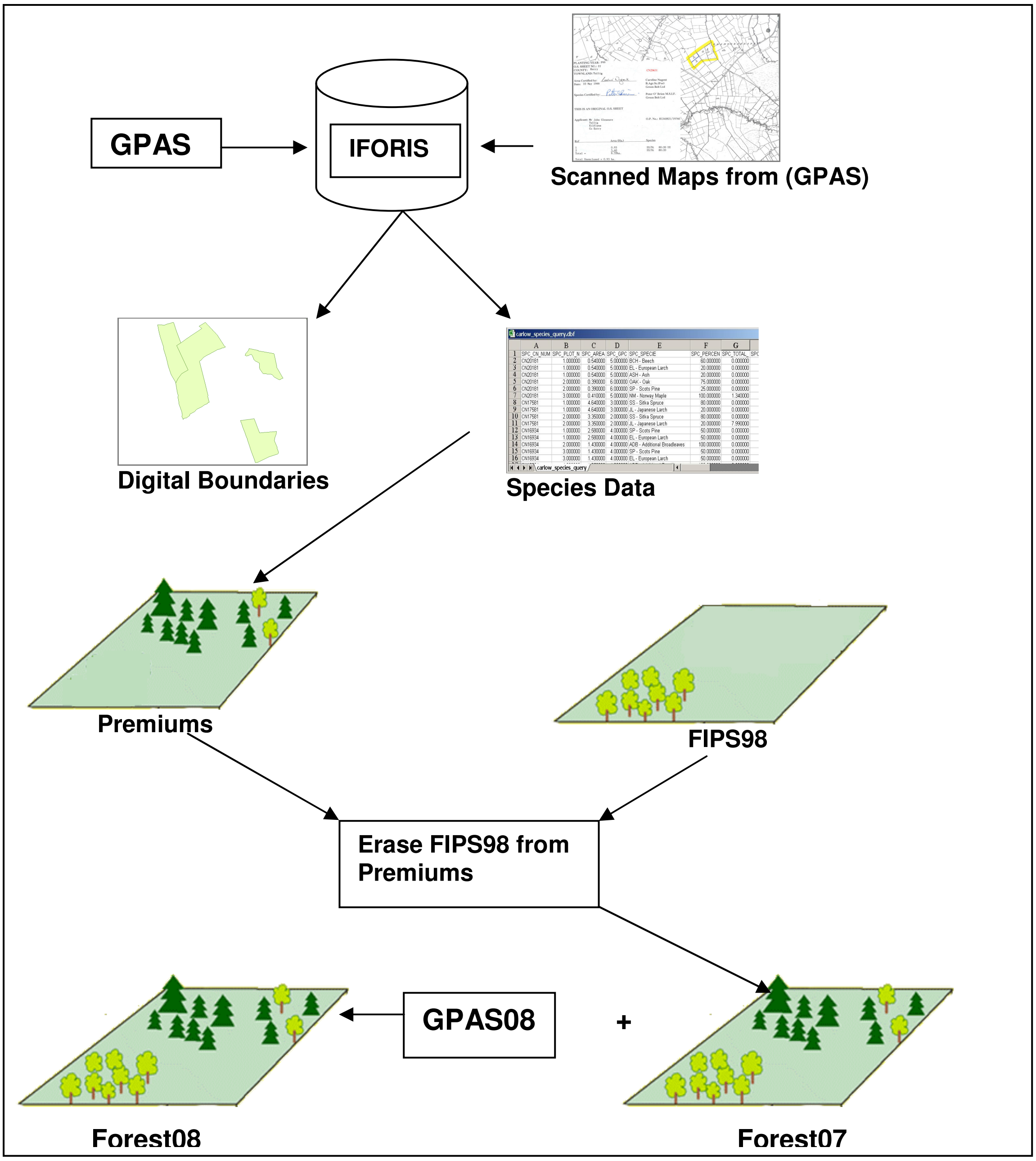


Figure 11.2: Schematic overview of data and procedures used to create spatially explicit data

11.2.3 Activity Data for Afforestation Areas

11.2.3.1 Use of National Forest Inventory data

Activity data inputs into the CARBWARE system for all activities reported as non-harvested afforested land up to 2006 (CRF Table 5(KP-I)A.1.1) were derived from National Forest Inventory statistics. To provide the required activity data for forest areas, Ireland's first National Forest Inventory was carried out in 2005 and 2006 using a sampling approach, based on a randomised systematic grid sample design. This system is also designed to track land use change trends when the inventory is repeated in 2011. A pilot study in Co. Wexford showed that a grid resolution of 2 km x 2 km was required to provide the density of plots needed to achieve a national estimate of timber volume with a precision of 95 percent at the 95 percent confidence level. This grid resolution equates to 17,423 points nationally, each representing approximately 400 ha.

There are three stages of land-use classification undertaken in the NFI, primarily to identify forest areas according to the forest definition. These stages are land-use type, land-use category and land-use class (Figure 11.3). They form the basis of the NFI, as the classification process dictates whether the sample points are included in the NFI or not, and also the range of attributes to be collected at the individual sample points.

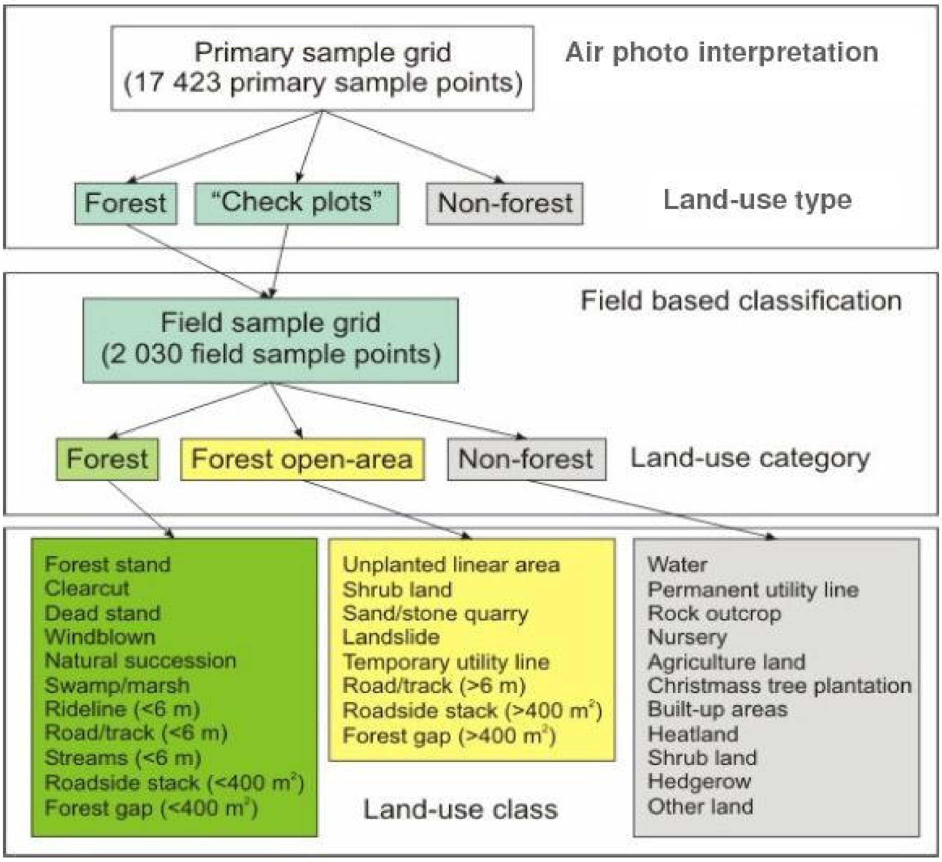
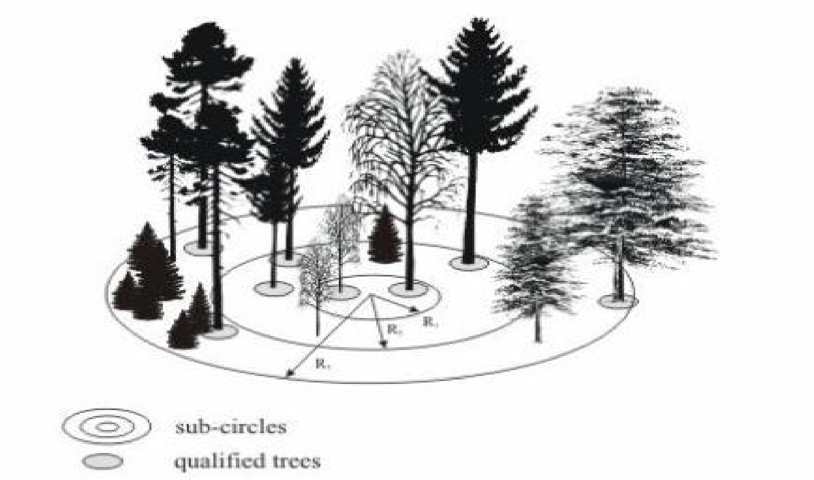


Figure 11.3: Overview of the NFI classification system (taken from NFI, 2007a)

The 2 km x 2 km grid is overlaid on the total land base map of the Republic of Ireland to facilitate land-use type (LUT) interpretation using colour air photographs (OSI, 2005). The primary focus of the interpretation is to identify forest land. In tandem with this, other land-use types are identified for LULUCF reporting under the Convention. The grid is permanent and this allows for the re-assessment of primary sample points at future dates to monitor forest and other land-use change (i.e. afforestation and deforestation) when the OSI produces the next range of ortho-rectified aerial photos in 2010 (NFI, 2007).

Once a forest plot has been identified, field measurements are undertaken in established permanent plots. The exact location of the centre of ground survey plots is identified in the field by navigating to a six digit Irish national grid co-ordinate using both GPS and electronic compass/laser technology. The total area of the circular sample plot is 500 m^2 (i.e. 25.24 m in diameter). Adjustments for slope are automatically made by the laser/range-finding equipment. The concentric circle approach, comprising three concentric circles with different radii is used for tree assessment. Trees of different dimensions are mapped and described on each particular plot (Figure 11.4). Individual trees in the plot are mapped and trimetric data are collected and archived in a GPS format. Forest mensuration measurements are made on selected **individual trees** within the plot based in the position within the plot and the threshold diameter (Figure 11.4). This information is used to estimate plot-level parameters and to scale up to 1 ha (section 11.3.2.1).



	R_1	R_2	R_3
Sub-circle radius (m)	3	7	12,62
Sub-circle area (m^2)	28,3	153,9	500
Treshold diameter (mm)	70	120	200

Figure 11.4: The concentric plot design and mapping of individual trees NFI, 2007a)

Soil surveys were also conducted in permanent sample plots. The soil group classification used in the NFI was a modification of the great soil groups employed in the National Soil Survey (Gardiner and Radford, 1980), with the addition of sand, making 11 great soil groups. These are brown earth, gley, regosol, grey brown podzolic, rendzina, sand, brown podzolic, basin peat, lithosol, podzol and blanket peat. For a soil to be classified as peat, the peat depth had to be greater than 30 cm. Soil categories were aggregated into three major groups on the basis of their soil carbon characteristics, which can be used to estimate carbon stock change in soils. All mineral soils were grouped together. All organic soils with a depth greater than 30 cm were classified as peats soils. Mineral soils with a organic layer less than 30 cm were classified as mineral/peat soils.

Forest stand attributes were also collected to classify forest age, rotation stage and management status so that inventories plots could be disaggregated into appropriate KP forest categories (see KP CRF 5 (KPI) A1.11/2). The activity data was used to derive different forest categories depicting the different productive capacity and carbon stock pool changes to improve transparency and comparability (Table 11.5)

Table 11.5. Forest Category Codes used in CRF Tables 5 (KP1)

Forest_Category_Code	Forest_Category_Description
1	Spruce (Pure). Mainly Sitka and Norway spruce
2	Pine (Pure). Prodominantly Scots and lodgepole pine
3	Larch (Pure)
4	Other conifers (Pure)
5	Fast growing broadleaves (Pure) such as ask, Alder, Sycamore, Birch
6	Slow growing broadleaves (Pure) such as Oak and Beech
7	Conifer mixes
8	Broadleaf mix
9	Conifer/Boradleaf mix
10	Open areas including biodiversity areas, roads within the forest boundary
11	Blown areas subjected to windthrow
12	Scrub, felled or failed areas (planted and unplanted)
13	New afforestation after 2006
14	Natural succession and regenreating land
101 to 115	Harvested areas. E.g 101 are harvested spruce areas
200	Burned areas

Forest stands were considered to be pure if one species represents 80 % or more of the canopy

11.2.3.2 Activity Data for Afforestation Areas after 2006

Activity data of land afforested in 2007 and 2008 after the completion of the first NFI was derived by GIS analysis of the updated Premium Layer (Figure 11.2), a digitised map of indicative forest soils (IFS) and intersection with NFI grid co-ordinates (Figure 11.5). The resulting species/soil matrix was used to derive productivity classes and individual tree height values based on CARBWARE growth models (see Appendix E3). These tables were used as inputs into the CARBWARE software to generate carbon gains and losses (see Figure 11.1)

The soils and land cover datasets were derived from a number of map sources, remotely-sensed and ground-truthed data. A land cover map with a minimum resolution of 1 ha was derived using aerial photography and satellite imagery (Fealy et al., 2006). The land cover mapping exercise used the known occurrence of grassland types in Ireland and their relation to soils. Thematic classes include grassland, bog and heath, rocky complexes, bare rock, forest (unenclosed) and scrub, urban land, coastal complexes, and water bodies. The land cover dataset was derived primarily from remotely sensed data, including 1995 Landsat TM satellite imagery, 1995 black and white stereo aerial photography and 2001 ETM satellite imagery.

The digital soil mapping project delivered soil and subsoil/parent material maps by extending information obtained from various surveys using a soil cover model (Fealy et al., 2006). Over 40 percent of the dataset is a direct derivative of the National Soil Survey (Gardiner and Radford 1980) and has a minimum mapping unit of 1 ha. Subsequently, the FIPS-IFS project produced a first-approximation soil classification for those areas not previously surveyed by the National Soil Survey (NSS), using a methodology based on remote sensing and GIS. A modelling approach was then adopted to produce a projected map for Ireland using a modular system based on different soil/peat forming factors, such as sub-soils, parent material, vegetation and topography (Fealy et al., 2006 and Loftus et al., 2002). These maps were then combined to create a predictive model of soil/peat occurrence, which is represented in GIS map form.

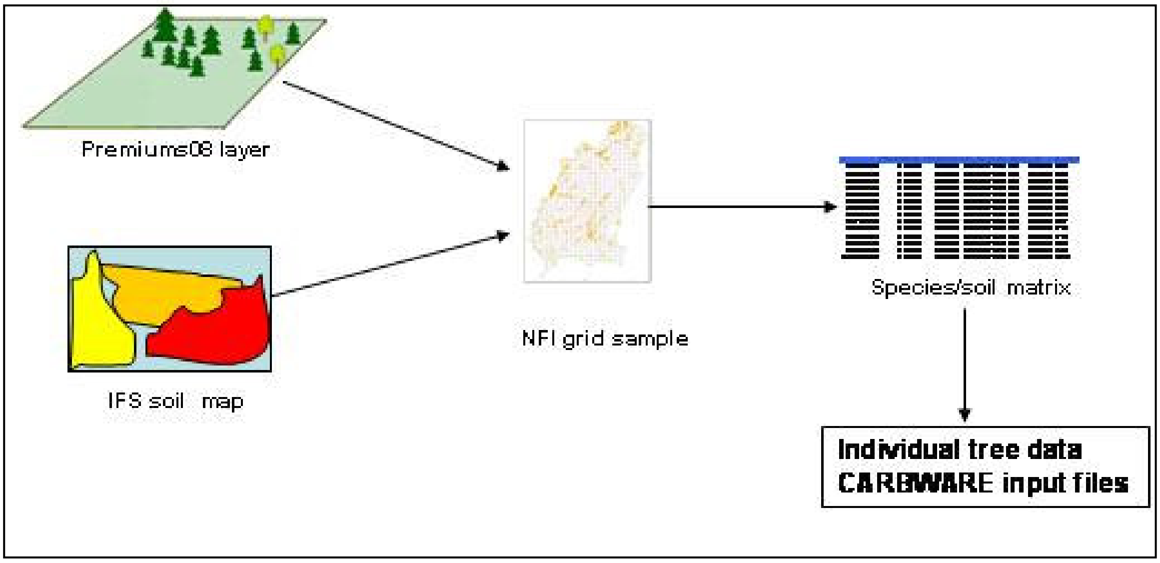


Figure 11.5. Procedure to derive activity data for Afforestation Areas after 2006

11.2.3.3 Harvest Activity Data

Activity data relating to the removal of timber from NFI permanent sample plots was obtained from felling licence information in respect of private sector forests and from the Coillte forest sub-compartment forecast inventory for State forests. The total timber volumes harvested from the afforestation areas was 372,864 m^3 in 2007 and 351,480 m^3 in 2008. No harvesting occurred on afforestation land prior to 2007. Harvesting from the Coillte lands represented 91 percent and 80 percent of the total timber harvest from article 3.3 forests (afforestation areas only) in 2007 and 2008, respectively.

Harvesting of State Forests

The NFI sample plot co-ordinates and Coillte sub-compartment polygons were intersected to produce a layer representing **NFI-Coillte plots** with harvest management statistics (Figure 11.6). Harvested volume and basal area removed during harvest was assigned to individual NFI plots, representing 400 ha, based on Coillte **Forecast** plans. The total volume removed in a given year was compared against independently derived **FAO**/**Eurostat** data and **Coillte invoice** information and adjusted if required. An **EventsTable** table for use in the **Carbw08_2005** database was created for input into the stand modification functions within the CARBWARE model to simulate the harvesting of trees. A final validation was performed on the individual tree tables (see Figure 11.1) to ensure adequate timber was removed during a thinning simulation. If the plot did not contain the threshold basal area, replacement plots more suitable for thinning were randomly selected from the same forest area category (AR areas). It will be possible in the future to re-valuate the activity data ‘ground truthed data’ from repeat NFI inventories of harvested plots.

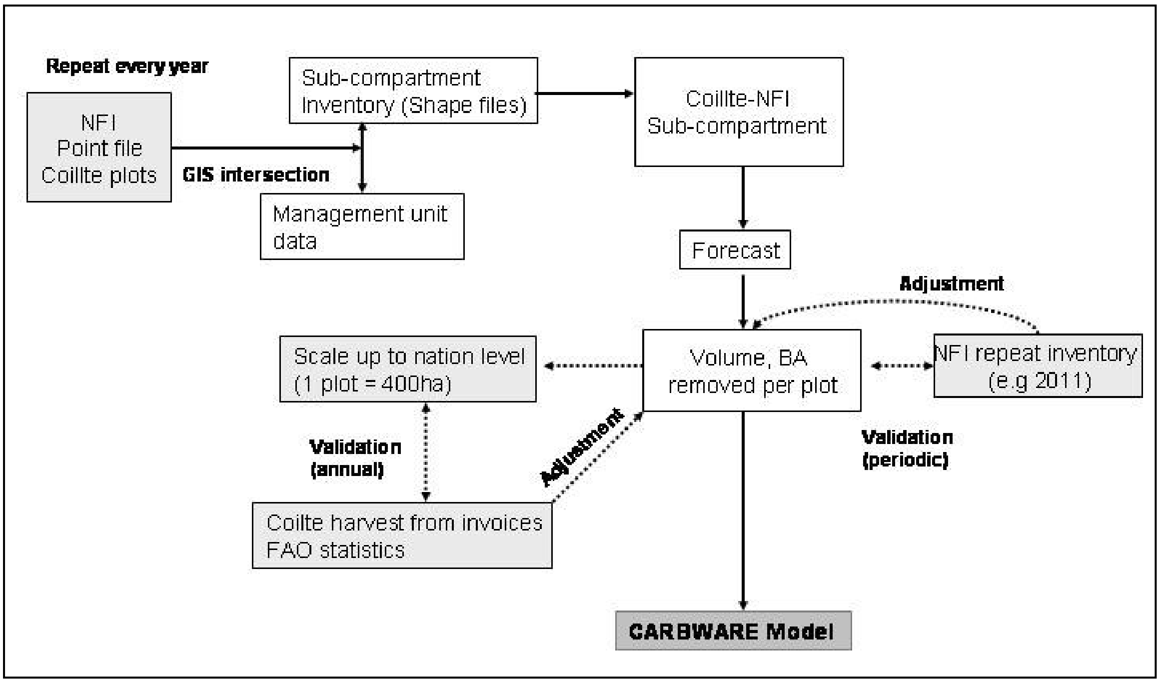


Figure 11.6: Methodology used to derive harvest information for State Forests.

Harvesting of Private Forests

A GIS layer was created by intersection of **Town land** boundaries and names (OSI) and the **Forest08 layer** compartments (see Figure 11.2) that contain **NFI plots**. This layer contains attributes which identifies permanent sample plots which may be subjected to harvesting activities as supplied on felling licence application forms (Figure 11.7). Once this layer is updated every year the Forest service carries out the following checks:

i. Forest inspectors open the GIS attribute table to check if the **Town land** in question (as specified on felling licence application) contains a **sample compartment**.
ii. If there is a sample compartment in the Town land, then an **aerial photo** layer is used to locate the compartment as indicated in the OS map in the hardcopy of the felling licence application.
iii. Once the compartment is located, a shaded area within or covering the entire area should be identified once the GIS layer is switched on. The shaded area will contain a unique number which is used as a reference (name - FID number).
iv. The inspector can then contact the contractor or owner to obtain information on area, species, **volume and basal area removed** due to harvest.

The **scaled up** total volume removed in a given year was compared against independently derived **FAO/Eurostat** information and adjusted if required. An 'EventsTable' table for in the Carbw08_2005 database was created for input into the stand modification functions within the CARBWARE model to simulate the harvesting of trees. A final validation was performed on the individual tree tables (see Figure 11.1) to ensure adequate timber was removed during a thinning simulation. If plot did not contain the threshold basal area, replacement plots, more suitable for thinning, and from the same forest area category (AR areas), were randomly selected. It will be possible in the future to re-valuate the activity data 'ground truthed data' from repeat NFI inventories of harvested plots.

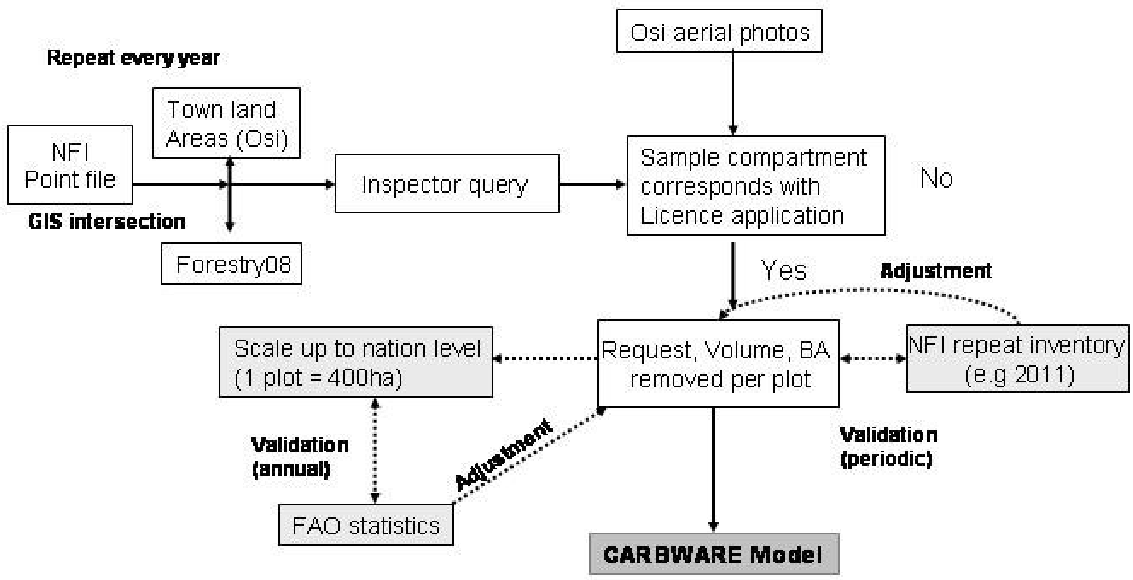


Figure 11.7 Procedure used to derive harvest activity data for private forested areas.

11.2.3.4 Deforestation Activity Information

Information for deforested areas supplied with the limited felling license application provides details of the species, areas, volume of timber clear felled and an indication of the applicable land use transition category (see CRF 5(KP-I)A.2) from the following:

Forest land to Grassland **(F-Grassland (01))**

Forest land to Cropland **(F-Cropland (02))**

Forest land to Wetland **(F-Wetland (03))**

Forest land to Settlement **(F-Settlement (04))**

Forest land to Other land **(F-Other (05)).** These areas include areas not specified above such as wind farms.

All of these deforested areas are reported for the years 1990-2008. The areas, species, stand age, soil type and volume of timber removed from these areas are used to derive carbon stock changes for biomass, litter, deadwood and soil. The harvest data is first verified using Forestry Commission yield tables to check if volumes removed are within acceptable thresholds. If information is not supplied, the Forestry Commission yield tables are used to derive the relevant information (Edwards and Christy, 1981).

11.3 Activity-specific Information

11.3.1 Methods for carbon stock change and GHG emission and removal estimates

Ireland has used the methodologies provided in the 2006 IPCC guidelines for estimating carbon stock changes and emissions and removals of greenhouse gases for activities under Article 3.3 of the Kyoto Protocol. The estimates are derived using the tier 3 national CARBWARE v 5 model the utility of which has been expanded considerably using the results of extensive national forest research and the NFI. The total carbon stock changes for a given forest category is calculated as the sum of the changes in the above-ground biomass (AB), below-ground biomass (BB), Litter (Li), deadwood (DW) and soil (So) carbon pools (Equation 2.3 in Chapter 2 of the 2006 IPCC guidelines):

$$\Delta C_{lu} = \Delta C_{AB} + \Delta C_{BB} + \Delta C_{Li} + \Delta C_{Dw} + \Delta C_{So} \quad (11.1)$$

Biomass estimates include biomass for trees only, non-tree vegetation is assumed to be in steady state following canopy closure. Below ground biomass includes all roots up to a diameter of 5cm. Litter is defined as deadwood with a diameter of less than 7cm. This includes abscised needles and leaves. The dead wood pool included all lying and standing deadwood, dead roots and stumps with a diameter greater than 7cm. organic and mineral/organic soils are reported (see section 11.3.1.2)

11.3.1.1 Biomass Carbon Stock Change

Biomass carbon stock changes are calculated using a tier 3 gain and loss method, corresponding to the process-based approach given by equation 2.4 in Chapter 2 of the 2006 IPCC guidelines, which gives the net carbon stock change as the sum of carbon gains and carbon losses

$$\Delta C = \Delta C_G + \Delta C_L \quad (11.2)$$

The biomass carbon gains (ΔC_G) for both above-ground biomass (AB) and below-ground biomass (BB) are calculated for each forest category i, listed in table 11.2 using

$$\Delta C_G = \sum_i \left(A_i \times GTOTAL_i \times CF \right) \quad (11.3)$$

where A_i is the area of the forest category, $GTOTAL_i$ is the biomass change (t dm/ha.yr) in area A_i and CF is the carbon fraction of biomass dry matter, which is taken as 50 percent for all carbon pools (Black et al., 2007). $GTOTAL_i$ is derived from the sum of all living individual tree components (i.e. AB or BB) within the forest category in the NFI data, for example:

$$GTOTAL_{AB} = AB_n - AB_{n-1} \quad (11.4)$$

where n is the year of inventory. The $GTOTAL_i$ value for each NFI permanent sample plot normalised to 1 ha (see section 11.3.1.1). The AB and BB of all trees were calculated using biomass algorithms for different species cohorts based on national research information (Appendix E2), where diameter at breast height (DBH) and tree height (H) are used as dependent variables. These variables are input data in the NFI 'individual tree table' for the first NFI (2005, See Figure 11.1). The increases in DBH and H of individual trees between NFI years were simulated in the single tree growth models (See Appendix E3; Table 11.1). The stocking (number of trees in a plot) is adjusted after every growth simulation cycle using the stand modification module (Figure 11.1), which removes trees based on natural mortality models and harvest activity data (Appendix E4).

Biomass carbon losses from the above-ground biomass pool ($\Delta C_{L(AB)}$) were calculated based on harvest (L_{timber}), harvest residue (L_{HR}), litter fall (L_{LF}), above-ground losses due to mortality ($L_{mort(AB)}$) and fire (L_{fire}):

$$\Delta C_{L(AB)} = L_{timber} + L_{HR} + L_{LF} + L_{mort(AB)} + L_{fire} \quad (11.5)$$

L_{timber} is calculated based on the above-ground biomass removed from harvest, simulated in the stand modification module (Appendix E4). The **allocation** algorithms for timber based on AB, H or DBH were derived from national research information (see Appendix E2 and Figure 11.1)). L_{HR} includes the harvest residue representing all stems and branches with a DBH less than 7cm and litter left on site after timber is removed:

$$L_{HR} = AG - L_{timber} \quad (11.6)$$

L_{LF} reflects the transfer of carbon from the AB pool to the litter pool. This is calculated in the **allocation module** (Figure 11.1), based on nationally derived leaf/needle biomass (LB) and the foliage turn over rates (F_t) (Tobin et al., 2006):

$$L_{LF} = LB \times F_t \quad (11.7)$$

Allometric equations and coefficients used for the calculation of LB for different species cohorts, with either AB or DBH as dependent variables, are shown in Appendix E2. The F_t rate was assumed to be 5 years (i.e. F_t = 0.2) for conifer crops and 1 year for broadleaf crops (Tobin et al., 2006). The mortality of trees is based on nationally derived single tree mortality models (Appendix E4). The above-ground biomass loss from mortality ($L_{mort(AB)}$) was calculated using DBH and H as dependent variables in biomass algorithms (Appendix E2). The AB carbon losses associated with fires (L_{fire}) was determined as described in section 7.3.4 of Chapter 7. These losses are estimated in respect of total biomass burned and reported under a separate forest category in CRF Table 5(KP-II)5. The above-ground biomass gains in previously burned forest areas are assumed to be zero.

Biomass carbon losses from the below-ground biomass pool ($\Delta C_{L(BB)}$) were calculated as the sum of losses due to death of roots after harvest (L_{HRroot}), natural mortality of roots ($L_{mort(BB)}$) and root death following fire (L_{fire}):

$$\Delta C_{L(BB)} = L_{HRroot} + L_{mort(BB)} + L_{fire} \quad (11.8)$$

L_{HRroot} is the root biomass transferred to the deadwood pool following harvest. All roots are assumed to die and decompose following harvest. The mortality of roots is assumed to follow that for trees, as estimated from nationally derived single tree mortality models (Appendix E4). The below-ground biomass loss from mortality ($L_{mort(BB)}$) was calculated using above-ground and total biomass algorithms (Appendix E2). The BB biomass losses associated with fires (L_{fire}) was determined in the same way as described above for AB losses due to fires and reported in Table 5(KP-II)5. The below-ground biomass gains in burned forest are assumed to be zero.

Carbon stock changes associated with deforestation reported in CRF Table 5(KP-I)A.2 include those for the total standing biomass of all trees removed at clear fell (i.e. all biomass carbon is assumed to be immediately oxidised):

$$\Delta C_{L(AB)} = TOTAL_{(AB)} \text{ and } \Delta C_{L(BB)} = TOTAL_{(BB)} \quad (11.9)$$

The carbon stocks in the AB and BB pools were calculated from the standing volume (V) of the forest stand, as specified on the limited felling licence application, a basic density (D) in the range 0.35 to 0.55 (depending on tree species), a biomass expansion factor (BEF) of 1.4 t/t^{-1}, a carbon fraction (CF) of 0.5 and a root to shoot ratio R of 0.2, as follows

$$TOTAL_{(AB)} = (V \times D \times BEF \times CF) \times (1 - R) \quad (11.10)$$

$$TOTAL_{(BB)} = V \times D \times BEF \times CF \times R \quad (11.11)$$

11.3.1.2 Litter Carbon Stock Change

Net litter stock change (ΔC_{Li}) was calculated based on litter inputs (gains) due to litterfall (L_{LF}), as given by equation 11.7, harvest residue litter input (L_{HR}) in equation 11.6, mortality litter inputs (M_{li}), and losses associated with decomposition of the litter pool (L_{decomp}):

$$\Delta C_{Li} = (L_{LF} + L_{HR} + M_{Li}) - L_{decomp} \quad (11.12)$$

where
M_{Li} is the input to the litter pool from natural mortality (i.e. all aboveground dead material with a diameter less than 7 cm). This is derived from the $L_{mort(AB)}$ minus the timber fraction of the new dead pool (L ($_{mort(tim)}$):

$$M_{Li} = L_{mort(AB)} - L_{mort(tim)} \quad (11.13)$$

The decomposition losses of the new input litter (L_{decomp}) and existing litter pool (L_{old}) are calculated using decomposition factors of 0.14 taken from national research (Saiz et al. 2007; Black et al. 2009b):

$$L_{decomp} = 1 - \left[\sum [L_{LF}, L_{HR}, M_{Li}, L_{old}]^{-D_{Lt}} \right] \quad (11.14)$$

$$L_{old} = \sum[\{(L_{LF}, L_{HR}, M_{Li})_{n-1,n-2,n-x}), L_{ini}\}]^{-D_{LI}} \qquad (11.15)$$

where, L_{ini} is the initial litter pool estimated following the completion of the first NFI in 2005 using the methodology described for litter inputs in section 7.3.2 of Chapter 7. Initial litter pool lookup '**stand attribute'** tables were constructed from static yield tables representing different forest categories (Table 11.2, Figure 11.1). The remaining litter from the newly input litter, harvest residue and mortality pools from the previous years (n-1, n-2 etc) were accumulated following decomposition.

The accumulated litter pool was assumed to be immediately oxidised when deforestation occurs (i.e. reported as an emission in the CRF 5 (KP-1) A2):

$$\text{Deforested } \Delta C_{Li} = L_{old} \times -1 \qquad (11.16)$$

The accumulated litter pool for these deforestation events is derived from the initial litter pool look up tables as described above.

11.3.1.3 Deadwood Carbon Stock Change

Net deadwood stock changes (ΔC_{DW}) were derived from carbon inputs associated with timber extraction residue (L_{tr}), timber from mortality (M_{timber}), dead roots from mortality ($L_{mort(BB)}$), roots from harvest (L_{HRroot}) and carbon loss due to decomposition of the new and previously existing deadwood pool (D_{DW}):

$$\Delta C_{DW} = (L_{tr} + M_{timber} + L_{mort(BB)} + L_{HRroot}) - D_{DW} \qquad (11.17)$$

A small amount (approximately 4 percent) of harvested timber is assumed to be left on site following harvest and this is used to estimate L_{tr}:

$$L_{tr} = L_{timber} \times RF \qquad (11.18)$$

The deadwood input from natural mortality (M_{timber}) is derived from allometric equations applied to the DBH and H of dead trees after mortality iterations (see Appendix E2), while $L_{mort(BB)}$ and L_{HRroot} are known from the analysis for the litter pool in the previous section above. The decomposition losses from the new input deadwood carbon pool (eq. 11.17), existing decaying logs (DL_{old}) and decaying stumps (DS_{old}) are calculated using equation 11.19 based on decomposition factors of 0.095 for stumps and 0.076 for roots (Tobin et al., 2007):

$$D_{DW} = 1 - \left[\sum[L_{tr}, M_{timber}, DL_{old}]^{-D_{\log}\times t} + \sum[L_{mort(BB)}, L_{HRroot}, DS_{old}]^{-D_{St}}\right] \qquad (11.19)$$

The volume and decay class of logs and stumps, measured in permanent sample plots during the NFI in 2005 and 2006, are used to calculate the carbon stocks in the decaying deadwood pools DL_{old} and DS_{old}, respectively. In the case of decaying logs

$$DL_{old} = \sum_i [VL_i \times DDC_i \times CF]^{-D_{\log}\times t} + \left[\sum(L_{tr}, M_{timber}\right]^{-D_{\log}}_{(n-1,n-2,n-x)} \qquad (11.20)$$

where VL is the log volume of the specific decay class (*i*, n=4), DDC is the density of the specific decay class (*i*) and CF is the carbon fraction (0.5). The density and decay classes described by Tobin et al (2007) were used to calculate the deadwood carbon pools in the NFI permanent sample plots (NFI, 2007b). L_{tr} and M_{timber} (n-1, n-2,..x) is the accumulated deadwood from the **stand modifier** functions (equation 11.17 and Figure 11.1) within the CARBWARE model for previous years (n). Similarly, decay class and volume functions were used to derive the carbon pool of decaying stumps in NFI sample plots (Tobin et al 2007, NFI, 2007b):

$$DS_{old} = \sum_j [VS_j \times DDC_j \times CF]^{-D_{St}\times t} + \sum\left[L_{mort(BB)}, L_{HRroot}\right]^{-D_{St}}_{(n-1,n-2,n-x)} \qquad (11.21)$$

where VS is the stump volume of the specific decay class (*j*, n=4), DDC is the density of the specific decay class (*i*) and CF is the carbon fraction (0.5). The density and decay classes described by Tobin et al (2007) were used to calculate the deadwood carbon pools in the NFI permanent sample plots

(NFI, 2007b). $L_{mort(BB)}$ and L_{HRroot} (n-1, n-2,..x) is the accumulated deadwood from the **stand modifier** functions (equation 11.17 and Figure 11.1) within the CARBWARE model for previous years (n). The carbon stock of the deadwood pool in NFI plots were attributed to each permanent sample plot using a deadwood look up function in the **stand attribute** table of CARBWARE (Figure 11.1). The decomposition emissions of the old and new deadwood carbon pools was then calculated using decay constant described by Tobin et al. (2007).

The accumulated deadwood and litter pools (DS_{old} and DL_{old}) were assumed to be immediately oxidised when deforestation occurs (see CRF 5 (KP-1) A2) so that

Deforested $\Delta C_{DW} = (DL_{old} + DS_{old}) \times -1$ ………………….. ……………………….(11.22)

The accumulated deadwood pool for these deforestation events is derived from the mean deadwood carbon pool of the forest category and age class, based on analysis of the NFI permanent sample plots.

11.3.1.4 Soil Carbon Stock Change

Soils are classified into three major groups; mineral, peat and peaty/mineral soils (see section 11.2.3). Peat soils are organic soils with a depth greater that 30 cm and peaty/mineral soils are a continuum between the peat and mineral categories. Current research information suggests that mineral soils in Ireland do not represent a source of carbon emissions, and therefore soil carbon stock changes are reported only for peats and peaty/mineral soils. The emission for peat soils given by equation 11.23 is based on published data from the UK (Hargreaves et al., 2003), as described for *Land Converted to Forest Land* in section 7.3.3 of this NIR, but information on soil classification and peat depth available from the NFI is also taken into account.

$$\Delta C_{So} = \sum_i \left(A_i \times EF_{soil} \right) \quad \text{……………………………………………………………..(11.23)}$$

The area (A_i) of the 0.05 ha plots with peat soils is multiplied by 20 to scale the measurement up to 1 ha. The EF_{soil} is 4 t C/ha^{-1}.yr^{-1} for the first four years following afforestation and is zero thereafter. Emissions from peaty/mineral soils are calculated in the same way (equation 11.24), but a soils depth function (SD) is applied to the emission factor to account for the smaller organic carbon pool available. If soil depth is less than 30 cm then,

$$\Delta C_{So} = \sum_j \left(A_j \times EF_{soil} \times SD \right) \quad \text{……………………………………..………...(11.24)}$$

and

$$SD = \frac{depth(cm)}{30cm} \quad \text{…………………………………………………………………(11.25)}$$

11.3.1.5 Emissions from Biomass Burning

The reporting of emissions and removals for Article 3.3 activities requires the inclusion of emissions associated with biomass burning, which occurs as controlled burning or through wildfires. Controlled burning is not undertaken in Ireland but wildfires do occur and therefore the inventory includes estimates of CH_4 and N_2O emissions due to wildfires. Forest fires are assumed to occur on afforestation lands that are not harvested, which accounted for 36 percent of the total forest area in 2008. Therefore, the emissions from forest fires reported in CRF Table 5(KP-II)5 are derived from the total emissions reported for the category *5.A.1 Forest Land Remaining Forest Land* in CRF Table 5(V) in the Convention inventory multiplied by a factor of 0.36. The emissions are calculated using equation 3.2.19 of the IPCC good practice guidance for LULUCF. A carbon release factor of 0.4 is used for wildfires (Table 3A.1.12 of the IPCC good practice guidance for LULUCF), with emission ratios for CH_4 and N_2O of 0.012 and 0.007, respectively (Table 3A.1.15 of the IPCC good practice guidance for LULUCF) and a C:N ratio of 0.01 is assumed for estimating N_2O.

11.3.2 Description of the Methodologies and Assumptions

11.3.2.1 Datasets used to develop the CARBWARE Models

Permanent Sample Plot

The pre-processing, growth and mortality model was calibrated on data extracted from the permanent sample plot record system of Coillte Teoranta (the Irish Forestry Board state commercial forestry company). Broad and Lynch (2006b) provide details of the dataset in the context of modelling plot volume. The database consists of records of many silvicultural and thinning trials. These longitudinal trials were established from the 1950s onwards, and were initially established as replicated and blocked experimental designs (Broad and Lynch, 2006a).

Individual tree sampling in the NFI and scaling assumptions

Tree measurements within NFI plots were systematically sampled (see Figure 11.4), so all trees were not measured in a plot. The sampling method, in conjunction with an assumption of homogeneous distribution of spatial diameter, informs the calculation of a sampling weight or *expansion factor* (EF) which is used to allow for the possibility that some trees on a given plot were not sampled. The expansion factor is inversely proportional to the prior probability that a given tree is included in the sample, based on the diameter class of the tree (see Figure 11.4). Each tree in the sample is thus replicated a number of times equal to its expansion factor. This replication is allowed for when calculating variables derived at plot level, such as density, by incorporating the expansion factor into the equations. For example, the estimated number of trees on a plot with a single sampled tree of greater that 70 mm is $(12.62/3)^2$. Figure 11.4 shows that trees of three diameter classes are only recorded if they are observed within a certain distance from the plot centre. The expansion factor used by the NFI assumes a random distribution for tree diameter in the plot. Because of that assumption, the weight assigned to a tree in the *i*th diameter class is:

$$\frac{R_3^2}{R_i^2} \quad \text{.......(11.26)}$$

where R_i denotes the radius of the concentric circle associated with the ith diameter class.

In practice, the expansion factor, or weight, is used to estimate plot-level features, e.g. basal area. In such calculations, the number of trees of the *i*th diameter class that were not included in the sample is estimated by $\frac{R_3^2}{R_i^2}$ x n_i, where n_i is the number of trees of the *i*th class that are included in the sample. The expansion factor therefore defines the relationship between each included tree and the estimated number of trees of the same class that were not included (Equation 2).

$$n_{ij} \times EF_{ij} = \hat{N}_{ij} \quad \text{.......(11.27)}$$

where n_{ij} _ EF_{ij} is the product of the expansion factor for the *j* th tree in the *I* th class, and $\check{N}_{ij}$ is the corresponding estimate. In the terminology of the NFI, the RHS of Equation 11.27 is the representative tree number. With minor and obvious changes to the equation, we can calculate other tree-level estimates, including representative basal area, and individual-tree estimates can be aggregated for the entire plot to give plot-level estimates, including representative density. For example the aboveground biomass carbon of a plot (t C/ha) $GTOTAL_{(AB)}$ of a plot is calculated as:

$$GTOTAL_{(AB)} = \frac{\sum[ABij \times EFij] \times 20}{1000} \quad \text{.......(11.28)}$$

where, 20 is the factor used to scale up to 1 ha and 1000 is used to convert kilogrammes of biomass carbon to tonnes.

Pre-processing functions

Raw data in the single tree tables and stand attributes are pre-processed by the CARBWARE software to provide variables used in the growth and modification models. In some cases, not all required variables, such as tree height (H) and crown ration (CR) are measured. These missing values are estimated using functions described in Appendix E3, section A.

Growth models
The availability of only one NFI cycle meant that that the CARBWARE model had to be developed and adapted to estimate carbon stock changes. This has been done by using diameter increment models for all trees with a DBH greater that 5cm and H increment models for trees with DBH less than 5cm (see Appendix E3, section B). The generated DBH and H values, produced after each growth iteration, were then used to derive biomass estimates for a range of different biomass functions (see Appendix E2).

Stand modification functions
The NFI permanent plots structure is modified at the end of each growth cycle to simulate the losses associated with natural mortality and harvest (see Appendix E4).

11.3.2.2 Justification for Omitting a Carbon Pool

National research information suggests that mineral soils are a carbon sink for a minimum of 50 years following afforestation (Black et al., 2009b). Changes in mineral soil carbon pools over time (ΔC_{so}) are not reported because of uncertainty in the magnitude and significance of this probable sink. Other information from 30 different sites (Figure 11.8) suggests that there is *no significant* change (P>0.1) of mineral soil carbon stocks over time following afforestation (Black, 2008). Therefore, Ireland does not report stock changes for mineral soils because these findings demonstrate that the pool is not a source.

Ongoing national research projects (FORESTSOIL carbon and CARBiFOR2) are investigating soil carbon stock changes, based on a paired plot approach. This involves the further characterisation of soil carbon dynamics across different mineral soils, species and previous land use transitions. It is envisaged that CARBWARE and associated methodologies will be updated using the outcome of these analyses in 2011.

11.3.2.3 Factoring Out of Indirect and Natural GHG

Indirect and natural GHG emissions and removals have not been factored out, due to a lack of robust scientific information.

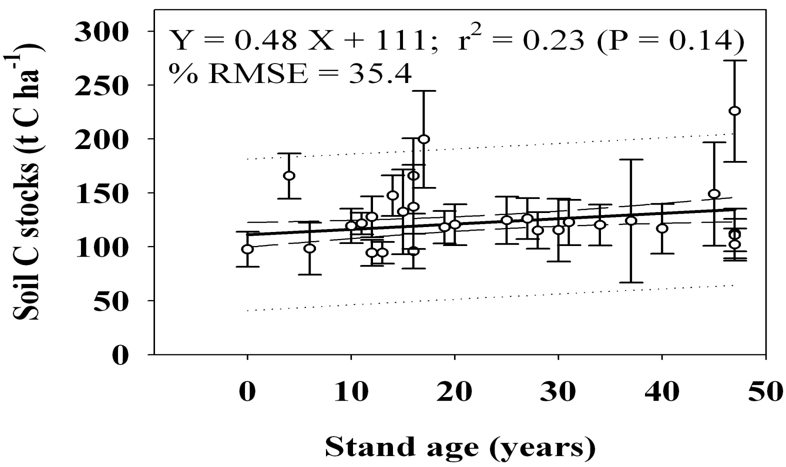


Figure 11.8: Variation in mineral soil carbon stocks and estimation of ΔC_{so} using national data
The solid line represents the linear change in carbon stock over time. The dashed and dotted lines represent the 95% confidence and prediction intervals.

11.3.2.4 Uncertainty Estimates

Characterisation of uncertainties associated with individual activity and area information was obtained directly or derived from already published studies. If no estimates were available expert judgement was applied (Table 11.3). Some uncertainties can not be quantified due to a lack of validation data. These include uncertainties associated with mortality models. However, mortality factors are selected where a tree has a 95 percent probability of being dead (see Appendix E4). Other assumptions regarding the number of locations and amount of timber removed during harvest can not be evaluated until the repeat NFI is completed in 2012. Uncertainty analysis on growth increment and mortality models using Baysean statistics will be included in the next submission.

The IPCC tier 1 approach is applied to estimate uncertainties for the Article 3.3 activities described in this chapter using the methods for combining uncertainties given in section 6.3 of the IPCC good practice guidance for LULUCF. However, many of the input variables are auto correlated with each other, and therefore violate the basic assumption in this approach that inputs are statistically independent. For example, biomass and litter pools are derived from DBH increment models and biomass equations. However the simple tier 1 method is adopted until the capacity to develop Monte Carlo approaches in developed and reported in future submissions.

The percentage input uncertainties in the various methodological parameters used for the analysis of carbon stock change in the relevant carbon pools and for the emissions of non-CO_2 gases are listed in Table 11.6. The combined uncertainties of the products of the respective parameters associated with each component pool are calculated using equation 11.29 (equation 6.4 of the IPCC good practice guidance):

$$U_{total} = \sqrt{U_1^2 + U_2^2 + U_3^2 + U_n^2} \quad \text{..........(11.29)}$$

where U_{total} is the combined uncertainty of the product of the input values U_1, U_2, U_3 and U_n given table 11.6. The calculated percentage uncertainties for pools are given in Table 11.7 which also indicates the associated input parameters whose uncertainties have been combined. The uncertainties in the reported carbon stock changes reported in the CRF tables are calculated in Table 11.8 as the sum of the uncertainties for carbon pools using equation 11.30 (equation 6.3 of the IPCC good practice guidance):

$$U_{total} = \frac{\sqrt{(U_1 \times x_1)^2 + (U_2 \times x_2)^2 + (U_n \times x_n)^2}}{|x_1 + x_2 + x_n|} \quad \text{..........(11.30)}$$

where U_{total} is the combined uncertainty, U_1, U_2 and U_n are the uncertainties of pool estimates (Table 11.4) and x_1, x_2 and x_n are the mean values for the respective pools reported in the CRF tables. For example, x_1 in the uncertainty equation in Table 11.8 for the net CO_2 removals for afforestation reported in CRF Table (KP-I)A.1.1 is 2.74 Mg C/ha (the mean net carbon stock change for the AB and BB pools), x_2 is the mean net carbon stock change of 0.57 Mg C/ha for the litter pool, x_3 is the carbon stock change of 0.01 Mg C/ha for deadwood and x_4 is the carbon stock change of 0.4 Mg C/ha for soils.

Table 11.6: Uncertainty estimates for individual activity and area data sets

Code	Parameter	Sub-category[a]	% uncertainty[b]	Source
A	Biomass algorithms	AB and BB, SB, NB, LT	12.0	Black et al., 2007
B	Carbon fraction	CF all pools	0.87	Black et al., 2007
C	DBH, H increment models	AB, BB	21.0	Black, 2008; Black et al., 2009b
D	Area data	GPAS (11.2.2)	0.60	Derived from Black et al, 2009a[c]
E	Litter	Li	3.1	Tobin et al., 2006
F	Deadwood	DW	22.0	Tobin et al., 2007
G	Biomass C stock	AG and BB deforestation	30.1	Black, 2008; Black et al., 2009b
H	Litter C stock	DLold	30.0	Black, 2008; Black et al., 2009b
I	Deadwood C stock	DSold	30.0	Black, 2008; Black et al., 2009b
J	Peat soil emission	EFsoil	90.0	Assume Tier 1 (Table 2.3.2.3.1 CH AFOLU 2006 IPCC GLs)
K	Fire C stocks	Fires	30.1	Black, 2008
L	Areas burned	Fires	50	Expert judgement

a refer to methodology section 11.3.1
b Uncertainties (no sign) are expressed as SEE at 95 % confidence interval
c Comparison of NFI area and GPAS data sources (see Table 2 in publication)

Table 11.7 Uncertainty estimates of major C pools

Code	Component	Reference equation in section 11.3.1	% uncertainty* equation 11.29	Individual parameter codes from Table 11.3
TB	Biomass	Eq 11.3 AB and BB		
TBA		Afforestation	24.21	A, B, C, D
TBD		Deforestation	30.12	B, D, G
Li	Litter	Eq 11.12 Li		
LiA		Afforestation	3.28	B, D, E
LiD		Deforestation	30.02	B, D, H
DW	Deadwood	Eq 11.7		
DWA		Afforestation	22.03	B, D, F
DWD		Deforestation	30.02	B, D, I
So	Soils	Eq 11.23	90.0	D, J
FI	Fire		58.36	K, L

Table 11.8: Combined uncertainties of reported values in the CRF tables

CRF Table	% uncertainty	Equation 11.30 and variable (See Table 11.4 and CRF totals)
5(KP-I)A.1.1	26.03	$\frac{\sqrt{(24.1\times 2.74)^2+(3.28\times 0.57)^2+(22.03\times -0.01)^2+(90\times -0.4)^2}}{\lvert 2.74+3.28-0.01-0.4\rvert}$
5(KP-I)A.1.2	69.66	$\frac{\sqrt{(24.1\times -16.26)^2+(3.28\times 7.9)^2+(22.03\times 3.3)^2+(90\times -0)^2}}{\lvert -16.26+7.9+3.3+0\rvert}$
5(KP-I)A.2	27.94	$\frac{\sqrt{(30.12\times -2)^2+(30.02\times -0.12)^2+(30.02\times -0.04)^2+(90\times 0)^2}}{\lvert -2-0.12-0.04+0\rvert}$
5(KP-II)5*	58.36	$\frac{\sqrt{(58.36\times -44.06)^2}}{-44.06}$
NIR-3 (total)	27.37	$\frac{\sqrt{(26.03\times -27.85)^2+(69.66\times 10.54)^2+(27.94\times 10.98)^2+(58.36\times 4.3)^2}}{\lvert -27.85+10.54+10.98+4.3\rvert}$

*The mean emission per unit area (44.06 Mg) for fires is derived from the CO_2 emissions (4.34 Gg) divided by the proportional area of 3.3 forests subjected to fire (98.5ha)

11.4 Other Information for Article 3.3 Activities

All afforested areas are a result of planting and establishing forest areas under guidelines of the Forest Service Grant and Premiums Scheme (Forest Service, 2003). The afforestation grant and premiums scheme was introduced under European Commission Council Regulation 2080/92 to support afforestation of agricultural land as part of accompanying measures to reform the Common Agricultural Policy. The afforestation grant and premiums dataset captures all areas afforested following successful grant application. All afforestation areas recorded by the Forest Service are verified using a strict control and referrals process, following a post establishment site visit by a forestry inspector (Forest Service 2003). All deforestation areas are assumed to be a direct human induced activity since these are derived from legally-binding licence applications under the forestry act.

In the case where deforestation does occur, but it is not detected using the felling license information or there is legal violation of the forestry act, retrospective NFI information can distinguishing between clearfell and deforestation. The NFI completes an inventory of all forest areas every 5 years on a rotation basis. ***If a clearfelled area has not been replanted within one NFI cycle (i.e. 5 years), the area is classified deforestation***. These areas will be reported for the year deforestation is detected.

The national geographic area is the boundary for reported deforestation events. If deforestation is detected in the NFI and it has not been previously reported, the area represented by the permanent sample plot grid (400 ha or a 2 km grid) is assumed to be the representative deforested area. In these cased deforestation, may be overestimated since forest parcels are usually less than 100 ha, with a mean size of 8 ha (Black et al., 2009a).

Chapter Twelve

Information on Accounting of Kyoto Units

12.1 Background Information

Ireland's Standard Electronic Format (SEF) report for 2009 (SEF_IE_2010_1_15-5-31 1-3-2010), containing the information required in paragraph 11 of the annex to decision 15/CMP.1 and adhering to the guidelines of the SEF, has been submitted to the UNFCCC Secretariat electronically (Table 12.1). The SEF tables show the numbers of Kyoto units held in various accounts of the national registry and they are reproduced in Annex J.

12.2 Summary of Information Reported in the SEF Tables

There was 314,935,862 AAUs in Ireland's National Emission Trading Registry at the end of the year 2009, of which 274,071,230 units were in the Party holding account; 21,195,872 units in the entity holding accounts; 245 units in the other cancellation accounts and 19,668,515 units in the retirement account.

There was 7,193,814 CERs in the registry at the end of 2009: 6,480,622 CERs were held in the entity holding accounts and 713,192 CERs were held in the retirement account.

The registry did not contain any ERUs, RMUs, t-CERs or l-CERs. There were no units in the Article 6 issuance and conversion accounts; no units in the Article 3.3 and Article 3.4 issuance or cancellation accounts and no units in the Article 12 afforestation and reforestation accounts. The total amount of the units in the registry corresponded to 322,129,676 tonnes CO_2 eq.

Ireland's assigned amount is 315,184,272 tonnes CO_2eq.

Table 12.1 Information on the SEF tables

Annual Submission Item	Reported in 2010
15/CMP.1 annex I.E paragraph 11: Standard electronic format (SEF)	Ireland's Standard Electronic Format report for 2009 containing the information required in paragraph 11 of the annex to decision 15/CMP.1 and adhering to the guidelines of the SEF has been submitted to the UNFCCC Secretariat electronically. SEF_IE_2010_1_15-5-31 1-3-2010.xls The contents of the SEF report (R1) can also be found in Annex J of this document.

12.3 Discrepancies and notifications

There were no discrepant transactions in 2009 and no CDM notifications were received by the national registry (Table 12.2).

Table 12.2 Discrepancies and notifications

Annual Submission Item	Reported in 2010
15/CMP.1 annex I.E paragraph 12: List of discrepant transactions	No discrepant transactions, pursuant of 15/CMP.1 annex I.E paragraph 12, occurred in the 2009 reporting period. The contents of the Report R2 can also be found in Appendix 1 – *SIAR Supplementary Information* of this document. Refer to Separate Electronic Attachment "SIAR Reports 2010-IE v 1.0.xls" Worksheet R2.
15/CMP.1 annex I.E paragraph 13 & 14: List of CDM notifications	No CDM notifications were received by the National Registry during the 2009 reporting period, pursuant of 15/CMP.1 annex I.E paragraphs 13 & 14. The contents of the Report R3 can also be found in Appendix 1 – *SIAR Supplementary Information* of this document. Refer to Separate Electronic Attachment "SIAR Reports 2010-IE v 1.0.xls" Worksheet R3.
15/CMP.1 annex I.E paragraph 15: List of non-replacements	No non-replacements occurred during the 2009 reporting period, pursuant of 15/CMP.1 annex I.E paragraph 15. The contents of the Report R4 can also be found in Appendix 1 – *SIAR Supplementary Information* of this document. Refer to Separate Electronic Attachment "SIAR Reports 2010-IE v 1.0.xls" Worksheet R4.
15/CMP.1 annex I.E paragraph 16: List of invalid units	No invalid units exist as at 31 December 2009, pursuant of 15/CMP.1 annex I.E paragraph 16. The contents of the Report R5 can also be found in Appendix 1 – *SIAR Supplementary Information* of this document. Refer to Separate Electronic Attachment "SIAR Reports 2010-IE v 1.0.xls" Worksheet R5.

12.4 Publicly Accessible Information

The public has access via the registry website to information on registry account types and account holders, information regarding Article 6 projects, information on transactions and the list of account holders authorised to hold Kyoto units in their account (Table 12.3).

Table 12.3 Publicly Accessible Information

Annual Submission Item	Reported in 2010
15/CMP.1 annex I.E Publicly accessible information	The following information is now deemed publicly accessible and as such is available via the homepage of the IE registry – www.etr.ie In accordance with the requirements of Annex E to Decision 13/CMP.1, all required information for a Party with an active Kyoto registry is provided with the exceptions as outlined below. **Account Information (Paragraph 45) and Account holders authorised to hold Kyoto units in their account (Paragraph 48)** In light of the forthcoming amendments introduced by Article 78 of the revised Registries Regulation (due to come into force in August 2010) and for security reasons, it is considered that the representative name and contact information (required by paragraph 45) and the legal entity contact information (required by paragraph 48) is held as confidential. Accordingly, this information is not included in the Account Information Report. **JI projects in Ireland (Paragraph 46)** Note that no Article 6 (Joint Implementation) project is reported as conversion to an ERU under an Article 6 project, as this did not occur in the specified period. In line with the Ireland's National Climate Change Strategy 2008-2012, Ireland does not host JI projects. **Holding and transaction information of units (Paragraph 47)** Holding and transaction information is provided on a holding type level, due to more detailed information being declared confidential by EU Regulation. Article 10 of EU Regulation 2216/2004/EC, provides that *"All information, including the holdings of all accounts and all transactions made, held in the registries and the Community independent transaction log shall be considered confidential for any purpose other than the implementation of the requirements of this Regulation, Directive 2003/87/EC or national law."*

Table 12.3 (Continued) Publicly Accessible Information

Annual Submission Item	Reported in 2010
15/CMP.1 annex I.E Publicly accessible information	Paragraph 47c Ireland does not host JI projects in line with the National Climate Change Strategy. Paragraph 47e Ireland does not perform LULUCF activities and therefore does not issue RMUs Paragraph 47g No ERUs, CERs, AAUs and RMUs have been cancelled on the basis of activities under Article 3, paragraphs 3 and 4 to date. Paragraph 47h No ERUs, CERs, AAUs and RMUs have been cancelled following determination by the Compliance Committee that the Party is not in compliance with its commitment under Article 3, paragraph 1 to date. Paragraph 47j No ERUs, CERs, AAUs and RMUs have been retired to date Paragraph 47k There is no previous commitment period to carry ERUs, CERs, and AAUs over from.

12.5 Calculation of the Commitment Period Reserve

The commitment period reserve (CPR) is the lower of the two values given by 90 percent of the assigned amount and five times the estimate of total emissions in the most recently reviewed inventory. The inventory for 2007 submitted in 2009 is the most recently reviewed inventory for Ireland (FCCC/ARR/2009/IRL). The total emissions in 2007 amounted to 69,205,155 tonnes CO_2 equivalent and five times this estimate is 346,025,775 tonnes CO_2 equivalent. This value is greater than 90 percent of the assigned amount (282,765,845 tonnes CO_2 equivalent) determined in the review of Ireland's initial report (FCCC/IRR/2007/IRL) and therefore the commitment period reserve is 282,765,845 tonnes CO_2 equivalent

12.6 Accounting for Activities under Article 3.3

In the initial report under the Kyoto Protocol (FCCC/IRR/2007/IRL), Ireland elected to account for the commitment period in regard to activities under Article 3.3 of the Kyoto Protocol. As such, accounting for the year 2008 is not applicable.

Chapter 13

Changes in National System

Ireland's national system is described in section 1.2 of Chapter 1. There were no changes in the institutions or resources involved in the national system during the 2010 reporting cycle. The provisions for reporting on afforestation and deforestation areas related to LULUCF under the Convention and Article 3.3 of the Kyoto Protocol were strengthened to some degree by the establishment of secondary memoranda of understanding (MOU) to formalise data collection by COFORD, the Council for Forest Research and Development, which is responsible for these parts of the inventory submission. The MOU were put into effect between COFORD and the Forest Service and between COFORD and Coillte. Signed copies of the MOUs are held on file along with other MOU underpinning the national system at the EPA offices in Dublin and Monaghan.

Chapter 14

Changes in National Registry

14.1 Introduction

The national registry of Ireland is described in the initial report under the Kyoto Protocol (FCCC/IRR/2007/IRL). Ireland's national registry was established initially for the implementation of Directive 2003/87/EC (EP and CEU, 2003) on emissions trading. The registry software was purchased from the Department of the Environment, Food and Rural Affairs in the UK and has been developed in consultation with other Member States that also purchased this software as part of the GRETA group. A number of important changes to the registry came into effect during 2009. These changes included changes to contacts, software and hosting provider along with other upgrades to improve functionality and application. The changes are summarised in this chapter and further details, including software release notes, readiness documentation and test reports are provided in electronic form as Appendix 1 *SIAR Supplementary Information* to the NIR.

14.2 Contacts

Reporting Item	Reported in 2010
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	Addition of contact details: **Dr. Eimear COTTER** Environmental Protection Agency Regional Inspectorate McCumiskey House Richview Clonskeagh Road Dublin 14 IRELAND Email: etradmin@epa.ie Telephone: +353 (0)1 268 0100 Fax: +353 (0)1268 0199 Removal of contact details: **Ms. Kelley KIZZIER** Environmental Protection Agency Regional Inspectorate McCumiskey House Richview Clonskeagh Road Dublin 14 IRELAND Email: etradmin@epa.ie Telephone: +353 (0)1 268 0100 Fax: +353 (0)1268 0199

14.3 Information on Changes in National Registry

<table>
<tr><th>Reporting Item</th><th></th></tr>
<tr><td>15/CMP.1 annex II.E paragraph 32.(b)
Change of cooperation arrangement</td><td>No change of the cooperation arrangement itself occurred during the 2009 reporting period.

However the GRETA collective of Registries (of which IE is a licensee) changed IT supplier from Siemens Services and Solutions Ltd. to SFW Ltd. due to the end of a framework contract.

Development and support has been taken over by SFW Ltd. as of 9 February 2009.</td></tr>
<tr><td>15/CMP.1 annex II.E paragraph 32.(c)
Change to database or the capacity of National Registry</td><td>The changes to IE's registry in 2009 cover changes to (i) Software and (ii) Hosting Provider – the details are provided below.

In relation to changes to the hosting provider, the following updated content for the Readiness documentation is provided: (i) Database and Application Backup Plan (ii) Test Plan and (iii) Test Report.</td></tr>
<tr><td colspan="2">Software Changes

A general description of functional changes to the IE GRETA Registry in 2009 is as follows:

<u>Version 4.0:</u> This new release enabled Operators to surrender Certified Emission Reduction Units (CERs) and Emission Reduction Units (ERUs) and to set CER/ERU percentage surrender limits for individual installations within their operating zone, in line with EU and national policy.

<u>Version 4.1</u>: This new release enabled Registry Administrators and thus Member States, perform a new EUA Conversion and Retirement Process (as specified in the EU Registry Regulations) as part of their EU annual compliance requirements.

<u>Version 4.2</u>: This new release implemented a number of significant performance and reliability improvements to the internal and external transfer functions to allow an intense period of high-value contract settlements to be performed and to provide a lower burden of local and central support calls.

Each new release also includes a 'maintenance' element whereby high-priority legacy bugs are also resolved.

Thus, in 2009 two registry software version updates have been implemented, namely to GRETA Version 4.1 in June 2009 and Version 4.2 in</td></tr>
</table>

November 2009. Please note that GRETA Version 4.1 included the changes made in Version 4.0:

Both upgrades (V4.1 and V4.2) have incorporated changes that increased the capacity of the Registry. The following capacity improving measures have been implemented compared to the previously used version.

Update from Version 3.0.84 to Version 4.1
Internal database procedures have been improved to increase resource efficiency.

Update from Version 4.1 to Version 4.2
A new windows service has been introduced to improve and simplify the logical design of the system. This service is designed to provide one single framework for the processing of incoming and outgoing messages, in time allowing to concentrate all logic concerning messaging in one part of the system. This creates a robust basis to start improving messaging reliability, efficiency and the capacity of the registry as a result.

Most checks on incoming messages are now performed asynchronously instead of synchronously, hereby considerably decreasing the time needed to create the synchronous response. This change has eliminated time-out errors in processing incoming messages.

The asynchronous processing of incoming messages is now performed in sequence as opposed to in parallel. These changes have increased the robustness of message processing and resource efficiency, hereby further increasing the capacity of the registry.

The functionality allowing the initiation of transfers has been improved by using a smarter data integrity algorithm. This change increases robustness of the system when several users are trying to initiate transfers from the same account. This further increases the capacity of the registry for outgoing transfers.

Together with the above improvements to the registry system, automated load and performance testing was introduced for system testing. With this, it was possible to test more and to better performance test the system.

Testing has proven that the system is now able to process in and outgoing messages containing 2500 unit blocks without problems on mainstream hardware. Calculations have been made suggesting the system is able to process messages containing up to 9000 unit blocks. This limit is likely imposed by network delays external to the system.

Please consult the release notes in the complete SIAR submission (Appendix 1 – *SIAR Supplementary Information*) for details on the changes compared to GRETA Version 3.0.84 used in 2008. Please note that GRETA Version 4.1 included the changes made in Version 4.0:

- Release Notes version 4.0.16
- Release Notes version 4.1.16
- Release Notes version 4.2.21

The following test reports are also included in the complete SIAR submission (Appendix 1 – *SIAR Supplementary Information)*:

- Test Report Version 4.1
- Test Report Version 4.2

Hosting Provider

On 17 March 2009, the production environment of the IE Registry migrated to a new hosting data centre. The Test and Training environments of the IE Registry followed in April and May 2009. Due to the requirements for connection to the UNFCCC's International Transaction Log (ITL) in accordance with the Kyoto Protocol it was deemed necessary for the hardware associated with these systems to be expanded and a new architecture to be implemented and maintained. In order to operate and maintain the registry environments to the standard specified under the UNFCCC compliance procedure a new hosting arrangement, including increased provision of monitoring, maintenance and database administration services, was required. Consequently, the new hosting provider is responsible for all network operations, monitoring and Database Administrator (DBA) service.

The technical architecture of the IE Registry is fully redundant. It is made up of both primary and secondary web and database servers. All firewalls and switches are Hot Standby Routing Protocol (HSPR) clustered.

Database mirroring has been implemented in the IE Registry environment to create a warm standby secondary server for the primary production database server. All IE Registry servers are protected by outer firewalls. Demilitarized Zones (DMZs) are used to isolate servers. The database servers have restricted access which blocks all internet traffic, with the web servers also having restricted access.

Extensive firewall and event logging is kept for all servers and firewalls. BMC Patrol records all historical data for each agent enabled server, as well as monitoring all hardware alerts. Anti-Virus services are provided by means of a solution based on the Symantec range of products. Microsoft SQL Server 2005 provides auditing on the system to trace and record activity for successful and failed logins to the production database.

Backups are performed over a dedicated backup network so as not to impact the operation of the production environment. Connection from the IE Registry to the ITL is via 2 way SSL over VPN.

The migration to a new hosting provider did not require further UN interoperability testing. The connectivity testing for the production environment was successfully completed with the ITL Administrator in February 2009. (Please see the complete SIAR submission, Appendix 1 – *SIAR Supplementary Information* for this connectivity testing sign off with the ITL Administrator).

Updated content for the appropriate sections of the Readiness documentation is provided below

Database and Application Backup

Backup Scope and Procedures

The EPA servers are included in the hosting provider's standard defined backup schedule.
No backups are taken between 2am-3am to avoid potential conflict with the reconciliation process.

All local server data is included in the backup by default.

- EPA-WEB1, EPA-WEB2, EPA-DB1, i.e. C: and D:
- All SQL databases on EPA-DB1 are backed up

Frequency of Database Backups

Windows servers

1. Daily incremental backups commence at 11.30 pm
2. Weekly full backup Saturday 11.30pm

SQL database

1. Transaction log backup every 2.5 hours from 8.30am to 8.30pm
2. Daily full database backup 11pm

All critical servers are backed up to tape on a daily basis and all backups are stored offsite in a 3rd party storage facility.

Backup Retention Periods

The standard defined Data Retention policy is:

- Incremental backups retained for 7 days 1 cycle
- Full backups retained for 28 days

Extended Data Retention

Web server log files on EPA-WEB1, EPA-WEB2 are retained for a period of 7 years.

Log Maintenance

Server logs are held on the production web servers EPA-WEB1 and EPA-WEB2 for a period of up to 30 days. The log files are made up of IE Registry application logs comprising time synchs, correlation, reconciliation, message, notification and error logs. Together with these logs, additional Microsoft IIS logs, server application system and event logs are also held.
Database audit logs for the production database are held on the primary database server EPA-DB1.
Firewall syslogs for both the production and test environments are also stored.

On the first of each month the server logs are transferred from the production web and database servers, production and test firewalls, test and training web servers to a central server (EPA-LOGIN) via Secure FTP using custom written transfer scripts.

The archived logs are stored in chronological order by individual server for ease of locating the log files. The archived logs are then transferred to backup tape media and stored at the same secure offsite location as the daily backup tape media.

The retention period for the logs files is in accordance with Section 7 of the Data Exchange Standards.

Disaster Recovery Plan
No change to the Disaster Recovery Plan for the reporting period 2009.

Test Plan and Test Report
As a requirement of the migration to the new hosting data centre in March 2009, the required connectivity testing with the ITL Administrator was completed in February 2009. Evidence of same is provided in the complete SIAR submission, Appendix 1 – *SIAR Supplementary Information* of this document.

Further to the software upgrade V4.1 and V4.2 the following test reports are also attached in the complete SIAR submission, Appendix 1 – *SIAR Supplementary Information*:
- Test Report Version 4.1
- Test Report Version 4.2

15/CMP.1 annex II.E paragraph 32.(d) Change of conformance to technical standards	No change in the registry's conformance to technical standards occurred for the 2009 reporting period.
15/CMP.1 annex II.E paragraph 32.(e) Change of procedures	No changes were made to the procedures to prevent and/or resolve discrepancies during the 2009 reporting period.
15/CMP.1 annex II.E paragraph 32.(f) Change of Security	The security changes to IE's registry in 2009 arise because of a change in hosting provider. Changes are therefore reported below in terms of the Security Plan and the Operational Plan. In relation to changes to the Security Plan, the following updated content for the Readiness documentation is provided: (i) Physical Access to the Registry Web, BackEnd and/or Database Servers (ii) Audit Trails to Record Activities at Web, BackEnd and/or Database Levels (iii) Firewalls and Anti Virus Measures. In relation to changes to the Operational Plan, the following updated content for the Readiness documentation is provided: (i) Incorporation of New or Updated Processes into the Working Operation of the Registry.

Due to the migration to the new hosting provider in March 2009, updated content for the appropriate sections of the Readiness documentation is provided below.

Security Plan

Physical Access to the Registry Web, BackEnd and/or Database Servers

Strict physical security is implemented by means of tightly controlled access to the data centre facility and enhanced by housing servers in locked racks. The Server room is monitored 24/7 by Closed Circuit television cameras and is located in the centre of the building with no external access. The server room is only physically accessible by security staff members of the hosting organisation using a biometric hand print reader.
Two nominated EPA staff are entitled to request access registration for individuals and/or contractors to the hosting data centre. A pre-approved personnel list also exists for those who are registered for on-site access to the Registry equipment or to escort un-registered visitors on-site. All persons visiting the hosting data centre must present Photo ID. Access is denied without valid Photo identification.

Audit Trails to Record Activities at Web, BackEnd and/or Database Levels

Database Access

Microsoft SQL Server 2005 provides auditing on the system to trace and record activity for successful and failed logins to the production database. These are recorded in the system event viewer log and the SQL Server database error logs.

Server User Access

All server user access is logged via server event logs together with firewall event logs. All user accounts use strong passwords and are granted privileges to only allow the user to carry out their specific role.
Extensive firewall and event logging is kept for all servers. BMC Patrol records all historical data for each agent enabled server, as well as monitoring all hardware alerts.

Application User Access

Users currently access the Registry system by means of a unique username and password. The EPA applies the following controls to ensure that unauthorised access is prevented and dealt with as promptly as possible.

- Automatic notification of transactions to the primary and secondary authorised representative via e-mail
- Strong passwords are used whereby they must be a minimum length of 8 characters and must be a mix of numerical and alphabetical characters.
- Passwords automatically expire after 90 days.

- Users are locked out of the registry after three failed attempts to logon. The password must be reset if the user is locked out which requires the user to make contact with the Registry Administrator and answer a series of security questions before regaining access.

Encryption of Communications: from Registry User to the Registry; from the ITL to the Registry and between Registry Nodes, if applicable

No change to the Encryption of Communications during the 2009 reporting period.

Firewalls and Anti Virus Measures

Firewalls: IE's Registry is protected by outer firewalls. All firewalls are Hot Standby Routing Protocol (HSPR) clustered. Demilitarized Zones (DMZs) are used to isolate servers.

Anti-Virus: Anti-Virus services are provided by means of a solution based on the Symantec range of products. Updates from Symantec are scheduled to run on a regular basis which are then updated to a Master server which sits in the Managed Hosting customers DMZ. The Master server in turn pushes the definition updates to the EPA servers. The anti-virus process employed ensures that the EPA servers always have the latest virus definition files installed and that high priority rapid response definitions are quickly deployed onto all EPA servers.

EPA Server Configurations:
All EPA servers are running the Symantec Anti-Virus client, which by default automatically cleans and quarantines files once a threat has been identified. Certain file types are automatically excluded from the scanning process.

Monitoring of Anti-Virus Service:
As the Symantec Anti-Virus client service is configured to start automatically, in the event of this service failing, then a monitoring alert will be generated and the standard incident management process will apply.

Password Policy
No change to Password Policy during 2009 reporting period.

Private Keys Protection Policies
No change to Private Keys Protection Policies during 2009 reporting period.

How User Ids/Passwords are Removed or Invalidated after Users have Become Inactive:
No change in the removal/invalidation of users process during the 2009 reporting period.

Security Audit

The EPA commissioned a comprehensive independent security audit in August 2009 to security test the Registry application and its supporting

infrastructure thus providing assurance to the EPA that the security posture of IE's Registry application and architecture provides adequate protection. The audit covered six areas: (i) network penetration test (ii) web application penetration test (iii) physical site security review (iv) system vulnerability test (v) IT technical procedures review and (vi) administrative procedures review. In general, the auditors found that the security of IE's Registry was in line with industry best practise. All findings and recommendations from the audit have been or are in the process of being implemented. **<u>Operational Plan</u>** <u>New or Updated Processes are Incorporated into the Working Operation of the Registry</u> Minor changes to the *Procedure Manual for Operation of Ireland's National Registry* must be approved by an EPA Director. Approval of the Board of the EPA is required to make major changes to the operational procedures of the Registry. Any changes will be notified immediately to all EPA users who must acknowledge receipt of the changed procedures.	
15/CMP.1 annex II.E paragraph 32.(g) Change of list of publicly available information	The following information is now deemed publicly accessible and as such is available via the homepage of the IE registry – www.etr.ie In accordance with the requirements of Annex E to Decision 13/CMP.1, all required information for a Party with an active Kyoto registry is provided with the exceptions as outlined below. **Account Information (Paragraph 45) and Account holders authorised to hold Kyoto units in their account (Paragraph 48)** In light of the forthcoming amendments introduced by Article 78 of the revised Registries Regulation (due to come into force in August 2010) and for security reasons, it is considered that the representative name and contact information (required by paragraph 45) and the legal entity contact information (required by paragraph 48) is held as confidential. Accordingly, this information is not included in the Account Information Report. **JI projects in Ireland (Paragraph 46)** Note that no Article 6 (Joint Implementation) project is reported as conversion to an ERU under an Article 6 project, as this did not occur in the specified period. In line with the Ireland's National Climate Change Strategy 2008-2012, Ireland does not host JI projects. **Holding and transaction information of units (Paragraph 47)** Holding and transaction information is provided on a holding type level, due to more detailed information being declared confidential by EU Regulation.

	Article 10 of EU Regulation 2216/2004/EC, provides that "*All information, including the holdings of all accounts and all transactions made, held in the registries and the Community independent transaction log shall be considered confidential for any purpose other than the implementation of the requirements of this Regulation, Directive 2003/87/EC or national law."* Paragraph 47c Ireland does not host JI projects in line with the National Climate Change Strategy. Paragraph 47e Ireland does not perform LULUCF activities and therefore does not issue RMUs Paragraph 47g No ERUs, CERs, AAUs and RMUs have been cancelled on the basis of activities under Article 3, paragraphs 3 and 4 to date. Paragraph 47h No ERUs, CERs, AAUs and RMUs have been cancelled following determination by the Compliance Committee that the Party is not in compliance with its commitment under Article 3, paragraph 1 to date. Paragraph 47j No ERUs, CERs, AAUs and RMUs have been retired to date Paragraph 47k There is no previous commitment period to carry ERUs, CERs, and AAUs over from.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	No change of the registry internet address occurred during the 2009 reporting period.
15/CMP.1 annex II.E paragraph 32.(i) Change of data integrity measure	The changes to data integrity measures in 2009 arise because of changes to (i) software and (ii) hosting provider in relation to database backup tools. In relation to changes to the hosting provider, the following updated content for the Readiness documentation is provided: (i) Application Logging Documentation (ii) Test Plan and (iii) Test Report.

Software Changes

A registry software version update was implemented in November 2009 which addressed improvements in data integrity. The functionality allowing the initiation of transfers has been improved by using a smarter data integrity algorithm making use of data check summing. This change increases robustness of the system when several users are trying to initiate transfers from the same account. It prevents data being changed concurrently which might lead to data integrity related problems.

The Greta Test report for Version 4.2 is included in the complete SIAR submission, Appendix 1 – *SIAR Supplementary Information* of this document.

Hosting Provider

Backups are performed over a dedicated backup network so as not to impact the operation of the production environment. Details of the backup procedure is provided in *Reporting Item 15/CMP.1 annex II.E paragraph 32.(c) – Changes to database or the capacity of national registry, Database and Application Backup plan*.

Updated content for the appropriate sections of the Readiness documentation is provided below.

Application Logging Documentation

Description of the Registry Data Model or File Structures Used to maintain a Transaction Log, a Notification Log, an Internal Audit Log as defined in the Data Exchange Standards.

Provided in *Reporting Item 15/CMP.1 annex II.E paragraph 32.(c) – Changes to database or the capacity of national registry, Database and Application Backup plan.*

Disaster Recovery Plan

No change in Disaster Recovery Plan during 2009 reporting period.

Test Plan and Test Report

Provided in *Reporting Item 15/CMP.1 annex II.E paragraph 32.(c) – Changes to database or the capacity of national registry, Test Plan and Test Report.*

15/CMP.1 annex II.E paragraph 32.(j) Change of test results	<u>Test Plan and Test Report</u> The following test plans and test results for version 4.1 and 4.2 of the Greta registry software have been included in the complete SIAR submission, Appendix 1 – *SIAR Supplementary Information*: - GRETA test plan and report for Version 4.1 and Version 4.2 - (C)ITL test plan and report for Version 4.1 - Certification email and report from the European Commission Evidence of the required connectivity testing with the ITL Administrator for the migration to the new hosting centre in March 2009 is also included in the complete SIAR submission, Appendix 1 – *SIAR Supplementary Information*.
Further Changes to Readiness Documentation:	Further to the migration to the new hosting data centre in March 2009, further changes to the Readiness documentation are outlined below : **<u>Time Validation Plan:</u>** <u>Identification of the Client Software or Hardware used as NTP Client</u> The IE Production environment servers use NTP to synch with time servers at 58 minutes past the hour, every hour. IE Production servers use tick.eircom.net and tock.eircom.net for NTP time synchronisation. The hosting provider servers take their stratum 1 synchronisation from the following sources: _ time.nist.gov _ ntp0.linx.net _ tt25.ripe.net <u>Version of NTP Used:</u> The registry uses Network Time Protocol (NTP, version 3) to synchronise its clock.

14.4 Response to Review Recommendations on the National Registry

Publicly Available Information (Paragraph 92 FCCC/ARR/2009/IRL)
See reporting item 15/CMP.1 annex II.E paragraph 32. (g) outlined in section 14.3 above.

Reconciliation (Paragraph 94 FCCC/ARR/2009/IRL)
The upgrade from GRETA Version 4.1 to Version 4.2 in November 2009 introduced a new windows service to improve and simplify the logical design of the system. This service is designed to provide one single framework for the processing of incoming and outgoing messages, in time allowing to concentrate all logic concerning messaging in one part of the system. This creates a robust basis to start improving messaging reliability, efficiency and the capacity of the registry as a result. Up to now improvements of messaging have been focussed on transactions messaging. GRETA Version 4.3, which was deployed in IE Registry March 2010, also includes several improvements to reconciliation messaging. GRETA Version 5.1, planned for mid 2010, will contain further changes to bring the improvements of transaction messaging to reconciliation messaging.

Information on Hosting Centre (Paragraph 98 FCCC/ARR/2009/IRL)
See reporting items 15/CMP.1 annex II.E paragraph 32.(c), 32.(f), 32.(i) and further changes to readiness documentation outlined in section 14.3 above.

Chapter 15

Minimization of Adverse Impacts under Article 3.14

15.1 Introduction

Article 3.14 of the Kyoto Protocol requires that Annex I Parties shall strive to meet their commitments under Article 3.1 of the Kyoto Protocol in such a way as to minimize adverse social environmental and economic impacts on developing country Parties, particularly those Parties identified in Article 4 paragraphs 8 and 9 of the Convention. Information on how commitments under Article 3.14 are being implemented is to be prioritised under a number of actions as set down in section H of the guidelines for the preparation of supplementary information required under Article 7.1 of the Kyoto Protocol. These requirements are addressed in this chapter.

15.2 Context

As a Member State of the European Union, Ireland's commitments under the Kyoto Protocol are being implemented under Decision 2005/166/EC, governing joint fulfilment under Article 4, and Decision 280/2004/EC, which covers specific emissions monitoring and reporting requirements. In this context, the minimization of adverse impacts on developing countries is also largely dictated by the European Commission's policy on climate change and by its policies and programmes affecting developing countries. Regulation at the European level also controls or influences market conditions, fiscal incentives, tax and duty exemptions and subsidies in all economic sectors in Member States.

The impact assessment of new policy initiatives has been established in the European Union, which allows their potential adverse social, environmental and economic impacts on various stakeholders, including developing country Parties, to be identified and limited at an early stage within the legislative process. Impact Assessment Guidelines specifically address impacts on third countries and also issues related to international relations. This provides a framework in which Member States like Ireland can also ensure a high level of protection of the environment and contribute to the integration of environmental considerations into the preparation and adoption of specified plans and programmes with a view to promoting sustainable development.

15.3 Specific Elements

a) The progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse-gas-emitting sectors, taking into account the need for energy price reforms to reflect market prices and externalities
Ireland's electricity market has been deregulated and the levy supporting the use of peat for electricity generation under a Public Service Agreement is being discontinued. Tax incentives contributed to the development of Ireland's most recent gas field off the west coast but such incentives will be severely curtailed for any similar developments in the future under new legislation. Reforms of the Common Agricultural Policy have resulted in changes to subsidies in agriculture, which are now linked to environmental, food safety and animal welfare standards. The EU Emissions Trading Scheme is a market-based emissions control measure which applies to major combustion

and process emission sources of CO_2 and a carbon tax is being introduced for fossil fuel use outside the ETS.

b) Removing subsidies associated with the use of environmentally unsound and unsafe technologies
Environmentally unsound and unsafe technologies may be regarded as technologies that would not conform to the concept of sustainable development and the objective and principles of the UNFCCC. The EC has addressed this issue by developing legislation to ensure that the price for coal produced in Member States is not lower than the price of coal of similar quality available from third countries and by phasing out subsidies on fossil fuel production and consumption by 2010. No environmentally unsound or unsafe technologies are in operation in Ireland.

c) Cooperating in the technological development of non-energy uses of fossil fuels, and supporting developing country Parties to this end;
The Irish Government is represented on the energy and environment strands of the Seventh Framework Programme (FP7) for Research and Technological Development (RTD). This representation includes the FP7 Energy Programme Committees that focuses on developing and agreeing the annual work programme and strategic vision for the FP7 Energy Work programme 2007–2013. Much of the focus of this (energy theme) initiative is on energy mitigation through supporting technological development and transfer through joint collaborations and calls with emerging economies including India, Russia and Brazil.

The International Energy Agency (IEA) is the energy forum and think-tank for 26 OECD countries. The Irish Government is a Party to four Renewable Energy Implementing Agreements of the IEA on Bioenergy, Ocean, Wind and RE Technology Deployment (RETD). Ireland provides national delegates to the executive committees of the Implementing Agreements and nominates and supports country experts to a number of tasks. The Government also sits on the Committee for Energy research and technology (CERT). Ireland is a member of the EU Expert Group on Technology, which supports the EC in climate negotiations. This expert group is focused on the transfer of technology to reduce the impacts of climate change and on supporting developing countries to this end.

d) Cooperating in the development, diffusion, and transfer of less-greenhouse-gas-emitting advanced fossil-fuel technologies, and/or technologies, relating to fossil fuels, that capture and store greenhouse gases, and encouraging their wider use; and facilitating the participation of the least developed countries and other non-Annex I Parties in this effort;
The EU collaborates with other Annex I and Non-Annex I Parties (Brazil, Saudi Arabia, China, Colombia, India, Korea, Mexico and South Africa) in the Carbon Sequestration Leadership Forum (CSLF). The CSLF is a ministerial-level international climate change initiative that is focused on the development of improved cost-effective technologies for the capture transport and long-term safe storage of CO_2. The mission of the CSLF is to facilitate the development and deployment of such technologies via collaborative efforts that address key technical, economic, and environmental obstacles. The CSLF will also promote awareness and champion legal, regulatory, financial, and institutional environments conducive to such technologies.

Ireland began its support to the Renewable Energy and Energy Efficiency Partnership (REEEP) in 2005. Following the decision by the Irish Government in 2007 to offset all its carbon emissions from official travel, REEEP was chosen as its implementing partner. REEEP is a Public-Private partnership and was launched by the United Kingdom along with other partners at the Johannesburg World Summit on Sustainable Development in August 2002. By providing opportunities for concerted collaboration among its partners, REEEP aims to accelerate the marketplace for renewable energy and energy efficiency. Funding from Ireland is being prioritised for projects in its programme countries of Ethiopia, Lesotho, Mozambique, Tanzania, Uganda, Zambia and Malawi.

Ireland provides development assistance in line with the priorities expressed by partner countries. To date requests for assistance in the area of technology are primarily in connection with water supply, transport infrastructure and agriculture. An innovative programme in Ethiopia carries out operational participatory research with farmers, extension workers and government officials to identify, develop, and disseminate new agricultural technologies. Some of the successful technologies are based on traditional practices, for example soil conservation techniques. Other new technologies are related to new crop varieties and irrigation. In addition to ODA, private companies also provide technology and advice to developing countries, particularly in the energy sector. Due to the range of funding sources no precise figure is available for funding attributed to technology development and transfer. Ireland's support to REEEP is worth mentioning again here as an example of Ireland's support for technology transfer. REEEP brings the private and public sectors together to facilitate the financing, development and transfer of renewable energy technologies. Ireland believes that this type of public-private collaboration is essential for the development of appropriate and environmentally sound technologies and to facilitate their application and use in developing countries.

e) Strengthening the capacity of developing country Parties identified in Article 4, paragraphs 8 and 9, of the Convention for improving efficiency in upstream and downstream activities relating to fossil fuels, taking into consideration the need to improve the environmental efficiency of these activities

The EU contributes to strengthening the capacities of countries engaged in the export of fossil fuels through the work of the Energy Expert Group of the Gulf Cooperation Council (GCC), in particular under the working sub-group on energy efficiency. As part of the EU's research programme, a project called "EUROGULF" was launched with the objective of to analyse The European Commission's planned e-network on clean energy technologies, is aiming to promote research and technical development of clean energy technologies in the GCC countries.

Ireland currently holds the Programme Chair of Renewable Energy and Energy Efficiency Partnership, a Type 2 International NGO. The Renewable Energy and Energy Efficiency Partnership (REEEP) is a global partnership that works to reduce the barriers in policy, regulatory and financial structures that bar and limit the uptake of renewable-energy and energy-efficiency technologies and projects. This Partnership focuses on deployment of projects in sub-Saharan Africa, Asia and Latin America. Ireland is actively involved in the partnership, alongside energy-related organisations from Australia, Austria, Canada, Germany, Italy, Spain, the Netherlands, New Zealand, Norway, the UK, the USA and the European Commission.

Ireland is a founding member of the UNEP SEFI Public Finance Alliance, or 'SEF Alliance'. This is a member-driven coalition of public and publicly backed organisations that finance sustainable-energy markets in various countries, including emerging and developing economies. . Members use the platform to exchange best practices, pool resources, launch joint projects and assist other governments in establishing new or similar financing models. The SEF Alliance is under the remit of the Sustainable Energy Finance Initiative (SEFI) of the United Nations Environment Programme (UNEP) but is governed directly by its members and pursues activities according to their interests. In 2008, the Alliance published Public Finance for Climate Change Mitigation, which provided an overview of mechanisms being used by the public sector to help scale up the climate mitigation markets, with a particular focus on the clean energy sector. In 2008, the SEF Alliance also published a Public Venture Capital Study which examined current clean-energy venture financing, focusing on the role of public sector-sponsored venture capital.

f) Assisting developing country Parties which are highly dependent on the export and consumption of fossil fuels in diversifying their economies.

Ireland supports a range of EU activities aimed at reducing dependence on the consumption of fossil fuels, in particular those EU support programmes for the promotion of renewable energies and energy efficiency in developing countries. Renewable energy cooperation with Mediterranean and Gulf countries which led to the Mediterranean Solar Plan, endorsed in 2008 with the objective of installing 20 GW of new generation capacity in solar and other renewable energy sources around the Mediterranean Sea by 2020. Another objective is to create a sub-regional electricity market between Morocco, Tunisia and Algeria and to progressively integrate it with the electricity market of the EU. Important initiatives which target energy efficiency and renewable energy projects in South America, Africa and Asia include the Africa, Caribbean and the Pacific (ACP-E) Energy Facility, the Latin

America Investment Facility (LAIF), the Euro-Solar Programme in Latin America and the Global Energy Efficiency and Renewable Energy Fund (GEEREF).

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Glossary

Annex 1 Parties	Countries listed in Annex I to the United Nations Framework Convention on Climate Change
Base year	The year or period under the Kyoto Protocol on which quantified emission limitation or reduction commitments in the commitment period are based.
BOD	Biochemical Oxygen Demand
CARBWARE	A forest model to calculate carbon stock change and growth increment for Irish forests
CFCs	Chlorofluorocarbons
CH_4	Methane
CHP	Combined Heat and Power.
CMMS	Cattle Movement and Monitoring System
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2 equivalent	The equivalent mass as CO_2 of other greenhouse gases converted on the basis of their global warming potential (GWP)
COFORD	National Council for Forest Research and Development
Commitment Period	The years 2008 to 2012 inclusive for which quantified emission limitation or reduction commitments are established under the Kyoto Protocol
COP	Conference of the Parties
CORINAIR	Co-ordinated Information on the environment in the European Community-AIR. CORINAIR was one of several collaborative exercises initiated under the CORINE programme to harmonise the collection and dissemination of information on the environment in the EU.
CRF	Common Reporting Format
DAF	Department of Agriculture and Food
DCENR	Department of Communications, Energy and Natural Resources
DEHLG	Department of Environment Heritage and Local Government
DNDC	DeNitrification-DeComposition, is a computer simulation model of carbon and nitrogen biogeochemistry in agri-ecosystems
EMEP	European Monitoring and Evaluation Programme, a co-operative programme for monitoring and evaluation of the long-range transmissions of air pollutants in Europe
Emission	(of a greenhouse gas). The release of greenhouse gases into the atmosphere.
Enteric Fermentation	The digestive process in ruminant animals (e.g cattle and sheep) where bacteria convert the feed to a usable form of energy for the animal, producing CH_4 as a by product
EUROSTAT	Statistical Agency of the European Union
FAO	Food and Agriculture Organisation of the United Nations
FFS	Farm Facilities Survey
FIPS	Forest Inventory and Planning System
Fluorinated Gases	HFCs, PFCs and SF_6
Fossil Fuel	Peat, coal, oil and natural gas and associated derivatives
FTA	Fraction of BOD in sludge that degrades anaerobically
GDP	Gross Domestic Product
Gg	Gigagram (10^9 g) = kilo tonne = 1,000 tonnes
Greenhouse Gas	A gas in the atmosphere that allows solar radiation through to the earth's surface, but traps some of the heat radiated back from the earth's surface
GWP	The cumulative warming over a specified time period, e.g. 100 years, resulting from a unit mass of a greenhouse gas emitted at the beginning of that time period, expressed relative to an absolute GWP of 1 for CO_2

HCFCs	Hydrochlorofluorocarbon
HFCs	Hydrofluorocarbons
HGV	Heavy Goods Vehicle
IEA	International Energy Agency
IEF	Implied Emission Factor
IPC	Integrated Pollution Control
IPCC	Intergovernmental Panel on Climate Change
IUCC	Information Unit on Climate Change
kt	kilo tonne (1,000 tonnes)
Kyoto Protocol	The Protocol to the UNFCCC adopted by Decision 1/CP.3 under which industrialised countries agreed to reduce their combined greenhouse gas emissions in 1990 by at least 5 percent by the period 2008-2012
Montreal Protocol	Protocol on substances that deplete the ozone layer
Mt	million tonnes or mega tonnes
N_2O	Nitrous Oxide
NIR	National Inventory Report
NMVOC	Non Methane Volatile Organic Compounds
NO_x	Nitrogen Oxides
NRA	National Roads Authority
OSPAR	Oslo and Paris Convention for the Protection of the Marine Environment
PFCs	Perfluorocarbons
SBSTA	Subsidiary Body for Scientific and Technological Advice
SEI	Sustainable Energy Ireland
SF_6	Sulphur Hexafluoride
Sink	The reservoir or pool in which sequestered carbon is stored; the process of sequestration
SO_2	Sulphur Dioxide
Teagasc	Irish Agriculture and Food Development Authority
TPER	Total Primary Energy Requirement
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
VOC	Volatile Organic Compounds

Annex A

Greenhouse Gases GWP and IPCC Reporting Format

Table A.1 Greenhouse Gases and GWP Values

Greenhouse Gas	Chemical Formula	IPCC GWP (1995)[a]
Carbon Dioxide	CO_2	1
Methane	CH_4	21
Nitrous Oxide	N_2O	310
Hydrofluorocarbons (HFC)		
HFC-23	CHF_3	11700
HFC-32	CH_2F_2	650
HFC-41	CH_3F	150
HFC-43-10mee	$C_5H_2F_{10}$	1300
HFC-125	C_2HF_5	2800
HFC-134	$C_2H_2F_4(CHF_2CHF_2)$	1000
HFC-134a	$C_2H_2F_4(CH_2FCF_3)$	1300
HFC-152a	$C_2H_4F_2(CH_3CHF_2)$	140
HFC-143	$C_2H_3F_3(CHF_2CH_2F)$	300
HFC-143a	$C_2H_3F_3(CF_3CH_3)$	3800
HFC-227ea	C_3HF_7	2900
HFC-236fa	$C_3H_2F_6$	6300
HFC-245ca	$C_3H_3F_5$	560
Perfluorocarbons(PFC)		
Perfluoromethane	CF_4	6500
Perfluoroethane	C_2F_6	9200
Perfluoropropane	C_3F_8	7000
Perfluorobutane	C_4F_{10}	7000
Perfluorocyclobutane	$c-C_4F_8$	8700
Perfluoropentane	C_5F_{12}	7500
Perfluorohexane	C_6F_{14}	7400
Sulphur Hexafluoride	SF_6	23900

(a) GWP (global warming potential) as provided by the IPCC in its Second Assessment Report

Table A.2 IPCC Reporting Format (Level 1 and Level 2)

IPCC SOURCE and SINK CATEGORIES	CO_2	CH_4	N_2O	HFC	PFC	SF6
1. Energy						
A. Fuel Combustion (Sectoral Approach)						
1. Energy Industries						
2. Manufacturing Industries and Construction						
3. Transport						
4. Other Sectors						
5. Other						
B. Fugitive Emissions from Fuels						
1. Solid Fuels						
2. Oil and Natural Gas						
2. Industrial Processes						
A. Mineral Products						
B. Chemical Industry						
C. Metal Production						
D. Other Production						
E. Production of Halocarbons and SF_6						
F. Consumption of Halocarbons and SF_6						
G. Other						
3. Solvent and Other Product Use						
A. Paint Application						
B. Degreasing and Dry Cleaning						
C. Chemical Products Manufacture & Processing						
D. Other						
4. Agriculture						
A. Enteric Fermentation						
B. Manure Management						
C. Rice Cultivation						
D. Agricultural Soils						
E. Prescribed Burning of Savannas						
F. Field Burning of Agricultural Residues						
G. Other						
5. Land-Use Change and Forestry						
A. Forestry						
B. Cropland						
C. Grassland						
D. Wetland						
E. Settlements						
F. Other Land						
G. Other						
6. Waste						
A. Solid Waste Disposal on Land						
B. Wastewater Handling						
C. Waste Incineration						
D. Other						
7. Other						
Memo Items:						
International Bunkers						
Multilateral Operations						
CO_2 Emissions from Biomass						

The grey cells indicate sources/sinks where no emissions/removals of the various gases are expected

Annex B

Expanded Energy Balance Sheets for 2008

Table B.1 Expanded Energy Balance Sheet 2008

2008 Units = ktoe	NACE	Coal	Bituminous Coal	Anthracite + Manufactured Ovoids	Coke	Lignite	Peat	Milled Peat	Sod Peat	Briquettes	Oil	Crude	Refinery Gas	Gasoline	Kerosene	Jet Kerosene
Indigenous Production		**0.00**	**0.00**				**645.09**	471.37	173.72		**0.00**					
Imports		**1,599.78**	**1,552.28**	**35.22**		12.28	**0.00**				**10,385.55**	3,266.96		1,201.88	459.99	1,261.38
Exports		**4.17**	**0.00**	**4.17**		0.00	**9.72**			9.72	**1,216.06**			6.35	0.00	0.00
Mar. Bunkers		**0.00**					**0.00**				**70.29**					
Stock Change		**-160.02**	**-157.54**	-2.36		-0.13	**209.52**	195.45	-0.15	14.22	**144.23**	-2.89		33.22	27.98	0.09
Primary Energy Supply (incl non-energy)		**1,435.59**	**1,394.74**	**28.69**	**0.00**	**12.16**	**844.88**	**666.82**	**173.56**	**4.50**	**9,243.42**	**3,264.07**	**0.00**	**1,228.75**	**487.97**	**1,261.47**
Primary Energy Requirement (excl. non-energy)		**1,435.59**	**1,394.74**	**28.69**	**0.00**	**12.16**	**844.88**	**666.82**	**173.56**	**4.50**	**8,963.98**	**3,264.07**	**0.00**	**1,228.75**	**487.97**	**1,261.47**
Transformation Input		**1,046.47**	**1,046.47**	**0.00**	**0.00**	**0.00**	**674.13**	**674.13**	**0.00**	**0.00**	**3,614.79**	**3,264.07**	**5.36**	**0.00**	**0.00**	**0.00**
Public Thermal Power Plants		**1,046.47**	1,046.47				**558.44**	558.44	0.00		**345.12**					
Combined Heat and Power Plants		**0.00**	0.00				**7.31**	7.31			**5.60**		5.36			
Pumped Storage Consumption																
Briquetting Plants		**0.00**					**108.38**	108.38			**0.00**					
Oil Refineries & other energy sector		**0.00**					**0.00**				**3,264.07**	3,264.07				
Transformation Output		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**92.40**	**0.00**	**0.00**	**92.40**	**3,410.60**	**0.00**	**96.17**	**645.29**	**221.57**	**0.00**
Public Thermal Power Plants		**0.00**					**0.00**				**0.00**					
Combined Heat and Power Plants - Electricity		**0.00**					**0.00**				**0.00**					
Combined Heat and Power Plants - Heat																
Pumped Storage Generation																
Briquetting Plants							**92.40**			92.40	**0.00**					
Oil Refineries							**0.00**				**3,410.60**		96.17	645.29	221.57	0.00
Exchanges and transfers		**12.13**	-12.90	25.03	0.00	0.00	**0.00**	0.00	0.00	0.00	**-11.58**	0.00	0.00	-0.00	188.74	-188.66
Electricity																
Heat																
Other		**12.13**	-12.90	25.03							**-11.58**			-0.00	188.74	-188.66
Own Use and Distribution Losses		**0.00**					**22.13**	22.13			**127.25**		90.81			
Available Final Energy Consumption		**401.25**	**335.36**	**53.73**	**0.00**	**12.16**	**241.01**	**-29.45**	**173.56**	**96.89**	**8,900.41**	**-0.00**	**0.00**	**1,874.04**	**898.27**	**1,072.81**
Non-Energy Consumption		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**279.44**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Final non-Energy Consumption (Feedstocks)		0.00					0.00				279.44					
Total Final Energy Consumption		**379.50**	**313.15**	**56.17**	**0.00**	**10.43**	**279.69**	**0.00**	**173.87**	**105.83**	**8,534.48**	**0.00**	**0.00**	**1,907.38**	**1,026.44**	**970.10**
Industry*		**125.34**	**125.09**	**0.25**			**0.00**	**0.00**	**0.00**	**0.00**	**949.89**	**0.00**	**0.00**	**0.00**	**139.00**	**0.00**
Non-Energy Mining	13-14	**0.00**	0.00				**0.00**				**93.75**				8.36	
Food & beverages	15	**17.70**	17.70				**0.00**				**148.05**				35.36	
Textiles and textile products	17 - 18	**0.00**	0.00				**0.00**				**6.73**				0.65	
Wood and wood products	20	**0.00**	0.00				**0.00**				**3.29**				0.25	
Pulp, paper, publishing and printing	21 - 22	**0.00**	0.00				**0.00**				**4.92**				0.75	
Chemicals & man-made fibres	24	**0.00**	0.00				**0.00**				**36.98**				6.55	
Rubber and plastic products	25	**1.18**	1.18				**0.00**				**10.92**				0.35	
Other non-metallic mineral products	26	**106.21**	106.21				**0.00**				**250.33**				3.81	
Basic metals and fabricated metal products	27 - 28	**0.25**	0.00	0.25			**0.00**				**300.21**				75.67	
Machinery and equipment n.e.c.	29	**0.00**	0.00				**0.00**				**7.02**				0.77	
Electrical and optical equipment	30 - 33	**0.00**	0.00				**0.00**				**75.11**				4.55	
Transport equipment manufacture	34 - 35	**0.00**	0.00				**0.00**				**3.30**				0.26	
Other manufacturing	36 - 37, 1(	**0.00**	0.00				**0.00**			0.00	**9.29**				1.68	
Transport		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**5,552.13**	**0.00**	**0.00**	**1,907.38**	**0.00**	**970.10**
Road Freight		**0.00**					**0.00**				**1,159.69**					
Road Private Car		**0.00**					**0.00**				**2,125.62**			1,530.41		
Public Passenger Services		**0.00**					**0.00**				**225.80**			53.68		
Rail		**0.00**					**0.00**				**45.60**					
Domestic Aviation		**0.00**					**0.00**				**42.51**			1.68		40.82
International Aviation		**0.00**					**0.00**				**929.27**					929.27
Fuel Tourism		**0.00**					**0.00**				**639.63**			179.75		
Unspecified		**0.00**					**0.00**				**384.01**			141.85		
Residential		**228.34**	**163.57**	55.04		**9.74**	**279.69**		**173.87**	**105.83**	**1,230.86**			**0.00**	**887.44**	
Commercial/Public Services		**26.07**	**24.49**	**0.88**	**0.00**	**0.70**	**0.00**	**0.00**	**0.00**	**0.00**	**550.31**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Commercial Services		**26.07**	24.49	0.88		0.70	**0.00**				**359.12**				0.00	
Public Services		**0.00**					**0.00**		0.00	0.00	**191.19**					
Agricultural		**0.00**	**0.00**				**0.00**				**251.29**			**0.00**	**0.00**	
Statistical Difference		**21.75**	**22.21**	**-2.45**	**0.00**	**1.73**	**-38.68**	**-29.45**	**-0.30**	**-8.94**	**86.49**	**-0.00**	**0.00**	**-33.34**	**-128.17**	**102.71**

Table B.1 (continued) Expanded Energy Balance Sheet 2008

Fueloil	LPG	Gasoil / Diesel /DERV	Petroleum Coke	Naphta	Bitumen	White Spirit	Lubricants	Natural Gas	Renewables	Hydro	Wind	Biomass	Landfill Gas	Biogas	Liquid Biofuel	Solar	Geothermal	Electricity	Heat	TOTAL
								354.91	**537.55**	83.28	207.26	164.59	25.91	9.47	24.00	2.89	20.14			1,537.55
756.04	146.98	2,740.27	267.55	0.00	244.01	2.10	38.38	**4,135.37**	**43.98**			11.41			32.57			64.76		16,229.44
1,144.99	12.93	20.64	0.37	25.73	0.00	0.00	5.05	**0.00**	**2.28**			0.16			2.12			26.04		1,258.28
44.81		25.48							**0.00**											70.29
52.94	-3.80	41.48	-4.85	0.06	0.00	0.00	0.00	**1.07**	**2.05**			1.02			1.03					196.84
-380.82	**130.25**	**2,735.63**	**262.33**	**-25.67**	**244.01**	**2.10**	**33.33**	**4,491.35**	**581.30**	**83.28**	**207.26**	**176.87**	**25.91**	**9.47**	**55.48**	**2.89**	**20.14**	**38.72**	**0.00**	**16,635.26**
-380.82	**130.25**	**2,735.63**	**262.33**	**-25.67**	**0.00**	**0.00**	**0.00**	**4,491.35**	581.30	**83.28**	**207.26**	**176.87**	**25.91**	**9.47**	**55.48**	**2.89**	**20.14**	**38.72**	**0.00**	**16,355.82**
334.73	**0.24**	**10.39**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**2,810.62**	**38.25**	**0.00**	**0.00**	**7.19**	**25.91**	**5.15**	**0.00**	**0.00**	**0.00**	**57.72**	**0.00**	**8,241.99**
334.73		10.39						**2,577.36**	**29.43**			3.51	25.91							4,556.82
0.00	0.24	0.00						**233.26**	**8.83**			3.68		5.15						255.00
																		44.97		44.97
									0.00											108.38
									0.00									12.76		3,276.83
1,169.69	**37.75**	**1,214.47**	**0.00**	**25.67**	**0.00**	**0.00**	**0.00**	**0.00**	**13.79**	**0.00**	**0.00**	**2.84**	**9.51**	**1.44**	**0.00**	**0.00**	**0.00**	**2,249.88**	**0.00**	**5,766.67**
									10.94			1.44	9.51					2,061.10		2,072.04
									2.85			1.41		1.44				160.29		163.14
									0.00											0.00
																		28.49		28.49
									0.00											92.40
1,169.69	37.75	1,214.47		25.67					**0.00**											3,410.60
4.47	0.00	-3.99	-12.13	0.00	0.00	0.00	0.00	**0.00**	**-304.33**	-83.28	-207.26	-2.84	-9.51	-1.44	0.00	0.00	0.00	**304.33**	**0.00**	0.55
									-304.33	-83.28	-207.26	-2.84	-9.51	-1.44				**304.33**		0.00
																				0.00
4.47		-3.99	-12.13						**0.00**											0.55
25.06	3.84	7.53						**63.46**	**0.00**									**370.62**		583.46
433.55	**163.92**	**3,928.19**	**250.20**	**-0.00**	**244.01**	**2.10**	**33.33**	**1,617.27**	**252.51**	**0.00**	**0.00**	**169.68**	**0.00**	**4.32**	**55.48**	**2.89**	**20.14**	**2,164.58**	**0.00**	**13,577.03**
0.00	**0.00**	**0.00**	**0.00**		**244.01**	**2.10**	**33.33**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**279.44**
					244.01	2.10	33.33	0.00	0.00											279.44
340.69	**187.97**	**3,858.59**	**242.26**	**1.05**	**0.00**	**0.00**	**0.00**	**1,659.00**	**253.42**	**0.00**	**0.00**	**170.65**	**0.00**	**4.32**	**55.53**	**2.89**	**20.14**	**2,294.04**	**0.00**	**13,400.14**
330.84	**82.46**	**177.66**	**218.88**	**1.05**	**0.00**	**0.00**	**0.00**	**596.16**	**138.72**	**0.00**	**0.00**	**137.33**		**1.38**	**0.00**	**0.00**	**0.00**	**686.01**	**0.00**	**2,495.87**
15.26	0.22	53.98	15.93					20.19	**0.00**									49.27		163.21
64.58	9.45	38.66	0.00					168.76	**41.49**			40.11		1.38				137.09		513.09
1.19	0.63	4.25	0.00					0.28	**0.00**									7.25		14.26
0.45	0.07	2.52	0.00					3.50	**87.64**			87.64						27.82		122.25
1.37	0.00	2.80	0.00					6.60	**0.00**									21.81		33.32
11.96	9.26	9.21	0.00					101.12	**0.00**									104.42		242.52
0.64	6.14	3.79	0.00					4.59	**0.00**									34.05		50.73
6.96	4.37	32.24	202.95					54.28	**9.59**			9.59						72.61		493.01
215.17	5.60	3.77	0.00					183.87	**0.00**									47.16		531.24
1.41	2.76	2.09	0.00					9.26	**0.00**									16.31		32.60
8.32	41.57	20.66	0.00					33.78	**0.00**									129.78		238.68
0.47	1.41	1.16	0.00					7.60	**0.00**									9.86		20.76
3.06	0.97	2.53	0.00	1.05				2.33	**0.00**									28.58		40.20
0.00	**1.21**	**2,673.44**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**55.53**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**55.53**	**0.00**	**0.00**	**4.73**	**0.00**	**5,612.39**
		1,159.69							**0.00**											1,159.69
	1.21	594.00							**55.53**						55.53					2,181.15
		172.12							**0.00**											225.80
		45.60							**0.00**									4.73		50.33
									0.00											42.51
									0.00											929.27
		459.87							**0.00**											639.63
0.00		242.15							**0.00**											384.01
0.00	**90.95**	**229.08**	**23.38**					**668.83**	**43.97**			**23.04**				**2.79**	**18.14**	**733.21**		**3,184.90**
9.85	**13.34**	**527.12**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**394.01**	**15.05**	**0.00**	**0.00**	**10.11**	**0.00**	**2.94**	**0.00**	**0.11**	**2.00**	**821.81**	**0.00**	**1,807.25**
0.96	9.93	348.23						**172.68**	**12.11**			10.11					2.00	589.18		1,159.17
8.89	3.41	178.89						**221.37**	**2.94**					2.94				232.66		648.16
	0.00	**251.29**						**0.00**	**0.17**			**0.17**						**48.28**		**299.73**
92.85	**-24.05**	**69.59**	**7.93**	**-1.05**	**0.00**	**0.00**	**0.00**	**-41.73**	**-0.91**	**0.00**	**0.00**	**-0.97**	**0.00**	**0.00**	**-0.05**	**0.00**	**0.00**	**-129.45**	**0.00**	**-102.55**

Annex C

Review of Emission Factors used in the Energy Sector in Ireland's Greenhouse Gas Inventories

Introduction

The Environmental Protection Agency has overall responsibility for the national greenhouse gas inventory in Ireland's national system established in 2007 under Article 5 of the Kyoto Protocol. The EPA Office of Climate Licensing and Resource Use (OCLR) performs the role of inventory agency in Ireland and undertakes all aspects of inventory preparation and management and the submission of results to meet UNFCCC and EU reporting requirements.

The methodologies used to estimate emissions in the Energy sector for all years from 1990-2007 are described in Ireland's National Inventory Report 2009 [NIR 2009]. All carbon dioxide (CO_2) emission factors, except for petroleum coke and biomass, are country specific values based on the carbon content and net calorific value of the fuels combusted in Ireland. In some sub-categories, bottom-up estimates are made using plant specific emission factors obtained through the Emissions Trading Scheme under Directive 2003/87/EC[3]. Default CO_2 emission factors from the IPCC Revised 1996 Guidelines are used for petroleum coke and biomass. For stationary combustion sources and all mobile sources except road transport, the inventories team uses default emission factors for methane (CH_4) and nitrous oxide (N_2O) largely based on the CORINAIR90 programme or the EMEP/CORINAIR Emission Inventory Guidebook (1st Edition, 1996), which predated the IPCC work on emission factors. In the case of CH_4, the emissions factors originally adopted by Ireland were chosen in many instances by arbitrary partitioning of CORINAIR emission factors for volatile organic compounds (VOC) into separate values for CH_4 and non-methane volatile organic compounds (NMVOC).

The OCLR inventories team carries out continuous inventory improvement on an annual basis focussing primarily on key categories identified in Tables 1.6-1.8 in Ireland's NIR. Emissions of CH_4 and N_2O from stationary combustion in the Energy sector are not identified as key categories and have not been subject to internal review heretofore. However, issues relating to emissions of these gases have been highlighted in various annual external review processes undertaken by the UNFCCC expert review teams and the European Union's own internal review process. The findings identified from these processes can be found in Appendix A of this Annex. In light of these findings the OCLR has undertaken a review of the use of all default CH_4 and N_2O emission factors in the Energy sector. During the course of this review it was decided to broaden the scope of this work to also look at the use of default CO_2 emission factors for petroleum coke and biomass fuels. It is intended to update all CH_4 and N_2O emission factors with default or higher tier IPCC Revised 1996 Guidelines or IPCC 2006 Guidelines emission factors and to use them for inventory reporting in 2010 and thereafter.

The greenhouse gas inventory submission to the UNFCCC in 2010 is the first submission of the Kyoto Protocol five-year commitment period 2008-2012. Inventory submissions for these years are subject to potential adjustments to estimates for missing sources or not estimated sources are judged to be underestimates by UNFCCC expert review teams. This review and revision process by the OCLR inventory team aims to improve the estimates and to ensure that there is no systematic underestimation of emissions in any Energy sub-category in Ireland's inventory due to the use of inappropriate emission factors.

[3] Directive 2003/87/EC of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC.

The starting point of this review was to compare Ireland's implied CH_4 and N_2O emission factors for solid, liquid and gaseous fuels with all other 40 Annex 1 Parties to the United Nations Framework Convention on Climate Change. This was done using the UNFCCC GHG Locator Review tool (version 3.3 July 2009). The outputs of this process are shown in Appendices B to F for the various Energy sector sub-categories, sorted by level of emission factor in the end year 2007. This process highlighted Ireland's emission factors as outliers in many of the sector's sub-categories. The results of this analysis along with the OCLR's revised emission factors are presented in more detail in the following sections by Energy subcategory; *1.A.1 Energy Industries, 1.A.2 Manufacturing Industries and Construction, 1.A.3 Transport and 1.A.4 Other Sectors.*

Emissions from 1.A.1Energy Industries

This sector is the largest contributor to Energy emissions producing 14.5 Mt of CO_2 equivalent in 2007. It comprises of three sub-categories; 1.A.1.a Public Electricity and Heat Production, 1.A.1.b Petroleum Refining and 1.A.1.c Manufacture of Solid Fuels and Other Energy Industries.

1.A.1.a. Public Electricity and Heat Production

This category covers all the electricity power generating stations operated by the Electricity Supply Board (ESB) and the more recent independent operators. Tables B.1-B.6 of Appendix B show Ireland's implied emission factors (IEFs) for solid, liquid and gaseous fuels in this sub-category. Ireland has the highest reported IEFs for N_2O for solid, liquid and gaseous fuels of any Annex 1 Party. Also, Ireland does not currently estimate CH_4 emissions for this sector, an obvious missing estimate or under estimate of emissions. The current emission factors along with the proposed changes are shown in Table C.1 below. The proposed emission factors in Table 1 are in line with those used by power generating companies in their reports under E-PRTR in accordance with Regulation (EC) No 166/2006[4] for 2007 and 2008 data.

Table C.1

	Previous Emission Factors			Revised Emission Factors			
Fuel	**CO_2 (t/TJ)**	**CH_4 (kg/TJ)**	**N_2O (kg/TJ)**	**CO_2 (t/TJ)**	**CH_4 (kg/TJ)**	**N_2O (kg/TJ)**	Reference Source for CH_4, N_2O
Coal	PS[1]	NE	14.00	PS[1]	0.70	0.50	2006 IPCC Guidelines Table 2.6
Milled Peat	PS[1]	NE	12.00	PS[1]	3.00	7.00	2006 IPCC Guidelines Table 2.6
Gasoil	PS[1]	NE	14.00	PS[1]	0.80	0.30	2006 IPCC Guidelines Table 2.6
Residual Fuel Oil (HFO)	PS[1]	NE	14.00	PS[1]	0.80	0.30	2006 IPCC Guidelines Table 2.6
Natural Gas (gas turbine)	PS[1]	NE	3.00	PS[1]	4.00	1.00	2006 IPCC Guidelines Table 2.6
Natural Gas (CCGT)	PS[1]	NE	3.00	PS[1]	1.00	3.00	2006 IPCC Guidelines Table 2.6
Landfill Gas	54.94	NE	3.00	54.94	1.00	0.10	2006 IPCC Guidelines Table 2.2

PS[1]: Plant Specific

The impact of these emission factor changes on emission estimates for all years from 1990-2008 on this sub-category is shown in Table C.2. Any increases in emissions due

[4] REGULATION (EC) No 166/2006 of the European Parliament and of the Council of 18 January 2006 concerning the establishment of a European Pollutant Release and Transfer Register and amending Council Directives 91/689/EEC and 96/61/EC.

to the inclusion of estimates of CH_4 are more than offset by large yearly reductions of N_2O emissions, up to 300 kt of CO_2 equivalent in 2008, resulting in a net reduction of approximately 2.1 percent for category 1A1a.

Table C.2

		1990	1995	2000	2001		2003	2004	2005	2006	2007	2008
Emissions Sub-Category 1A1a NEW	**Gg**											
CO2	CO_2 eq.	10876.49	13051.27	15667.31	16799.71	15830.46	15108.59	14736.82	15136.45	14410.77	13932.81	14005.00
CH4	CO_2 eq.	5.44	6.47	9.01	9.43	8.91	8.34	7.27	7.50	7.10	7.10	7.08
N2O	CO_2 eq.	73.80	76.90	80.24	87.17	97.88	108.32	91.41	105.45	111.96	119.04	137.00
Total	**CO_2 eq.**	**10955.73**	**13134.64**	**15756.56**	**16896.31**	**15937.24**	**15225.25**	**14835.50**	**15249.39**	**14529.84**	**14058.95**	**14149.08**
Emissions Sub-Category 1A1a OLD												
CO2	CO_2 eq.	10876.49	13051.27	15667.31	16799.71	15830.46	15108.59	14736.82	15136.45	14410.77	13932.81	14005.00
CH4	CO_2 eq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N2O	CO_2 eq.	411.62	512.54	589.03	650.06	589.19	516.39	519.43	551.15	510.41	441.53	441.20
Total	**CO_2 eq.**	**11288.11**	**13563.82**	**16256.34**	**17449.77**	**16419.65**	**15624.98**	**15256.25**	**15687.60**	**14921.18**	**14374.35**	**14446.20**
Difference												
CO2	CO_2 eq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH4	CO_2 eq.	5.44	6.47	9.01	9.43	8.91	8.34	7.27	7.50	7.10	7.10	7.08
N2O	CO_2 eq.	-337.83	-435.65	-508.79	-562.89	-491.32	-408.07	-428.02	-445.70	-398.44	-322.49	-304.20
Total	**CO_2 eq.**	**-332.38**	**-429.18**	**-499.78**	**-553.46**	**-482.41**	**-399.73**	**-420.75**	**-438.21**	**-391.34**	**-315.39**	**-297.12**
% Change		**-2.94%**	**-3.16%**	**-3.07%**	**-3.17%**	**-2.94%**	**-2.56%**	**-2.76%**	**-2.79%**	**-2.62%**	**-2.19%**	**-2.06%**

1.A.1.b. Petroleum Refining

This category covers Ireland's only petroleum refinery in Whitegate Co. Cork. Tables B.7-B.8 of Appendix B show Ireland's IEFs for liquid fuels in Ireland's one refinery. Ireland has the second highest reported IEF for N_2O and the second lowest IEF for CH_4 for liquid fuels of any Annex 1 Party. Ireland does not currently estimate CH_4 emissions for the two primary fuels used by the refinery, heavy fuel oil and refinery gas. The current emission factors along with the proposed changes are shown in Table C.3 below.

Table C.3

	Previous Emission Factors			Revised Emission Factors			
Fuel	**CO_2 (t/TJ)**	**CH_4 (kg/TJ)**	**N_2O (kg/TJ)**	**CO_2 (t/TJ)**	**CH_4 (kg/TJ)**	**N_2O (kg/TJ)**	Reference Source for CH_4, N_2O
Refinery Gas	PS	NE	3.00	PS	1.00	0.10	2006 IPCC Guidelines Table 2.2
Gasoil	PS	2.00	10.00	PS	3.00	0.60	2006 IPCC Guidelines Table 2.2
Residual Fuel Oil (HFO)	PS	NE	10.00	PS	3.00	0.60	2006 IPCC Guidelines Table 2.2
LPG	PS	2.00	3.00	54.94	1.00	0.10	2006 IPCC Guidelines Table 2.2

The impact of these emission factor changes on emission estimates for all years from 1990-2008 on this sub-category is shown in Table C.4. Any increases in emissions due to the changes in CH_4 emission factors are more than offset by yearly reductions of N_2O emissions, up to 7.6 kt of CO_2 equivalent in 2008, giving a net reduction of 2.0 percent in category 1A1b.

Table C.4

		1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
Emissions Sub-Category												
1A1b NEW	**Gg**											
CO2	CO_2 eq.	181.99	197.05	296.29	348.51	369.91	369.53	366.50	411.22	376.53	360.20	366.89
CH4	CO_2 eq.	0.09	0.09	0.14	0.16	0.17	0.16	0.16	0.19	0.18	0.17	0.17
N2O	CO_2 eq.	0.19	0.18	0.33	0.36	0.36	0.33	0.34	0.42	0.39	0.39	0.38
Total	**CO_2 eq.**	**182.27**	**197.32**	**296.77**	**349.03**	**370.44**	**370.01**	**367.00**	**411.83**	**377.10**	**360.76**	**367.44**
Emissions Sub-Category												
1A1b OLD												
CO2	CO_2 eq.	181.99	197.05	296.29	348.51	369.91	369.53	366.50	411.22	376.53	360.20	366.89
CH4	CO_2 eq.	0.01	0.02	0.01	0.02	0.02	0.02	0.03	0.02	0.01	0.01	0.02
N2O	CO_2 eq.	4.04	4.01	6.76	7.59	7.74	7.32	7.45	8.90	8.38	8.19	8.12
Total	**CO_2 eq.**	**186.04**	**201.07**	**303.06**	**356.12**	**377.67**	**376.86**	**373.98**	**420.15**	**384.92**	**368.39**	**375.03**
Difference												
CO2	CO_2 eq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH4	CO_2 eq.	0.07	0.07	0.13	0.15	0.15	0.14	0.13	0.17	0.17	0.16	0.15
N2O	CO_2 eq.	-3.85	-3.83	-6.43	-7.23	-7.38	-6.99	-7.12	-8.48	-7.99	-7.80	-7.74
Total	**CO_2 eq.**	**-3.77**	**-3.75**	**-6.30**	**-7.08**	**-7.24**	**-6.85**	**-6.98**	**-8.32**	**-7.82**	**-7.63**	**-7.59**
% Change		**-2.03%**	**-1.87%**	**-2.08%**	**-1.99%**	**-1.92%**	**-1.82%**	**-1.87%**	**-1.98%**	**-2.03%**	**-2.07%**	**-2.02%**

1.A.1.c. Manufacture of Solid Fuels and Other Energy Industries

This category includes two milled peat fired peat briquetting plants operated by Bórd na Móna (BnM). Tables B.9-B.10 of Appendix B show Ireland's IEFs for solid fuels for this sector. The IEFs for CH_4 and N_2O are among the highest reported by Annex 1 Parties. The current emission factors along with the proposed changes are shown in Table 5 below.

Table C.5

	Previous Emission Factors			Revised Emission Factors			
Fuel	**CO_2 (t/TJ)**	**CH_4 (kg/TJ)**	**N_2O (kg/TJ)**	**CO_2 (t/TJ)**	**CH_4 (kg/TJ)**	**N_2O (kg/TJ)**	Reference Source
							for CH_4, N_2O
Milled Peat	PS	50	5.00	PS	2.00	1.50	2006 IPCC Guidelines Table 2.3

The impact of these emission factor changes on emission estimates for all years from 1990-2008 (on this sub-category is shown in Table C.6. Emission estimates of both CH_4 and N_2O have decreased by approximately 2.6 kt of CO_2 equivalent annually.

Table C.6

		1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
Emissions Sub-Category												
1A1c NEW	**Gg**											
CO2	CO_2 eq.	100.13	69.15	86.78	118.35	144.97	165.32	180.19	109.63	119.68	113.62	123.55
CH4	CO_2 eq.	0.03	0.02	0.03	0.04	0.05	0.06	0.05	0.04	0.03	0.04	0.05
N2O	CO_2 eq.	0.38	0.27	0.35	0.46	0.59	0.66	0.60	0.42	0.36	0.43	0.57
Total	**CO_2 eq.**	**100.54**	**69.45**	**87.16**	**118.85**	**145.61**	**166.04**	**180.84**	**110.08**	**120.07**	**114.10**	**124.18**
Emissions Sub-Category												
1A1c OLD												
CO2	CO_2 eq.	100.13	69.15	86.78	118.35	144.97	165.32	180.19	109.63	119.68	113.62	123.55
CH4	CO_2 eq.	0.85	0.61	0.78	1.05	1.32	1.50	1.35	0.95	0.81	0.98	1.29
N2O	CO_2 eq.	1.26	0.91	1.16	1.55	1.96	2.21	1.99	1.40	1.20	1.44	1.91
Total	**CO_2 eq.**	**102.24**	**70.67**	**88.72**	**120.94**	**148.25**	**169.03**	**183.53**	**111.97**	**121.69**	**116.04**	**126.76**
Difference												
CO2	CO_2 eq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH4	CO_2 eq.	-0.82	-0.59	-0.75	-1.00	-1.27	-1.44	-1.30	-0.91	-0.78	-0.94	-1.24
N2O	CO_2 eq.	-0.88	-0.63	-0.81	-1.08	-1.37	-1.55	-1.39	-0.98	-0.84	-1.01	-1.34
Total	**CO_2 eq.**	**-1.70**	**-1.22**	**-1.56**	**-2.09**	**-2.64**	**-2.98**	**-2.69**	**-1.89**	**-1.62**	**-1.94**	**-2.58**
% Change		**-1.66%**	**-1.73%**	**-1.76%**	**-1.73%**	**-1.78%**	**-1.76%**	**-1.47%**	**-1.69%**	**-1.33%**	**-1.68%**	**-2.04%**

Emissions from *1.A.2 Manufacturing Industries and Construction*

This category is the smallest contributor to Energy emissions producing 6.0 Mt of CO_2 equivalent in 2007. It comprises six sub-categories; 1.A.2.a Iron and Steel, 1.A.2.b Non-ferrous Metals, 1.A.2.c Chemicals, 1.A.2.d Pulp, Paper and Print, 1.A.2.e Food Processing, Beverages and Tobacco and 1.A.2.f Other industries. In this review all six sub-categories are looked at together, as the same emission factors are currently used in all six.

Tables C.1-C.8 of Appendix C show Ireland's implied emission factors (IEFs) for solid, liquid, gaseous and biomass fuels in this Energy category. All IEFs for N_2O except for biomass fuels are among the highest of all Annex 1 Parties. The IEFs for CH_4 liquid and solid fuels are also high whilst those for gaseous and biomass fuels are average across all Parties. The current emission factors along with the proposed changes are shown in Table C.7 below.

Table C.7

	Previous Emission Factors			Revised Emission Factors			
Fuel	**CO_2 (t/TJ)**	**CH_4 (kg/TJ)**	**N_2O (kg/TJ)**	**CO_2 (t/TJ)**	**CH_4 (kg/TJ)**	**N_2O (kg/TJ)**	Reference Source
							for CH_4, N_2O
Coal	94.60	100.00	3.00	94.60	10.00	1.50	2006 IPCC Guidelines Table 2.3
Anthracite	98.26	100.00	3.00	98.26	10.00	1.50	2006 IPCC Guidelines Table 2.3
Peat Briquettes	98.86	50.00	5.00	98.86	2.00	1.50	2006 IPCC Guidelines Table 2.3

Table C.7 contd.

	Previous Emission Factors			Revised Emission Factors			
Fuel	**CO_2 (t/TJ)**	**CH_4 (kg/TJ)**	**N_2O (kg/TJ)**	**CO_2 (t/TJ)**	**CH_4 (kg/TJ)**	**N_2O (kg/TJ)**	Reference Source
Kerosene	71.40	5.00	10.00	71.40	3.00	0.60	2006 IPCC Guidelines Table 2.3
Residual Fuel Oil (HFO)	76.00	NE	10.00	76.00	3.00	0.60	2006 IPCC Guidelines Table 2.3
LPG	63.70	2.00	3.00	63.70	1.00	0.10	2006 IPCC Guidelines Table 2.3
Gasoil	73.30	5.00	10.00	73.30	3.00	0.60	2006 IPCC Guidelines Table 2.3
Petroleum Coke	100.80	50.00	12.00	CS[2]	3.00	0.60	2006 IPCC Guidelines Table 2.3
Natural Gas	56.87	2.00	3.00	56.87	1.00	0.10	2006 IPCC Guidelines Table 2.3
Biomass (wood)	110.00	30.00	4.00	110.00	30.00	4.00	2006 IPCC Guidelines Table 2.3
Biogas	84.20	NE	NE	54.60	1.00	0.10	2006 IPCC Guidelines Table 2.3

CS[2] : Country Specific

The 2006 IPCC Guidelines has revised the default emission factor for Petroleum Coke from 100.8 t CO_2/TJ to 97.5 t CO_2/TJ. It is proposed to use this or a similar country specific emission factor based on data submitted in the Emissions Trading Scheme. The ETS installations account for over 80 percent of all petroleum coke combusted in Ireland annually (2008 Energy Balance, SEI) and the reported country specific emission factor ranges from 95.13 t CO_2/TJ in 2005 to 92.93 t CO_2/TJ in 2008. This emission factor range is considerably lower than the IPCC Revised 1996 Guidelines value of 100.8 t CO_2/TJ that is currently used in the inventory.

The impact of these emission factor changes on emission estimates for all years from 1990-2008 on this Energy sector is shown in Table C.8.

Table C.8

		1990	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Emissions Sub-Category												
1A2 NEW	**Gg**											
CO2	CO_2 eq.	3940.06	4300.79	5564.42	5508.27	5230.92	5238.16	5621.59	5713.95	5597.90	5845.47	5522.96
CH4	CO_2 eq.	5.60	5.03	7.04	7.41	7.16	7.07	7.88	9.00	8.59	8.45	7.80
N2O	CO_2 eq.	12.95	12.24	16.72	17.42	16.73	16.58	18.14	20.43	19.16	18.93	17.48
Total	**CO_2 eq.**	**3958.61**	**4318.06**	**5588.18**	**5533.10**	**5254.81**	**5261.81**	**5647.60**	**5743.38**	**5625.66**	**5872.85**	**5548.25**
Emissions Sub-Category												
1A2 OLD												
CO2	CO_2 eq.	3954.11	4323.59	5612.32	5572.75	5289.64	5301.02	5686.29	5767.69	5663.83	5928.58	5595.07
CH4	CO_2 eq.	24.51	13.46	22.15	26.37	24.89	26.11	28.70	31.70	28.28	30.74	27.24
N2O	CO_2 eq.	112.35	144.09	182.08	179.48	169.62	169.39	176.19	180.13	169.91	175.52	165.10
Total	**CO_2 eq.**	**4090.98**	**4481.14**	**5816.54**	**5778.59**	**5484.15**	**5496.52**	**5891.19**	**5979.52**	**5862.03**	**6134.84**	**5787.40**
Difference												
CO2	CO_2 eq.	-14.05	-22.80	-47.90	-64.48	-58.72	-62.86	-64.71	-53.74	-65.93	-83.11	-72.10
CH4	CO_2 eq.	-18.92	-8.42	-15.11	-18.96	-17.73	-19.03	-20.83	-22.70	-19.69	-22.29	-19.44
N2O	CO_2 eq.	-99.40	-131.86	-165.35	-162.06	-152.88	-152.81	-158.06	-159.70	-150.75	-156.58	-147.61
Total	**CO_2 eq.**	**-132.37**	**-163.08**	**-228.36**	**-245.49**	**-229.33**	**-234.71**	**-243.59**	**-236.14**	**-236.37**	**-261.99**	**-239.15**
% Change		**-3.24%**	**-3.64%**	**-3.93%**	**-4.25%**	**-4.18%**	**-4.27%**	**-4.13%**	**-3.95%**	**-4.03%**	**-4.27%**	**-4.13%**

Overall emissions from the sector will decrease by just over 4.1 percent or approximately 240 kt of CO_2 equivalent in 2008 primarily due to the decrease in N_2O emission factors for liquid fuels and the CO_2 emission factor for petroleum coke.

Emissions from *1.A.3 Transport*

This category is the second largest contributor to Energy emissions producing 14.4 Mt of CO_2 equivalent in 2007. It comprises five sub-categories; 1.A.3.a Civil Aviation, 1.A.3.b Road Transportation, 1.A.3.c Railways, 1.A.3.d Navigation and 1.A.3.e Other Transportation. This review will focus on the following sub-categories that use default methods and emission factors, railways and navigation.

1.A.3.c. Railways

Tables D.1-D.2 of Appendix D show Ireland's implied emission factors (IEFs) for liquid fuels in this Transport sub-category. The IEF for N_2O is the second highest of all Annex 1 Parties while the IEF for CH_4 liquid fuels is higher than the average. The current emission factors along with the proposed changes are shown in Table C.9 below.

Table C.9

	Previous Emission Factors			Revised Emission Factors			
Fuel	**CO_2 (t/TJ)**	**CH_4 (kg/TJ)**	**N_2O (kg/TJ)**	**CO_2 (t/TJ)**	**CH_4 (kg/TJ)**	**N_2O (kg/TJ)**	Reference Source
							for CH_4, N_2O
Gasoil	73.30	5.00	30.00	73.30	4.15	28.60	2006 IPCC Guidelines Table 3.4.1

The impact of these minor emission factor changes on emission estimates for all years from 1990-2008 on this transport sub-category is shown in Table C.10. Combined emissions of CH_4 and N_2O have decreased by 0.6 percent each year or by approximately 0.9 kt of CO_2 equivalent.

Table C.10

		1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
Emissions Sub-Category												
1A3c NEW	**Gg**											
CO2	CO_2 eq.	133.19	111.40	123.16	134.42	117.54	129.82	136.87	122.10	122.10	132.04	139.94
CH4	CO_2 eq.	0.16	0.13	0.15	0.16	0.14	0.15	0.16	0.15	0.15	0.16	0.17
N2O	CO_2 eq.	16.11	13.47	14.90	16.26	14.22	15.70	16.56	14.77	14.77	15.97	16.93
Total	**CO_2 eq.**	**149.46**	**125.01**	**138.20**	**150.84**	**131.90**	**145.67**	**153.59**	**137.01**	**137.01**	**148.17**	**157.03**
Emissions Sub-Category												
1A3c OLD												
CO2	CO_2 eq.	133.19	111.40	123.16	134.42	117.54	129.82	136.87	122.10	122.10	132.04	139.94
CH4	CO_2 eq.	0.19	0.16	0.18	0.19	0.17	0.19	0.20	0.17	0.17	0.19	0.20
N2O	CO_2 eq.	16.90	14.13	15.63	17.05	14.91	16.47	17.37	15.49	15.49	16.75	17.75
Total	**CO_2 eq.**	**150.28**	**125.70**	**138.96**	**151.67**	**132.62**	**146.47**	**154.44**	**137.76**	**137.76**	**148.98**	**157.89**
Difference												
CO2	CO_2 eq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH4	CO_2 eq.	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03
N2O	CO_2 eq.	-0.79	-0.66	-0.73	-0.80	-0.70	-0.77	-0.81	-0.72	-0.72	-0.78	-0.83
Total	**CO_2 eq.**	**-0.82**	**-0.69**	**-0.76**	**-0.83**	**-0.72**	**-0.80**	**-0.84**	**-0.75**	**-0.75**	**-0.81**	**-0.86**
% Change		**-0.55%**	**-0.55%**	**-0.55%**	**-0.55%**	**-0.55%**	**-0.55%**	**-0.55%**	**-0.55%**	**-0.55%**	**-0.55%**	**-0.55%**

1.A.3.d. Navigation

Tables D.3-D.6 of Appendix D show Ireland's implied emission factors (IEFs) for liquid fuels in this Transport sub-category. The IEF for N_2O for diesel and residual fuel oil are the highest of all Annex 1 Parties while the IEF for CH_4 for liquid fuels are close to the average. The current emission factors along with the proposed changes are shown in Table C.11 below.

Table C.11

	Previous Emission Factors			Revised Emission Factors			
Fuel	**CO_2 (t/TJ)**	**CH_4 (kg/TJ)**	**N_2O (kg/TJ)**	**CO_2 (t/TJ)**	**CH_4 (kg/TJ)**	**N_2O (kg/TJ)**	Reference Source for CH_4, N_2O
Gasoil	73.30	5.00	30.00	73.30	7.00	2.00	2006 IPCC Guidelines Table 3.5.3
Residual Fuel Oil (HFO)	76.00	5.00	30.00	76.00	7.00	2.00	2006 IPCC Guidelines Table 3.5.3

The impact of these emission factor changes on emission estimates for all years from 1990-2008 on this transport sub-category is shown in Table C.12. Combined emissions of CH_4 and N_2O have decreased by over 10 percent each year or by approximately 0.5 kt of CO_2 equivalent in 2008. The actual impact in latter years is much less since residual fuel oil is no longer allocated to this transport sub-category in the national energy balance.

Table C.12

		1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
Emissions Sub-Category												
1A3d NEW	**Gg**											
CO2	CO_2 eq.	84.16	99.64	133.59	124.06	60.30	57.17	59.57	60.08	3.86	4.05	4.25
CH4	CO_2 eq.	0.16	0.19	0.26	0.24	0.12	0.11	0.12	0.12	0.01	0.01	0.01
N2O	CO_2 eq.	0.69	0.82	1.11	1.03	0.49	0.47	0.49	0.49	0.03	0.03	0.04
Total	**CO_2 eq.**	**85.02**	**100.65**	**134.96**	**125.33**	**60.91**	**57.75**	**60.17**	**60.68**	**3.90**	**4.10**	**4.29**
Emissions Sub-Category												
1A3d OLD												
CO2	CO_2 eq.	84.16	99.64	133.59	124.06	60.30	57.17	59.57	60.08	3.86	4.05	4.25
CH4	CO_2 eq.	0.12	0.14	0.19	0.17	0.08	0.08	0.08	0.08	0.01	0.01	0.01
N2O	CO_2 eq.	10.40	12.33	16.60	15.46	7.40	7.01	7.30	7.37	0.49	0.51	0.54
Total	**CO_2 eq.**	**94.67**	**112.11**	**150.37**	**139.69**	**67.78**	**64.27**	**66.96**	**67.53**	**4.35**	**4.57**	**4.79**
Difference												
CO2	CO_2 eq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH4	CO_2 eq.	0.05	0.06	0.07	0.07	0.03	0.03	0.03	0.03	0.00	0.00	0.00
N2O	CO_2 eq.	-9.70	-11.51	-15.49	-14.43	-6.90	-6.55	-6.82	-6.88	-0.46	-0.48	-0.50
Total	**CO_2 eq.**	**-9.66**	**-11.45**	**-15.41**	**-14.36**	**-6.87**	**-6.51**	**-6.78**	**-6.84**	**-0.45**	**-0.48**	**-0.50**
% Change		**-10.20%**	**-10.22%**	**-10.25%**	**-10.28%**	**-10.14%**	**-10.14%**	**-10.13%**	**-10.13%**	**-10.44%**	**-10.44%**	**-10.44%**

Emissions from *1.A.4 Other Sectors*

This category is the third largest contributor to Energy emissions producing 10.6 Mt of CO_2 equivalent in 2007. It comprises of three sub-categories; 1.A.4.a Commercial/Institutional, 1.A.4.b Residential, 1.A.4.c Agriculture/Forestry/Fisheries.

1.A.4.a. Commercial/Institutional

Tables E.1-E.8 of Appendix E show Ireland's implied emission factors (IEFs) for solid, liquid, gaseous and biomass fuels in this sub-category. Ireland has the highest reported IEFs for N_2O for liquid and solid fuels of any Annex 1 Party while the IEF for N_2O for gaseous fuels is also one of the highest reported. The IEF for CH_4 from solid fuels is one of the highest reported by Annex 1 Parties, whilst the IEF for CH_4 from biomass fuels is one of the lowest reported. The remaining IEFs for CH_4 from liquid and gaseous fuels are broadly in line with those reported by other Parties and will be revised according to the proposed changes outlined in Table C.13.

Table C.13

	Previous Emission Factors			Revised Emission Factors			
Fuel	**CO_2 (t/TJ)**	**CH_4 (kg/TJ)**	**N_2O (kg/TJ)**	**CO_2 (t/TJ)**	**CH_4 (kg/TJ)**	**N_2O (kg/TJ)**	Reference Source for CH_4, N_2O
Coal	94.60	100.00	12.00	94.60	10.00	1.50	2006 IPCC Guidelines Table 2.4
Anthracite	98.26	100.00	12.00	98.26	10.00	1.50	2006 IPCC Guidelines Table 2.4
Lignite	101.20	50.00	12.00	101.20	10.00	1.50	2006 IPCC Guidelines Table 2.4
Sod Peat	104.00	50.00	5.00	104.00	10.00	1.40	2006 IPCC Guidelines Table 2.4
Peat Briquettes	98.86	50.00	5.00	98.86	10.00	1.40	2006 IPCC Guidelines Table 2.4
Residual Fuel Oil (HFO)	76.00	NE	10.00	76.00	10.00	0.60	2006 IPCC Guidelines Table 2.4
LPG	63.70	NE	2.00	63.70	5.00	0.10	2006 IPCC Guidelines Table 2.4
Gasoil	73.30	5.00	10.00	73.30	10.00	0.60	2006 IPCC Guidelines Table 2.4
Petroleum Coke	100.80	50.00	12.00	CS	10.00	0.60	2006 IPCC Guidelines Table 2.4
Natural Gas	56.87	5.00	2.00	56.87	5.00	0.10	2006 IPCC Guidelines Table 2.4
Biomass (wood)	110.00	30.00	4.00	110.00	300.00	4.00	2006 IPCC Guidelines Table 2.4
Biogas	84.20	NE	NE	54.60	5.00	0.10	2006 IPCC Guidelines Table 2.4

The impact of these emission factor changes on emission estimates for all years from 1990-2008 on this Other Sector sub-category is shown in Table C.14. Emissions of CH_4 have increased by 2.8 kt of CO_2 equivalent and N_2O have decreased by approximately 80 kt CO_2 equivalent in 2008.

Table C.14

		1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
Emissions Sub-Category 1A4a NEW	**Gg**											
CO2	CO_2 eq.	2338.27	2277.11	2543.83	2621.91	2565.53	2720.02	2591.56	2754.52	2653.37	2670.94	2759.93
CH4	CO_2 eq.	6.30	6.05	6.50	6.66	6.56	6.91	6.58	7.05	7.10	8.04	9.48
N2O	CO_2 eq.	5.64	4.91	4.98	5.07	5.03	5.58	5.30	5.63	5.49	5.48	5.76
Total	**CO_2 eq.**	**2350.21**	**2288.07**	**2555.32**	**2633.64**	**2577.13**	**2732.51**	**2603.44**	**2767.20**	**2665.96**	**2684.46**	**2775.17**
Emissions Sub-Category 1A4a OLD												
CO2	CO_2 eq.	2338.27	2277.11	2543.83	2621.91	2565.53	2722.56	2591.56	2754.52	2653.37	2670.94	2759.93
CH4	CO_2 eq.	4.01	3.32	3.97	4.12	3.98	6.60	6.04	6.31	6.19	6.35	6.64
N2O	CO_2 eq.	86.80	81.41	83.49	84.97	84.52	89.98	85.23	90.64	87.20	84.20	85.22
Total	**CO_2 eq.**	**2429.08**	**2361.84**	**2631.30**	**2711.00**	**2654.04**	**2819.13**	**2682.83**	**2851.47**	**2746.76**	**2761.49**	**2851.79**
Difference												
CO2	CO_2 eq.	0.00	0.00	0.00	0.00	0.00	-2.53	0.00	0.00	0.00	0.00	0.00
CH4	CO_2 eq.	2.29	2.73	2.53	2.54	2.58	0.31	0.54	0.73	0.91	1.69	2.84
N2O	CO_2 eq.	-81.16	-76.50	-78.51	-79.89	-79.49	-84.39	-79.93	-85.00	-81.71	-78.72	-79.45
Total	**CO_2 eq.**	**-78.87**	**-73.77**	**-75.98**	**-77.36**	**-76.90**	**-86.62**	**-79.39**	**-84.27**	**-80.80**	**-77.03**	**-76.61**
% Change		**-3.25%**	**-3.12%**	**-2.89%**	**-2.85%**	**-2.90%**	**-3.07%**	**-2.96%**	**-2.96%**	**-2.94%**	**-2.79%**	**-2.69%**

1.A.4.b. Residential

Tables F.1-F.8 of Appendix F show Ireland's implied emission factors (IEFs) for solid, liquid, gaseous and biomass fuels in this sub-category. The IEFs for N_2O for liquid, solid and gaseous fuels are some of the highest reported of any Annex 1 Party. The IEFs for CH_4 from solid and biomass fuels are some of the lowest reported. The current emission factors along with the proposed changes are shown in Table C.15 below.

Table C.15

	Previous Emission Factors			Revised Emission Factors			
Fuel	**CO_2 (t/TJ)**	**CH_4 (kg/TJ)**	**N_2O (kg/TJ)**	**CO_2 (t/TJ)**	**CH_4 (kg/TJ)**	**N_2O (kg/TJ)**	Reference Source for CH_4, N_2O
Coal	94.60	100.00	12.00	94.60	300.00	1.50	2006 IPCC Guidelines Table 2.5
Anthracite	98.26	100.00	12.00	98.26	300.00	1.50	2006 IPCC Guidelines Table 2.5
Lignite	101.20	50.00	12.00	101.20	300.00	1.50	2006 IPCC Guidelines Table 2.5
Sod Peat	104.00	50.00	5.00	104.00	300.00	1.40	2006 IPCC Guidelines Table 2.5
Peat Briquettes	98.86	50.00	5.00	98.86	300.00	1.40	2006 IPCC Guidelines Table 2.5
Kerosene	71.40	5.00	10.00	76.00	10.00	0.60	2006 IPCC Guidelines Table 2.5
LPG	63.70	NE	2.00	63.70	5.00	0.10	2006 IPCC Guidelines Table 2.5
Gasoil	73.30	5.00	10.00	73.30	10.00	0.60	2006 IPCC Guidelines Table 2.5
Petroleum Coke	100.80	50.00	12.00	CS	10.00	0.60	2006 IPCC Guidelines Table 2.5
Natural Gas	56.87	5.00	2.00	56.87	5.00	0.10	2006 IPCC Guidelines Table 2.5
Biomass (wood)	110.00	30.00	4.00	110.00	300.00	4.00	2006 IPCC Guidelines Table 2.5

The impact of these emission factor changes on emission estimates for all years from 1990-2008 on this Other Sector sub-category is shown in Tables C.16a and C.16b. Total emissions from this sub-category increased from 1990 to 1996 mainly due to the increase in CH_4 emissions from solid fuel use. From 1997 to 2008 total emissions show a decrease as the CH_4 increases are offset by reductions in N_2O and to a lesser extent CO_2 from petroleum coke combustion. This is primarily due to fuel switching in this sector from solid to liquid or gaseous fuels from the late 1990s onwards. Overall emissions have increased by over 100 kt of CO_2 equivalent in 1990 and have decreased by a similar amount in 2008.

Table C.16a

		1990	1991	1992	1993	1994	1995	1996	1997	1998
Emissions Sub-Category 1A4b NEW	**Gg**									
CO2	CO_2 eq.	7054.17	7113.30	6336.72	6300.67	6176.56	6165.01	6292.36	5980.66	6489.71
CH4	CO_2 eq.	371.71	363.04	308.30	300.06	264.33	239.13	238.72	208.92	221.58
N2O	CO_2 eq.	30.41	29.99	25.60	25.20	23.40	22.32	22.57	20.71	22.17
Total	**CO_2 eq.**	**7456.30**	**7506.32**	**6670.62**	**6625.93**	**6464.29**	**6426.46**	**6553.65**	**6210.29**	**6733.46**
Emissions Sub-Category 1A4b OLD										
CO2	CO_2 eq.	7059.93	7122.05	6343.17	6306.43	6185.08	6174.91	6300.42	5994.71	6501.68
CH4	CO_2 eq.	89.97	91.81	73.10	71.97	60.81	53.12	58.56	50.64	54.49
N2O	CO_2 eq.	193.77	203.24	168.27	168.77	163.83	164.41	179.43	171.29	187.59
Total	**CO_2 eq.**	**7343.66**	**7417.10**	**6584.54**	**6547.17**	**6409.73**	**6392.44**	**6538.41**	**6216.63**	**6743.76**
Difference										
CO2	CO_2 eq.	-5.76	-8.75	-6.45	-5.76	-8.52	-9.90	-8.06	-14.05	-11.97
CH4	CO_2 eq.	281.75	271.23	235.19	228.09	203.51	186.02	180.17	158.28	167.09
N2O	CO_2 eq.	-163.36	-173.25	-142.67	-143.57	-140.43	-142.09	-156.86	-150.58	-165.41
Total	**CO_2 eq.**	**112.63**	**89.23**	**86.08**	**78.76**	**54.56**	**34.03**	**15.25**	**-6.35**	**-10.30**
% Change		**1.53%**	**1.20%**	**1.31%**	**1.20%**	**0.85%**	**0.53%**	**0.23%**	**-0.10%**	**-0.15%**

Table C.16b

		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Emissions Sub-Category 1A4b NEW	**Gg**										
CO2	CO_2 eq.	6194.89	6287.52	6575.98	6505.58	6642.28	6851.06	7108.37	7022.83	6799.24	7392.67
CH4	CO_2 eq.	169.07	168.60	160.63	158.16	149.75	147.27	153.65	149.40	144.56	153.44
N2O	CO_2 eq.	19.30	19.24	19.37	19.19	18.95	19.10	19.91	19.48	19.18	20.59
Total	**CO_2 eq.**	**6383.26**	**6475.35**	**6755.98**	**6682.93**	**6810.98**	**7017.43**	**7281.93**	**7191.70**	**6962.99**	**7566.70**
Emissions Sub-Category 1A4b OLD											
CO2	CO_2 eq.	6206.64	6300.64	6594.40	6519.40	6655.17	6859.35	7116.12	7030.56	6808.31	7400.37
CH4	CO_2 eq.	44.06	45.42	44.12	42.35	40.93	40.09	41.74	40.43	38.90	41.43
N2O	CO_2 eq.	188.70	190.62	200.53	198.62	202.48	207.45	216.16	210.30	205.36	223.19
Total	**CO_2 eq.**	**6439.39**	**6536.69**	**6839.05**	**6760.37**	**6898.59**	**7106.89**	**7374.01**	**7281.28**	**7052.58**	**7664.99**
Difference											
CO2	CO_2 eq.	-11.74	-13.13	-18.42	-13.82	-12.90	-8.29	-7.75	-7.73	-9.07	-7.70
CH4	CO_2 eq.	125.01	123.18	116.51	115.80	108.82	107.17	111.92	108.97	105.66	112.01
N2O	CO_2 eq.	-169.40	-171.38	-181.16	-179.43	-183.54	-188.35	-196.25	-190.82	-186.18	-202.60
Total	**CO_2 eq.**	**-56.13**	**-61.33**	**-83.07**	**-77.44**	**-87.61**	**-89.46**	**-92.08**	**-89.58**	**-89.59**	**-98.29**
% Change		**-0.87%**	**-0.94%**	**-1.21%**	**-1.15%**	**-1.27%**	**-1.26%**	**-1.25%**	**-1.23%**	**-1.27%**	**-1.28%**

1.A.4.c. Agriculture/Forestry/Fisheries

This sub-category accounts for emissions from combustion of gasoil and biomass within mainly the Agricultural sector. Previous estimates of emissions of CH_4 and N_2O used default emission factors for stationary combustion. This review proposes to split the amount of gasoil fuel used in this sector to 90 percent mobile (agricultural machinery) and 10 percent stationary (space heating). This will bring the GHG inventory in line with other air pollution inventories for Ireland. The current emission factors along with the proposed changes are shown in Table C.17 below.

Table C.17

	Previous Emission Factors			Revised Emission Factors			
Fuel	**CO_2 (t/TJ)**	**CH_4 (kg/TJ)**	**N_2O (kg/TJ)**	**CO_2 (t/TJ)**	**CH_4 (kg/TJ)**	**N_2O (kg/TJ)**	Reference Source for CH_4, N_2O
Gasoil (Stationary)	73.30	5.00	10.00	73.30	10.00	0.60	2006 IPCC Guidelines Table 2.5
Gasoil (Mobile)	73.30	5.00	10.00	73.30	4.15	28.60	2006 IPCC Guidelines Table 3.3.1
Biomass (wood)	110.00	30.00	4.00	110.00	300.00	4.00	2006 IPCC Guidelines Table 2.5

The impact of these emission factor changes on emission estimates for all years from 1990-2008 on this Other Sector sub-category is shown in Tables C.18. Minor reductions in CH_4 emissions are offset by increases in N_2O emissions of approximately 50 kt of CO_2 equivalent annually.

Table C.18

		1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
Emissions Sub-Category												
1A4c NEW	**Gg**											
CO2	CO_2 eq.	660.30	911.08	822.19	831.72	834.89	838.07	803.15	861.84	825.46	774.74	771.19
CH4	CO_2 eq.	0.90	1.24	1.12	1.13	1.13	1.14	1.09	1.17	1.12	1.09	1.09
N2O	CO_2 eq.	72.05	99.41	89.71	90.75	91.10	91.44	87.63	94.04	90.07	84.54	84.16
Total	**CO_2 eq.**	**733.24**	**1011.73**	**913.02**	**923.60**	**927.12**	**930.65**	**891.87**	**957.04**	**916.65**	**860.37**	**856.43**
Emissions Sub-Category												
1A4c OLD												
CO2	CO_2 eq.	660.30	911.08	822.19	831.72	834.89	838.07	803.15	861.84	825.46	774.74	771.19
CH4	CO_2 eq.	0.95	1.31	1.18	1.19	1.20	1.20	1.15	1.23	1.18	1.15	1.15
N2O	CO_2 eq.	27.93	38.53	34.77	35.17	35.31	35.44	33.97	36.45	34.91	32.77	32.62
Total	**CO_2 eq.**	**689.17**	**950.92**	**858.14**	**868.08**	**871.40**	**874.71**	**838.26**	**899.52**	**861.55**	**808.66**	**804.96**
Difference												
CO2	CO_2 eq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH4	CO_2 eq.	-0.05	-0.07	-0.06	-0.06	-0.06	-0.06	-0.06	-0.07	-0.06	-0.06	-0.06
N2O	CO_2 eq.	44.12	60.88	54.94	55.58	55.79	56.00	53.67	57.59	55.16	51.77	51.53
Total	**CO_2 eq.**	**44.07**	**60.81**	**54.88**	**55.51**	**55.73**	**55.94**	**53.61**	**57.52**	**55.10**	**51.71**	**51.47**
% Change		**6.39%**	**6.39%**	**6.39%**	**6.39%**	**6.39%**	**6.39%**	**6.39%**	**6.39%**	**6.39%**	**6.39%**	**6.39%**

Conclusion

The overall impact of this review and revision of greenhouse gas emission factors on total emissions of all years from 1990-2008 from combustion in the Energy sector can be seen in Tables C.19 and C.20. Emission estimates for all years show decreases ranging from 400 kt of CO_2 equivalent in 1990 to almost 700 kt in 2008, giving percentage decreases of 1.3 and 1.5 percent, respectively.

The revised CO_2, CH_4 and N_2O emission factors adopted in the 2010 submission bring Ireland into line with other Annex 1 Parties in reporting for these gases. This comprehensive revision provides for more robust estimates of emissions from this sector and eliminates potential under estimation and non-estimation of emissions in the 2008 inventory.

Table C.19

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Emissions Sub-Category 1A NEW	**Gg**																			
1.A.1 Energy Industries	CO_2 eq.	11238.54	11699.00	12363.63	12378.59	12716.77	13401.40	14120.58	14782.31	15167.24	15822.28	16140.48	17364.19	16453.29	15761.31	15383.33	15771.30	15027.01	14533.81	14640.70
1.A.2 Manufacturing Indusrties and Construction	CO_2 eq.	3958.61	4059.53	3752.46	3965.61	4216.66	4318.06	4151.43	4529.84	4549.76	4760.65	5588.18	5533.10	5254.81	5261.81	5647.60	5743.38	5625.66	5872.85	5548.23
1.A.3 Transport	CO_2 eq.	5160.32	5366.33	5817.25	5790.22	6037.13	6272.02	7332.73	7690.71	9068.62	10028.18	10766.26	11279.71	11471.12	11644.17	12272.39	13031.89	13719.23	14376.11	14254.98
1.A.4 Other Sectors	CO_2 eq.	10539.74	10660.76	9785.97	9756.59	9893.27	9726.26	9750.23	9453.18	9938.37	9768.94	9943.70	10313.22	10187.18	10474.14	10512.74	11006.18	10774.32	10507.82	11198.31
Total	**CO_2 eq.**	**30897.22**	**31785.63**	**31719.32**	**31891.01**	**32863.83**	**33717.74**	**35354.98**	**36456.04**	**38723.99**	**40380.05**	**42438.62**	**44490.22**	**43366.41**	**43141.43**	**43816.06**	**45552.75**	**45146.21**	**45290.59**	**45642.22**
Emissions Sub-Category 1A OLD																				
1.A.1 Energy Industries	CO_2 eq.	11576.40	12072.50	12769.06	12776.66	13137.67	13835.56	14559.97	15247.30	15685.84	16359.98	16648.12	17926.82	16945.58	16170.87	15813.75	16219.72	15427.79	14858.78	14947.99
1.A.2 Manufacturing Indusrties and Construction	CO_2 eq.	4090.98	4202.41	3884.47	4100.60	4374.44	4481.14	4291.26	4704.69	4720.05	4941.72	5816.54	5778.59	5484.15	5496.52	5891.19	5979.52	5862.03	6134.84	5786.36
1.A.3 Transport	CO_2 eq.	5170.80	5376.79	5828.34	5801.74	6050.03	6284.16	7345.35	7704.02	9082.67	10044.01	10782.44	11294.89	11478.72	11651.48	12280.02	13039.48	13720.43	14377.40	14256.34
1.A.4 Other Sectors	CO_2 eq.	10461.91	10605.18	9731.28	9707.95	9869.07	9705.20	9761.52	9484.77	9971.93	9849.40	10026.13	10418.14	10285.81	10592.43	10627.99	11125.01	10889.60	10622.72	11321.73
Total	**CO_2 eq.**	**31300.08**	**32256.88**	**32213.15**	**32386.95**	**33431.21**	**34306.05**	**35958.11**	**37140.78**	**39460.48**	**41195.11**	**43273.23**	**45418.44**	**44194.25**	**43911.30**	**44612.95**	**46363.73**	**45899.85**	**45993.74**	**46312.43**
Difference																				
1.A.1 Energy Industries	CO_2 eq.	-337.85	-373.50	-405.42	-398.07	-420.90	-434.16	-439.39	-464.99	-518.60	-537.70	-507.64	-562.63	-492.29	-409.56	-430.42	-448.41	-400.78	-324.97	-307.29
1.A.2 Manufacturing Indusrties and Construction	CO_2 eq.	-132.37	-142.88	-132.01	-134.99	-157.77	-163.08	-139.83	-174.85	-170.28	-181.07	-228.36	-245.49	-229.33	-234.71	-243.59	-236.14	-236.37	-261.99	-238.13
1.A.3 Transport	CO_2 eq.	-10.48	-10.46	-11.09	-11.52	-12.90	-12.14	-12.62	-13.31	-14.06	-15.83	-16.17	-15.19	-7.59	-7.31	-7.63	-7.60	-1.21	-1.29	-1.36
1.A.4 Other Sectors	CO_2 eq.	77.83	55.58	54.70	48.64	24.19	21.06	-11.29	-31.59	-33.55	-80.46	-82.43	-104.92	-98.62	-118.29	-115.25	-118.83	-115.28	-114.90	-123.43
Total	**CO_2 eq.**	**-402.86**	**-471.25**	**-493.82**	**-495.95**	**-567.38**	**-588.31**	**-603.13**	**-684.74**	**-736.49**	**-815.07**	**-834.61**	**-928.22**	**-827.84**	**-769.88**	**-796.88**	**-810.98**	**-753.64**	**-703.15**	**-670.21**
% Change		**-1.29%**	**-1.46%**	**-1.53%**	**-1.53%**	**-1.70%**	**-1.71%**	**-1.68%**	**-1.84%**	**-1.87%**	**-1.98%**	**-1.93%**	**-2.04%**	**-1.87%**	**-1.75%**	**-1.79%**	**-1.75%**	**-1.64%**	**-1.53%**	**-1.45%**

Table C.20

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Emissions Sub-Category 1A NEW	Gg																			
CO2	CO_2 eq.	30190.80	31080.22	31065.44	31235.60	32220.34	33078.01	34706.49	35814.76	38037.43	39738.40	41781.01	43821.62	42697.91	42478.50	43178.69	44888.13	44489.90	44640.80	45003.97
CH4	CO_2 eq.	437.76	430.80	379.01	366.52	329.40	307.89	310.32	279.22	293.47	240.55	237.45	228.32	220.53	209.15	203.67	209.94	203.19	197.58	206.02
N2O	CO_2 eq.	268.66	274.61	274.87	288.89	314.09	331.85	338.17	362.06	393.10	401.09	420.17	440.28	447.98	453.78	433.70	454.68	453.13	452.20	432.23
Total	**CO_2 eq.**	**30897.22**	**31785.63**	**31719.32**	**31891.01**	**32863.83**	**33717.74**	**35354.98**	**36456.04**	**38723.99**	**40380.05**	**42438.62**	**44490.22**	**43366.41**	**43141.43**	**43816.06**	**45552.75**	**45146.21**	**45290.59**	**45642.22**
Emissions Sub-Category 1A OLD																				
CO2	CO_2 eq.	30210.60	31109.69	31087.09	31255.18	32249.35	33110.70	34725.14	35857.36	38074.50	39777.32	41842.03	43904.51	42770.44	42556.79	43251.69	44949.61	44563.55	44732.98	45082.78
CH4	CO_2 eq.	167.98	172.34	146.51	142.54	123.82	121.66	131.62	121.88	126.34	113.68	118.48	119.68	112.15	112.07	110.73	113.30	106.60	106.29	104.68
N2O	CO_2 eq.	921.50	974.85	979.55	989.23	1058.04	1073.69	1101.35	1161.54	1259.64	1304.12	1312.72	1394.25	1311.66	1242.44	1250.53	1300.82	1229.70	1154.47	1124.97
Total	**CO_2 eq.**	**31300.08**	**32256.88**	**32213.15**	**32386.95**	**33431.21**	**34306.05**	**35958.11**	**37140.78**	**39460.48**	**41195.11**	**43273.23**	**45418.44**	**44194.25**	**43911.30**	**44612.95**	**46363.73**	**45899.85**	**45993.74**	**46312.43**
Difference																				
CO2	CO_2 eq.	-19.80	-29.47	-21.65	-19.57	-29.01	-32.70	-18.65	-42.60	-37.07	-38.92	-61.02	-82.90	-72.53	-78.29	-73.00	-61.48	-73.66	-92.18	-78.82
CH4	CO_2 eq.	269.78	258.46	232.51	223.97	205.59	186.23	178.70	157.34	167.12	126.87	118.96	108.64	108.38	97.08	92.94	96.64	96.59	91.30	101.34
N2O	CO_2 eq.	-652.84	-700.24	-704.69	-700.35	-743.96	-741.84	-763.18	-799.48	-866.54	-903.02	-892.55	-953.96	-863.68	-788.66	-816.83	-846.14	-776.57	-702.27	-692.74
Total	**CO_2 eq.**	**-402.86**	**-471.25**	**-493.82**	**-495.95**	**-567.38**	**-588.31**	**-603.13**	**-684.74**	**-736.49**	**-815.07**	**-834.61**	**-928.22**	**-827.84**	**-769.88**	**-796.88**	**-810.98**	**-753.64**	**-703.15**	**-670.21**
% Change		-1.29%	-1.46%	-1.53%	-1.53%	-1.70%	-1.71%	-1.68%	-1.84%	-1.87%	-1.98%	-1.93%	-2.04%	-1.87%	-1.75%	-1.79%	-1.75%	-1.64%	-1.53%	-1.45%

Appendix A. Energy sector review process

Comments from UNFCCC annual review reports

UNFCCC REPORT OF THE INDIVIDUAL REVIEW OF THE GREENHOUSE GAS INVENTORY OF IRELAND SUBMITTED IN THE YEAR 2001

Energy

24. The 1999 emissions estimates presented for the energy sector are on the whole complete and appear to be of good quality. The ERT recommends that in its next submission Ireland provide estimates for the entire time series. The ERT also notes that some of the emission factors used for N_2O and CH_4 appear anomalous and should be explained.

3. Emission factors

38. IEFs (implied emission factors) for CO_2 for the various fuels in the various sectors appear to be consistent and were close to, though not always identical with, IPCC default values. CORINAIR emission factors were used for CH_4 and N_2O in all sectors. However, IEFs for these gases revealed a number of apparent anomalies, as follows:

(a) IEFs for CH_4 were zero in the following subsectors: electricity generation (1.A.1.a) - all fuels - and 1.A.1.b (gaseous fuels). In the latter case, Ireland indicated in its response to the draft S&A report that this was in fact refinery gas;

(b) IEFs for both CH_4 and N_2O from biomass were zero in all subsectors of other sectors (1.A.4). This would not seem to conform to physical reality;

(c) For all other fuels in all other sectors, IEFs for CH_4 were somewhat lower than IPCC tier 1 default values, but this may be consistent with a widespread use of emission control equipment, and is presumably consistent with CORINAIR;

(d) On the other hand, for all other fuels in all other sectors, IEFs for N_2O were significantly higher than IPCC tier 1 default values (on average, by a factor greater than 10). If the CORINAIR values have been used correctly, this implies a major inconsistency between CORINAIR and the IPCC. If, for the sake of illustration, emission factors for N_2O in the energy sector were lower by a factor of 10, emissions from the energy sector as a whole would be lower by 1,364 Gg, equivalent to 3.3% of total energy sector emissions.

39. In its response to the draft desk review report Ireland noted that it will investigate the IEFs.

59. (c) Thirdly, the draft S&A report 2001 noted the apparently anomalously high IEF values for N_2O in most sectors, as also noted above. Ireland should explain these values.

[FCCC/WEB/IRI(1)/2001/IRL]

UNFCCC REPORT OF THE INDIVIDUAL REVIEW OF THE GREENHOUSE GAS INVENTORY OF IRELAND SUBMITTED IN 2003

Other sectors: oil – N_2O

52. The 2001 N_2O IEF for liquid fuels (28.01 kg/TJ) for the Agriculture/Forestry/Fisheries subcategory is 57 per cent higher than the 2000 value and one of the highest among reporting Parties. Ireland has explained this as a result of revising the proportion of gas oil consumption split between stationary and mobile[7] consumption in agriculture in 2001 (i.e., 90:10 in 2001 versus 50:50 beforehand). The ERT recommends the Party to revise the value of the EF and AD used for estimating N2O emissions for this subcategory and ensure consistency in the time series.

[7] *Ireland noted that the N_2O EF for mobile combustion of gas oil is about three times the EF for stationary combustion.*

Energy industries: oil, coal, gas and biomass – CH_4, biomass – CO_2 and N_2O

53. CH_4 emissions in 2001 from the Public Electricity and Heat Production subcategory have not been reported and notation keys are not provided. Also, N_2O emissions from biomass are not reported and no notation keys have been provided. During the in-country review, the Irish officials informed the ERT that Ireland will resolve this issue for future inventories. The ERT encourages Ireland to report the CH_4 and N_2O emissions from this source and to follow the recommendations of the IPCC good practice guidance regarding the use of a tier 2 method for its estimation.

[FCCC/WEB/IRI(2)/2003/IRL]

UNFCCC REPORT OF THE INDIVIDUAL REVIEW OF THE GREENHOUSE GAS INVENTORY OF IRELAND SUBMITTED IN 2009

Stationary combustion: liquid and solid fuels – N_2O

47. The 2007 N_2O implied EF was found to be high when compared with corresponding data reported by other Parties. In response to a question raised by the ERT, the Party indicated that in its 2010 annual inventory submission it intends to revise the N_2O EFs used to estimate emissions from liquid and solid fuels that are used in public electricity and heat production. Ireland indicated to the ERT that it will develop technology-specific tier 3 N_2O EFs based on the IPCC good practice guidance and the 2006 IPCC Guidelines for its next inventory submission, since, according to the Party, this is the best available information. The ERT recommends that Ireland in the 2010 annual submission report its justification for use of the 2006 IPCC Guidelines where applicable, elaborate on the new methodology, report on recalculations, and explain the impact of the revision of these EFs on emission levels and trends.

Public electricity and heat production: liquid fuels – CH_4

48. Ireland reports CH_4 emissions as not occurring. In response to a question raised by the ERT, Ireland indicated that it would undertake a major review of the CH_4 and N_2O EFs used for this category. The ERT found that the Party has reported CH_4 emissions as

“NO” even though these emissions do occur. The ERT recommends that the Party undertake the above-mentioned review and report thereon in its next annual submission.

[FCCC/ARR/2009/IRL]

Comments from UNFCCC synthesis and assessment reports (S&A part II)

UNFCCC SYNTHESIS AND ASSESSMENT REPORT 2009

1.A.1.a. Public Electricity and Heat Production (Liquid Fuels-N_2O)

The N_2O IEF time series has been identified as an outlier as it is the highest of all reporting Parties for all years, and is constant at 14 kg/TJ which is significantly higher than the IPCC default range of 0.3-0.6 kg/TJ.

1.A.1.a. Public Electricity and Heat Production (Solid Fuels-N_2O)

The N_2O IEF time series has been identified as an outlier as it is one of the highest of all reporting Parties (highest of all Parties between 1997-2007), and ranges between 13.333-13.654 kg/TJ.

From S&A Part II 2009 (July 2009)

Problems/Findings from EU consistency reports

EU CONSISTENCY AND COMPLETENESS REPORT 2008

1.A.1.a Public Electricity and Heat Production (Solid fuels-IEF N_2O)
Why is the IEF so high (about 13.5 in 2006) compared to the IPCC default N_2O IEF for solid fuels (mean 1.5, upper limit of 5.0)?

1.A.4.b Residential Combustion (Biomass-IEF CH_4)
IEF of 30 t/TJ is the lowest among parties.

From Consistency report IE (March 2008)

EU CONSISTENCY AND COMPLETENESS REPORT 2009

1.A.1.a Public Electricity and Heat Production (Solid fuels-IEF N_2O)
The IEF of about 13.5 kg/TJ across the whole time series is the highest value of all EU MS. We have raised this already last year. In response to last year's question you informed that the CORINAIR90 emission factor was used and that the emission factor would be reviewed for submission 2009. Did you carry out the review?

From Consistency report IE (March 2009)

Data presented in Appendices B-F below are implied emission factors (IEFs) from the UNFCCC GHG Locator Review Tool v3.3 (July 2009). This tool contains all 41 Annex 1 Parties' GHG inventory data submissions for 2009 (for years 1990-2007).

Appendix B. CH_4 and N_2O implied emission factors in Energy Industries (Annex 1 Parties)
Table B.1

1.AA.1.A-Public Electricity and Heat Production,,Liquid Fuels,Implied emission factor,N2O,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Netherlands	0.60	0.60	0.60	0.54	0.38	0.18	0.18	0.17	0.15	0.15	0.11	0.12	0.11	0.12	0.12	0.11	0.13	0.12
Japan	0.24	0.24	0.25	0.26	0.26	0.27	0.27	0.28	0.29	0.29	0.30	0.31	0.30	0.30	0.30	0.28	0.28	0.27
Croatia	0.30	0.30	0.30	0.31	0.32	0.32	0.32	0.32	0.31	0.32	0.33	0.32	0.32	0.32	0.33	0.33	0.32	0.32
Iceland	0.40	0.39	0.39	0.38	0.38	0.41	0.43	0.44	0.43	0.51	0.58	0.56	0.56	0.58	0.59	0.58	0.58	0.36
New Zealand	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.40	0.30	0.30	0.30	0.40	0.30	0.30	0.40	0.40	0.40	0.40
Norway	0.66	0.67	0.66	0.68	0.69	0.69	0.70	0.70	0.70	0.94	0.82	0.54	0.51	0.57	0.60	0.64	0.57	0.53
Bulgaria	0.31	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.26	0.27	0.20	0.34	0.53
Belgium	0.62	0.60	0.63	0.61	0.59	0.59	0.53	0.60	0.61	0.67	0.67	0.60	0.59	0.60	0.60	0.59	0.69	0.57
Belarus	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.57	0.60	0.58
Slovakia	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Turkey	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.56	0.56	0.56	0.57	0.56	0.56	0.56	0.56	0.60	0.61	0.60
Czech Republic	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Estonia	0.60	0.53	0.60	0.60	0.61	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Greece	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Hungary	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Italy	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Latvia	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Luxembourg	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Monaco	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	NO	NO	NO	NO	NO	0.60	0.60
Poland	0.59	0.59	0.59	0.59	0.59	0.60	0.60	0.60	0.60	0.59	0.59	0.59	0.59	0.60	0.59	0.58	0.60	0.60
Portugal	0.60	0.60	0.60	0.60	0.60	0.60	0.61	0.60	0.61	0.62	0.64	0.63	0.61	0.65	0.66	0.65	0.68	0.60
Romania	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Russian Federation	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	1.01	1.03	0.60
Slovenia	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Switzerland	0.75	0.75	0.75	0.70	0.73	0.75	0.75	0.70	0.77	0.71	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Ukraine	0.60	NE	NE	NE	NE	NE	NE	NE	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
United States of America	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Australia	0.63	0.65	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.64	0.63	0.64	0.64	0.63
United Kingdom of Great Britain and Northern Ireland	0.63	0.64	0.67	0.68	0.68	0.68	0.66	0.63	0.58	0.58	0.58	0.57	0.57	0.56	0.57	0.70	0.77	0.84
Germany	1.13	1.09	1.06	1.09	1.10	1.33	1.34	1.28	1.16	1.13	1.15	1.16	1.13	1.15	1.12	1.11	1.16	1.10
Austria	1.39	1.33	1.20	1.22	1.28	1.23	1.26	1.33	1.33	1.45	1.27	1.19	1.27	1.36	1.33	1.37	1.34	1.29
Spain	1.55	1.55	1.53	1.56	1.57	1.54	1.55	1.56	1.55	1.54	1.55	1.55	1.55	1.60	1.61	1.62	1.65	1.68
European Community (15)	0.95	1.07	1.05	1.05	1.12	1.08	1.20	1.21	1.33	1.47	1.33	1.44	1.33	1.49	1.68	1.75	1.84	1.80
Denmark	2.00	2.00	2.00	2.10	1.99	2.00	1.98	1.99	1.93	2.00	1.99	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Denmark (Denmark (mainland) and Greenland)	2.00	2.00	2.00	2.10	1.99	2.00	1.98	1.99	1.93	2.00	1.99	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Canada	2.16	2.18	2.05	2.16	2.33	2.41	2.78	2.23	2.03	2.03	2.04	1.99	2.00	1.94	1.96	2.03	2.41	2.28
Lithuania	2.45	2.46	2.48	2.48	2.49	2.48	2.48	2.49	2.49	2.49	2.49	2.50	2.50	2.49	2.49	2.49	2.50	2.49
Finland	2.53	2.54	2.54	2.53	2.51	2.63	2.41	2.57	2.73	2.78	2.78	2.70	2.50	2.42	2.69	2.73	2.70	2.79
Sweden	4.38	4.43	4.40	4.38	4.34	4.18	4.28	4.22	4.24	4.03	3.95	4.06	4.10	4.06	4.01	4.09	4.27	4.08
France	1.73	1.74	1.73	1.72	1.72	1.73	1.74	1.74	1.74	1.73	1.73	1.73	1.95	4.04	4.04	3.87	4.11	4.33
France (KP)	1.73	1.74	1.73	1.73	1.73	1.73	1.74	1.74	1.75	1.73	1.74	1.74	1.99	4.27	4.27	4.08	4.37	4.66
Ireland	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Liechtenstein	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B.2

1.AA.1.A-Public Electricity and Heat Production,,Solid Fuels,Implied emission factor,N2O,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Estonia	0.06	0.05	0.06	0.07	0.07	0.10	0.10	0.09	0.08	0.07	0.07	0.08	0.09	0.08	0.07	0.07	0.08	0.08
Austria	1.21	1.31	1.41	1.57	1.46	1.39	1.05	0.90	1.35	1.41	1.39	1.28	1.31	1.25	1.36	0.50	0.50	0.51
Denmark	0.86	0.85	0.84	0.83	0.81	0.81	0.80	0.80	0.78	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Denmark (Denmark (mainland) and Greenland)	0.86	0.85	0.84	0.83	0.81	0.81	0.80	0.80	0.78	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Australia	1.08	1.08	1.08	1.07	1.07	1.07	1.06	1.07	1.09	1.09	1.09	1.08	1.08	1.07	1.08	1.08	1.04	1.01
Belgium	1.21	1.26	1.28	1.28	1.28	1.25	1.25	1.24	1.18	1.20	1.22	1.23	1.21	1.21	1.16	1.14	1.11	1.17
Netherlands	1.30	1.29	1.29	1.27	1.29	1.26	1.29	1.27	1.27	1.25	1.27	1.27	1.27	1.27	1.27	1.25	1.28	1.25
Spain	0.81	0.93	1.10	1.34	1.59	1.88	2.04	1.96	1.90	1.87	1.65	1.93	1.75	1.70	1.54	1.45	1.45	1.37
Portugal	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38
Slovakia	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.42	1.44	1.40
Turkey	1.08	1.11	1.12	1.13	1.18	1.16	1.18	1.18	1.19	1.22	1.20	1.23	1.20	1.19	1.20	1.40	1.40	1.40
Ukraine	1.40	NE	NE	NE	NE	NE	NE	NE	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Belarus	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.39	8.36	1.40
Czech Republic	1.41	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Romania	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Russian Federation	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.41	1.42	1.40
Slovenia	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Norway	1.42	1.38	1.40	1.39	1.36	1.36	1.39	1.42	1.41	1.41	1.41	1.41	1.42	1.42	1.42	1.41	1.42	1.41
Poland	1.49	1.50	1.49	1.50	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49
Greece	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Hungary	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Italy	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
United States of America	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Japan	1.08	1.07	0.87	0.88	0.87	1.91	1.87	1.81	1.83	1.85	1.77	1.74	1.68	1.63	1.62	1.57	1.60	1.55
Latvia	2.37	2.69	2.70	2.80	3.02	3.11	3.39	3.55	3.49	3.32	3.62	3.36	3.47	3.43	2.04	1.93	1.82	1.56
Croatia	1.59	1.50	1.53	1.55	1.58	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
New Zealand	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
Canada	1.62	1.61	1.62	1.68	1.69	1.70	1.69	1.67	1.61	1.60	1.58	1.59	1.63	1.59	1.61	1.64	1.64	1.61
Finland	1.39	1.55	1.74	1.58	1.37	1.45	1.31	1.33	1.52	1.46	1.43	1.43	1.47	1.39	1.43	1.82	1.78	1.92
United Kingdom of Great Britain and Northern Ireland	2.67	2.65	2.65	2.65	2.67	2.61	2.61	2.59	2.57	2.56	2.55	2.56	2.54	2.55	2.54	2.54	2.53	2.53
European Community (15)	2.89	2.95	3.04	3.05	3.02	3.05	3.13	3.11	3.15	3.07	3.04	3.04	2.97	2.90	2.86	2.87	2.86	2.87
Bulgaria	3.77	3.22	3.47	3.26	3.56	3.74	3.78	3.69	3.67	3.60	3.60	3.48	3.46	3.52	3.47	3.39	3.39	3.40
Lithuania	3.06	3.11	3.09	3.10	3.14	3.19	3.26	3.26	3.24	3.37	3.22	3.23	3.29	3.29	3.32	3.33	3.36	3.67
Germany	3.78	3.84	3.84	3.87	3.87	3.87	3.87	3.85	3.86	3.84	3.82	3.79	3.78	3.79	3.78	3.79	3.80	3.81
France	2.94	3.69	4.58	4.60	4.46	4.96	5.40	6.44	5.64	5.02	5.58	5.66	5.07	4.18	4.22	4.10	4.21	4.17
France (KP)	2.94	3.69	4.58	4.60	4.46	4.96	5.40	6.44	5.64	5.02	5.58	5.66	5.07	4.18	4.22	4.10	4.21	4.17
Sweden	15.71	15.44	15.46	15.02	14.43	13.52	15.08	12.13	11.32	10.95	10.52	9.95	9.94	10.62	9.69	8.87	9.85	8.75
Ireland	13.35	13.33	13.38	13.41	13.42	13.45	13.45	13.44	13.48	13.42	13.50	13.48	13.46	13.45	13.65	13.47	13.49	13.45
Iceland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Liechtenstein	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Luxembourg	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Monaco	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Switzerland	1.60	1.60	1.60	1.60	1.60	1.60	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B.3

1.AA.1.A-Public Electricity and Heat Production,,Gaseous Fuels,Implied emission factor,N2O,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Estonia	0.09	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Belarus	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Bulgaria	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Croatia	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Czech Republic	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Greece	NO	NO	NO	NO	NO	NO	NO	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Italy	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Latvia	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Liechtenstein	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Luxembourg	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Monaco	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Netherlands	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
New Zealand	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Poland	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Romania	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Russian Federation	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.12	0.11	0.11	0.10
Slovakia	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Slovenia	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Switzerland	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Turkey	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Ukraine	0.10	NE	NE	NE	NE	NE	NE	NE	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
United States of America	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Australia	0.11	0.12	0.12	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.13	0.14	0.11	0.11	0.10	0.10
United Kingdom of Great Britain and Northern Ireland	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Japan	0.24	0.25	0.25	0.26	0.27	0.28	0.29	0.32	0.34	0.36	0.36	0.37	0.37	0.37	0.37	0.37	0.37	0.37
Norway	NO	NO	NO	NO	NO	NO	NO	0.12	0.12	0.12	0.12	0.12	0.12	0.15	0.26	0.29	0.28	0.47
Belgium	0.10	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.17	0.19	0.19	0.17	0.19	0.51	0.51	0.50
European Community (15)	0.50	0.51	0.50	0.46	0.45	0.46	0.46	0.44	0.42	0.41	0.40	0.41	0.45	0.48	0.48	0.53	0.55	0.53
Austria	0.55	0.56	0.56	0.55	0.59	0.58	0.48	0.40	0.49	0.47	0.48	0.50	0.48	0.47	0.46	0.57	0.56	0.57
Germany	0.67	0.70	0.68	0.70	0.69	0.79	0.75	0.76	0.77	0.78	0.78	0.77	0.76	0.87	0.84	0.80	0.77	0.74
Lithuania	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.99	0.99	0.99	0.99	1.00	1.00	0.99	0.99	1.00
Finland	1.02	1.03	1.04	1.06	1.04	1.03	1.03	1.03	1.03	1.02	1.02	1.03	1.02	1.02	1.02	1.03	1.02	1.02
Canada	1.25	1.23	1.30	1.32	1.28	1.29	1.27	1.24	1.26	1.25	1.28	1.28	1.27	1.29	1.26	1.28	1.23	1.25
Spain	0.90	0.90	0.90	0.90	0.90	0.90	0.95	0.95	1.03	1.14	1.20	1.22	1.20	1.30	1.28	1.27	1.29	1.31
Portugal	NO	NO	NO	NO	NO	NO	NO	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Denmark	1.14	1.15	1.28	1.37	1.34	1.34	1.43	1.36	1.34	1.45	1.46	1.48	1.54	1.54	1.55	1.50	1.56	1.56
Denmark (Denmark (mainland) and Greenland)	1.14	1.15	1.28	1.37	1.34	1.34	1.43	1.36	1.34	1.45	1.46	1.48	1.54	1.54	1.55	1.50	1.56	1.56
Sweden	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
France	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.54	2.50	2.50	2.50	2.50	2.50
France (KP)	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.54	2.50	2.50	2.50	2.50	2.50
Hungary	3.00	2.80	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	2.70	3.00	2.80	2.80	2.80	2.98	2.99	2.99
Ireland	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Iceland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B.4

1.AA.1.A-Public Electricity and Heat Production,,Liquid Fuels,Implied emission factor,CH4,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Japan	0.12	0.12	0.13	0.13	0.13	0.13	0.13	0.14	0.14	0.14	0.15	0.16	0.15	0.15	0.15	0.14	0.15	0.14
New Zealand	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Switzerland	3.30	3.21	3.30	2.54	2.97	3.29	3.25	2.50	3.48	2.59	1.00	1.00	1.00	1.00	1.00	1.00	1.03	1.00
Croatia	0.90	0.90	0.90	0.96	1.04	1.05	1.09	1.04	1.00	1.03	1.10	1.06	1.06	1.01	1.13	1.09	1.06	1.03
Austria	0.87	0.92	1.00	1.06	0.97	1.08	1.12	1.01	1.03	0.82	0.89	0.99	0.99	0.82	0.88	1.06	1.14	1.18
Belgium	0.94	1.05	0.98	1.05	0.91	0.96	0.91	1.07	0.95	1.26	1.24	0.85	0.94	0.86	0.88	1.10	1.34	1.19
Canada	1.18	1.24	1.09	1.17	1.28	1.31	1.45	1.18	1.09	1.13	1.12	1.09	1.11	1.10	1.12	1.13	1.34	1.28
Iceland	1.89	1.85	1.85	1.70	1.71	1.99	2.24	2.37	2.19	3.10	3.82	3.56	3.59	3.75	3.91	3.74	3.84	1.55
Finland	1.48	1.41	1.35	1.34	1.43	1.76	1.77	1.54	1.69	1.71	1.39	1.37	1.42	1.40	1.42	1.41	1.38	1.58
Bulgaria	1.55	1.30	1.36	1.33	1.39	1.42	1.20	1.11	2.09	2.03	2.10	2.14	2.19	1.64	1.61	1.38	1.87	1.63
Sweden	1.79	1.81	1.80	1.79	1.78	1.73	1.76	1.74	1.75	1.68	1.65	1.69	1.70	1.69	1.67	1.70	1.76	1.70
Portugal	0.81	0.82	0.79	0.83	0.92	0.90	1.08	1.12	0.97	1.01	1.13	1.05	0.99	1.28	1.53	1.23	1.62	1.71
France (KP)	1.44	1.27	1.52	1.77	1.97	1.71	1.66	1.85	1.57	1.65	1.67	1.83	2.01	1.84	1.99	1.67	1.68	1.83
France	1.47	1.29	1.54	1.80	2.01	1.75	1.71	1.89	1.61	1.71	1.71	1.85	2.01	1.86	1.99	1.70	1.72	1.86
Germany	3.30	3.31	3.38	3.42	3.28	3.39	3.39	3.33	3.21	3.07	2.68	2.77	2.61	2.39	2.19	2.19	2.25	2.15
Spain	1.21	1.22	1.06	1.36	1.41	1.28	1.34	1.40	1.23	1.16	1.23	1.20	1.16	1.66	1.74	1.86	2.12	2.44
Norway	2.40	2.36	2.39	2.42	2.34	2.33	2.33	2.32	2.33	2.32	2.34	2.36	2.35	2.39	2.39	2.37	2.47	2.46
European Community (15)	2.65	2.58	2.58	2.69	2.69	2.67	2.69	2.66	2.49	2.40	2.44	2.38	2.38	2.46	2.39	2.27	2.39	2.47
Denmark	2.72	2.86	2.83	4.03	2.92	2.95	2.93	2.94	2.84	2.96	2.94	2.93	2.96	2.82	2.85	2.88	2.88	2.83
Denmark (Denmark (mainland) and Greenland)	2.72	2.86	2.83	4.03	2.92	2.95	2.93	2.94	2.84	2.96	2.94	2.93	2.96	2.82	2.85	2.88	2.88	2.83
Italy	2.98	2.98	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.95	2.93	2.96	2.97	2.95	2.97	2.96	2.96	2.94
Turkey	2.74	2.73	2.74	2.75	2.75	2.75	2.77	2.78	2.77	2.82	2.83	2.79	2.80	2.81	2.81	3.00	3.01	2.99
Belarus	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	2.87	3.01	3.00
Czech Republic	3.00	3.00	3.00	3.01	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Greece	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Hungary	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Latvia	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Luxembourg	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Monaco	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	NO	NO	NO	NO	NO	3.00	3.00
Poland	2.97	2.98	2.98	2.97	2.96	3.00	3.00	3.00	2.98	2.98	2.98	2.98	2.98	2.99	2.98	2.93	3.00	3.00
Romania	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Russian Federation	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	5.06	5.14	3.00
Slovakia	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Slovenia	3.00	3.00	3.00	3.00	3.00	3.00	3.00	2.98	2.98	2.97	2.98	3.00	2.96	2.95	2.95	2.99	2.98	3.00
United States of America	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Ukraine	3.00	NE	NE	NE	NE	NE	NE	NE	3.05	3.07	3.10	3.13	2.99	2.98	2.99	3.01	3.01	3.02
Estonia	3.02	3.01	3.01	3.00	3.04	3.01	3.29	3.06	3.06	3.07	3.11	3.10	3.10	3.08	3.09	3.11	3.14	3.12
United Kingdom of Great Britain and Northern Ireland	3.14	3.18	3.33	3.38	3.40	3.39	3.30	3.01	2.86	2.88	2.90	2.85	2.82	2.80	2.83	2.90	3.16	3.14
Australia	2.59	2.66	3.29	3.27	3.03	3.55	1.63	1.89	3.69	3.24	3.76	3.40	3.69	3.46	3.79	3.54	3.41	3.33
Netherlands	1.95	3.40	3.40	3.42	3.49	3.43	3.43	3.48	3.51	3.50	3.53	3.48	3.53	3.50	3.53	3.56	3.53	3.52
Lithuania	3.31	3.35	3.42	3.43	3.44	3.40	3.42	3.43	3.46	3.47	3.49	3.49	3.51	3.52	3.53	3.49	3.74	3.53
Ireland	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Liechtenstein	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B.5

1.AA.1.A-Public Electricity and Heat Production,,Solid Fuels,Implied emission factor,CH4,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Austria	1.17	1.22	1.13	1.05	0.81	0.57	0.37	0.36	0.19	0.15	0.20	0.17	0.14	0.13	0.19	0.10	0.10	0.11
Japan	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.15	0.15	0.15	0.15	0.15	0.15
Netherlands	0.46	0.47	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Belgium	0.67	0.68	0.67	0.67	0.66	0.66	0.65	0.64	0.61	0.62	0.62	0.62	0.62	0.62	0.60	0.58	0.56	0.53
Estonia	0.27	0.20	0.24	0.33	0.36	0.56	0.63	0.59	0.53	0.43	0.43	0.56	0.63	0.52	0.46	0.45	0.57	0.56
Spain	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.61	0.60	0.60	0.60	0.60	0.60	0.60
Portugal	0.71	0.71	0.70	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
Croatia	0.72	0.72	0.71	0.71	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
New Zealand	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
France	0.82	0.81	0.83	0.93	1.05	0.89	0.75	0.77	0.81	0.84	0.77	0.96	0.84	0.75	0.72	0.72	0.74	0.79
France (KP)	0.82	0.81	0.83	0.93	1.05	0.89	0.75	0.77	0.81	0.84	0.77	0.96	0.84	0.75	0.72	0.72	0.74	0.79
United Kingdom of Great Britain and Northern Ireland	0.85	0.84	0.84	0.84	0.85	0.83	0.83	0.82	0.82	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.80	0.80
Australia	0.80	0.80	0.80	0.81	0.81	0.81	0.81	0.80	0.85	0.84	0.79	0.80	0.83	0.82	0.83	0.83	0.83	0.83
Slovakia	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.02	1.03	1.00
Belarus	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Czech Republic	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Greece	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Romania	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Russian Federation	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.00
Slovenia	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
United States of America	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Turkey	0.77	0.79	0.80	0.81	0.84	0.83	0.84	0.84	0.85	0.87	0.86	0.88	0.86	0.85	0.86	1.00	1.00	1.00
Ukraine	1.00	NE	NE	NE	NE	NE	NE	NE	1.19	1.20	1.16	1.19	1.16	1.11	1.11	1.11	1.00	1.00
Poland	1.07	1.12	1.10	1.10	1.11	1.06	1.05	1.05	1.07	1.05	1.06	1.06	1.08	1.05	1.07	1.09	1.09	1.08
Finland	1.08	1.06	1.03	1.02	1.01	1.02	1.02	1.01	1.01	1.03	1.07	1.07	1.09	1.08	1.09	1.17	1.08	1.10
European Community (15)	1.29	1.25	1.23	1.24	1.24	1.15	1.16	1.15	1.15	1.14	1.13	1.15	1.15	1.14	1.15	1.13	1.14	1.15
Canada	1.13	1.12	1.13	1.17	1.18	1.18	1.17	1.16	1.12	1.11	1.10	1.11	1.14	1.19	1.23	1.19	1.22	1.20
Hungary	3.00	3.20	3.45	3.50	3.50	1.58	1.25	1.25	1.25	1.25	1.21	1.25	1.32	1.30	1.30	1.26	1.25	1.25
Norway	1.23	1.87	1.64	1.67	2.34	2.24	1.65	1.20	1.29	1.37	1.26	1.48	1.28	1.11	1.28	1.52	1.34	1.44
Germany	1.82	1.74	1.72	1.67	1.67	1.50	1.50	1.49	1.49	1.49	1.49	1.48	1.48	1.48	1.48	1.48	1.48	1.48
Bulgaria	2.14	1.85	1.74	1.64	1.63	1.61	1.59	1.59	1.51	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Italy	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Denmark	1.84	1.78	1.76	1.67	1.57	1.56	1.52	1.51	1.47	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Denmark (Denmark (mainland) and Greenland)	1.84	1.78	1.76	1.67	1.57	1.56	1.52	1.51	1.47	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Latvia	11.85	15.36	15.54	16.56	19.03	20.10	23.17	25.01	24.35	22.42	25.72	22.83	24.06	23.64	8.17	6.90	5.66	2.74
Sweden	6.01	6.27	6.24	6.75	6.68	7.46	5.62	6.95	8.16	7.05	7.39	7.63	8.30	7.48	7.98	7.99	7.39	8.11
Lithuania	15.93	16.81	16.58	16.71	17.33	18.25	19.48	19.48	19.03	21.21	19.05	18.98	19.90	19.92	20.47	20.61	21.18	26.33
Iceland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Ireland	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Liechtenstein	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Luxembourg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Monaco	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Switzerland	10.00	10.00	10.00	10.00	10.00	10.00	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B.6

1.AA.1.A-Public Electricity and Heat Production,,Gaseous Fuels,Implied emission factor,CH4,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Japan	0.32	0.34	0.35	0.36	0.38	0.39	0.41	0.44	0.47	0.50	0.50	0.51	0.51	0.51	0.51	0.52	0.51	0.51
Austria	0.41	0.41	0.46	0.51	0.50	0.50	0.68	0.84	0.76	0.77	0.77	0.72	0.78	0.85	0.89	0.46	0.53	0.51
Estonia	0.89	0.91	0.90	0.76	0.75	0.78	0.77	0.78	0.64	0.83	0.80	0.80	0.77	0.77	0.79	0.79	0.77	0.79
Portugal	NO	NO	NO	NO	NO	NO	NO	0.10	0.10	0.10	0.10	0.22	0.25	0.31	0.63	0.73	0.91	0.90
Hungary	1.72	1.70	1.71	1.80	1.30	1.24	2.00	1.86	2.00	1.97	1.90	1.72	1.30	1.30	1.30	1.53	1.02	0.93
Belarus	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Turkey	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	0.96	0.96	0.98	0.97	1.00	1.00	1.00
Czech Republic	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Greece	NO	NO	NO	NO	NO	NO	NO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Latvia	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Luxembourg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Poland	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Romania	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Russian Federation	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.16	1.05	1.05	1.00
Slovenia	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sweden	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
United States of America	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Ukraine	1.00	NE	NE	NE	NE	NE	NE	NE	1.06	1.06	1.07	1.14	1.07	1.01	1.01	1.02	1.00	1.00
Slovakia	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.02
United Kingdom of Great Britain and Northern Ireland	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11
Germany	0.72	0.81	0.79	0.81	0.77	1.01	0.86	0.87	0.92	0.95	0.99	0.99	1.02	1.38	1.36	1.37	1.37	1.37
Italy	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Bulgaria	2.02	1.94	1.97	1.64	1.52	1.55	1.53	1.45	1.75	1.78	1.79	1.80	1.82	1.80	1.81	1.56	1.57	1.91
Belgium	0.38	0.38	0.34	0.33	1.31	1.41	1.43	1.54	1.91	1.90	2.17	2.42	2.33	2.26	2.47	2.54	2.50	2.37
Finland	1.04	1.33	1.59	1.39	1.52	1.80	1.92	2.39	2.55	2.29	2.15	2.31	3.54	3.56	3.22	2.85	2.82	2.42
Lithuania	3.09	3.04	3.30	3.32	3.38	3.34	3.30	3.26	3.21	3.18	3.20	3.11	3.02	2.97	2.86	2.88	2.88	2.88
France	2.17	2.16	2.20	2.43	2.59	2.61	2.97	2.97	2.88	2.94	2.42	2.55	3.31	3.33	3.35	2.87	3.04	2.92
France (KP)	2.17	2.16	2.20	2.43	2.59	2.61	2.97	2.97	2.88	2.94	2.42	2.55	3.31	3.33	3.35	2.87	3.04	2.92
New Zealand	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05
Croatia	1.13	0.64	1.13	1.38	1.11	2.28	1.21	1.02	1.17	1.04	1.80	2.49	2.50	3.71	3.52	4.26	3.85	3.35
Spain	0.10	0.10	0.10	0.10	0.10	0.10	0.58	0.42	0.89	1.07	0.93	0.79	1.73	3.16	3.36	3.39	3.72	3.78
European Community (15)	2.37	2.82	3.29	4.18	5.92	8.68	9.27	8.29	7.99	7.10	6.74	7.07	6.70	6.32	5.74	4.90	4.47	3.79
Monaco	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Switzerland	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Netherlands	6.35	6.48	6.71	6.95	7.42	7.94	8.35	8.46	8.45	8.38	8.53	8.18	8.12	7.87	6.65	6.71	6.77	6.79
Canada	8.91	8.20	10.38	10.85	10.32	10.19	9.57	9.78	10.47	10.05	10.60	10.57	10.55	10.63	10.25	10.63	9.88	10.18
Australia	1.53	1.77	2.17	1.81	1.73	2.05	1.88	1.09	15.65	15.43	21.41	18.00	24.09	16.91	19.48	19.44	15.84	19.95
Norway	NO	NO	NO	NO	NO	NO	NO	1.16	1.17	1.17	1.17	1.18	1.19	2.82	9.30	11.15	10.68	21.66
Liechtenstein	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Denmark	15.55	23.50	39.35	89.57	158.11	243.01	247.73	223.07	211.09	197.31	184.77	189.82	184.20	179.98	172.06	161.26	127.30	125.79
Denmark (Denmark (mainland) and Greenland)	15.55	23.50	39.35	89.57	158.11	243.01	247.73	223.07	211.09	197.31	184.77	189.82	184.20	179.98	172.06	161.26	127.30	125.79
Iceland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Ireland	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

Table B.7

1.AA.1.B-Petroleum Refining,,Liquid Fuels,Implied emission factor,N2O,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Slovakia	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.12	0.11	0.11	0.12	0.11	0.12	0.12	0.13
Netherlands	0.14	0.14	0.13	0.27	0.27	0.29	0.31	0.27	0.24	0.25	0.23	0.21	0.29	0.30	0.28	0.28	0.27	0.27
New Zealand	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Poland	0.40	0.39	0.42	0.39	0.41	0.47	0.51	0.49	0.54	0.53	0.50	0.50	0.51	0.51	0.50	0.51	0.50	0.46
Austria	0.46	0.51	0.51	0.53	0.49	0.52	0.49	0.50	0.50	0.54	0.50	0.53	0.57	0.54	0.54	0.54	0.46	0.48
Norway	0.94	1.01	0.94	0.96	0.98	1.09	1.03	1.05	1.11	1.02	0.50	0.48	0.49	0.49	0.49	0.49	0.48	0.48
Hungary	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.58
Croatia	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Czech Republic	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Greece	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Russian Federation	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	0.60
Slovenia	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	14.29	0.60	0.60
Turkey	0.59	0.59	0.59	0.59	0.59	0.61	0.59	0.60	0.60	0.59	0.60	0.59	0.60	0.59	0.59	0.60	0.60	0.60
Ukraine	IE	NE	NE	NE	NE	NE	NE	NE	0.26	0.23	0.26	0.22	0.19	0.18	0.16	0.60	0.60	0.60
Switzerland	0.64	0.63	0.63	0.62	0.63	0.64	0.63	0.63	0.63	0.63	0.64	0.64	0.63	0.63	0.62	0.61	0.61	0.62
Australia	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63
Japan	0.28	0.28	0.27	0.34	0.40	0.47	0.45	0.50	0.56	0.63	0.64	0.66	0.68	0.68	0.68	0.66	0.67	0.68
Germany	1.13	1.11	1.05	1.13	1.18	0.73	0.71	0.71	0.71	0.72	0.70	0.71	0.70	0.68	0.68	0.69	0.69	0.69
Portugal	1.04	1.01	0.98	0.97	0.98	0.98	0.98	0.99	0.93	0.96	0.94	0.94	0.93	0.94	0.94	0.95	0.94	0.94
European Community (15)	1.60	1.62	1.60	1.61	1.64	1.56	1.59	1.62	1.61	1.64	1.67	1.61	1.68	1.68	1.64	1.47	1.49	1.44
Spain	1.56	1.58	1.63	1.66	1.74	1.75	1.79	1.79	1.78	1.77	1.77	1.78	1.78	1.76	1.72	1.73	1.74	1.72
France	1.76	1.76	1.76	1.75	1.80	1.77	1.71	1.76	1.76	1.79	1.79	1.69	1.77	1.80	1.78	1.78	1.79	1.79
France (KP)	1.76	1.76	1.76	1.75	1.80	1.77	1.71	1.76	1.76	1.79	1.79	1.69	1.77	1.80	1.78	1.78	1.79	1.79
Finland	1.79	1.79	1.79	1.80	1.74	1.71	1.73	1.77	1.83	1.79	1.79	1.78	1.81	1.80	1.79	1.84	1.83	1.84
United Kingdom of Great Britain and Northern Ireland	1.31	1.36	1.36	1.33	1.24	1.39	1.34	1.43	1.49	1.56	1.69	1.40	1.48	1.45	1.42	1.60	2.05	1.84
Lithuania	1.86	1.91	1.95	1.87	1.84	1.84	1.83	1.86	1.81	1.87	1.79	1.78	1.77	1.73	1.72	1.74	1.75	1.86
Italy	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Denmark	2.00	2.00	2.00	2.02	2.02	2.02	2.04	2.04	2.04	2.05	2.05	2.05	2.05	2.04	2.05	2.04	2.04	2.05
Denmark (Denmark (mainland) and Greenland)	2.00	2.00	2.00	2.02	2.02	2.02	2.04	2.04	2.04	2.05	2.05	2.05	2.05	2.04	2.05	2.04	2.04	2.05
Belgium	7.43	6.40	5.71	5.88	8.28	6.85	7.57	7.65	7.56	7.98	8.45	8.07	8.07	7.93	7.78	3.17	2.42	2.18
Sweden	2.32	2.33	2.25	2.26	2.28	2.33	2.30	2.32	2.32	2.27	2.26	2.28	2.23	2.24	2.27	2.22	2.21	2.18
Ireland	4.85	5.33	4.24	4.35	4.42	4.39	4.62	4.57	4.29	4.53	5.00	4.75	4.54	4.27	4.39	4.71	4.69	4.81
Canada	3.97	3.91	4.13	3.95	4.37	4.58	4.54	2.66	2.85	3.07	3.11	3.93	3.64	3.59	4.03	4.10	4.55	4.98
Belarus	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Romania	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
United States of America	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Bulgaria	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Estonia	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Iceland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Latvia	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Liechtenstein	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Luxembourg	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Monaco	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B.8

1.AA.1.B-Petroleum Refining,,Liquid Fuels,Implied emission factor,CH4,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Australia	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.92	0.92	0.92	1.03	1.04	1.05	1.05
Ireland	0.23	0.07	0.10	0.23	0.22	0.25	0.25	0.21	0.09	0.15	0.14	0.14	0.16	0.15	0.23	0.19	0.10	0.10
Denmark	2.09	2.12	2.19	2.13	2.11	1.90	0.74	1.17	0.95	0.14	0.13	0.13	0.13	0.10	0.12	0.12	0.13	0.19
Denmark (Denmark (mainland) and Greenland)	2.09	2.12	2.19	2.13	2.11	1.90	0.74	1.17	0.95	0.14	0.13	0.13	0.13	0.10	0.12	0.12	0.13	0.19
Japan	0.19	0.20	0.20	0.21	0.21	0.22	0.23	0.23	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Finland	1.00	1.00	1.00	1.01	1.00	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.00	1.02	1.00	1.00
Sweden	1.11	1.11	1.08	1.09	1.09	1.11	1.10	1.11	1.11	1.09	1.09	1.09	1.08	1.08	1.09	1.07	1.07	1.06
Germany	1.83	1.84	1.75	1.86	1.78	1.44	1.35	1.32	1.37	1.37	1.30	1.35	1.29	1.20	1.20	1.25	1.25	1.24
Switzerland	1.66	1.42	1.37	1.34	1.40	1.53	1.44	1.50	1.39	1.45	1.58	1.53	1.40	1.50	1.30	1.22	1.15	1.29
Spain	1.31	1.32	1.35	1.39	1.58	1.61	1.62	1.57	1.58	1.58	1.57	1.68	1.65	1.62	1.57	1.60	1.61	1.57
Norway	11.70	12.23	10.06	9.62	9.39	10.29	8.87	8.47	8.49	7.71	1.92	1.89	1.91	1.81	1.68	1.65	1.93	1.59
European Community (15)	1.89	1.90	1.88	2.00	2.03	1.93	1.88	1.90	1.86	1.84	1.84	1.88	1.93	1.91	1.87	1.87	1.87	1.88
Slovenia	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.93	2.00	2.00
United Kingdom of Great Britain and Northern Ireland	2.13	2.19	2.21	2.19	2.21	2.17	2.17	2.21	2.22	2.15	2.01	2.08	2.14	2.19	2.07	2.07	2.01	2.01
Italy	1.86	1.81	1.77	1.80	1.75	1.89	1.90	1.91	1.82	1.75	1.97	2.12	2.14	2.11	2.00	1.94	2.03	2.05
Poland	2.21	2.16	2.29	2.16	2.23	2.46	2.65	2.54	2.74	2.71	2.60	2.61	2.62	2.63	2.59	2.62	2.60	2.46
Lithuania	2.67	2.72	2.75	2.68	2.65	2.61	2.58	2.58	2.55	2.61	2.54	2.54	2.56	2.52	2.51	2.53	2.53	2.60
France	2.71	2.72	2.71	2.72	2.70	2.70	2.62	2.71	2.68	2.71	2.70	2.63	2.70	2.76	2.73	2.71	2.71	2.72
France (KP)	2.71	2.72	2.71	2.72	2.70	2.70	2.62	2.71	2.68	2.71	2.70	2.63	2.70	2.76	2.73	2.71	2.71	2.72
Portugal	2.69	2.70	2.72	2.73	2.72	2.72	2.71	2.70	2.74	2.72	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73
Ukraine	IE	NE	NE	NE	NE	NE	NE	NE	3.85	4.13	3.91	4.02	3.51	3.49	3.52	2.33	2.90	2.85
Hungary	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	2.90
Turkey	2.93	2.93	2.96	2.97	2.96	3.06	2.97	2.98	2.97	2.97	2.98	2.97	2.98	2.97	2.96	3.00	3.00	3.00
Croatia	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Czech Republic	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Greece	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
New Zealand	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Russian Federation	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	3.00
Netherlands	2.13	2.38	2.39	3.26	3.29	2.74	2.69	2.66	2.41	2.53	2.51	2.31	3.37	3.41	3.45	3.45	3.46	3.48
Slovakia	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	4.92	4.94	4.96	4.91	4.94	4.93	4.90	4.90
Austria	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Belarus	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Belgium	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Canada	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Romania	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
United States of America	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Bulgaria	2.90	2.90	NO	NO	NO	NO	NO	NO	NO	2.90	NO	NO	NO	NO	NO	NO	NO	NO
Estonia	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Iceland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Latvia	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Liechtenstein	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Luxembourg	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Monaco	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B.9

1.AA.1.C-Manufacture of Solid Fuels and Other Energy Industries,,Solid Fuels,Implied emission factor,N2O,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Belgium	0.39	0.36	0.33	0.34	0.33	0.25	0.17	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Hungary	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	0.14	0.12
Bulgaria	0.24	0.39	0.42	0.43	0.32	0.27	0.28	0.29	0.43	0.36	0.35	0.30	0.27	0.20	0.17	0.16	0.16	0.20
Japan	0.13	0.13	0.14	0.16	0.12	0.12	0.14	0.12	0.12	0.14	0.15	0.16	0.12	0.14	0.13	0.14	0.18	0.23
Ukraine	IE	NE	NE	NE	NE	NE	NE	NE	0.64	0.63	0.57	0.52	0.40	0.42	0.38	0.39	0.40	0.37
Canada	0.55	0.56	0.56	0.57	0.57	0.57	0.57	0.57	0.58	0.59	0.60	0.61	0.60	0.61	0.60	0.59	0.58	0.58
Poland	0.37	0.35	0.30	0.70	0.93	0.98	0.99	0.96	0.98	0.97	0.86	0.84	0.69	0.68	0.62	0.61	0.49	0.66
Australia	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
Finland	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Czech Republic	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Russian Federation	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	1.40
Italy	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Spain	1.66	1.61	1.60	1.61	1.64	1.73	1.73	1.74	1.74	1.73	1.66	1.67	1.66	1.68	1.68	1.70	1.71	1.71
Sweden	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Latvia	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	3.88	3.79	3.83	3.50	2.08	2.12	2.12	2.53	4.00	2.12
United Kingdom of Great Britain and Northern Ireland	2.57	2.59	2.53	2.41	2.28	2.21	2.22	2.36	2.40	2.38	2.50	2.52	2.42	2.23	2.25	2.24	2.22	2.22
France	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
France (KP)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
European Community (15)	3.20	3.42	3.51	3.67	3.75	3.56	3.48	3.36	3.08	3.14	3.05	3.06	3.09	3.09	3.09	2.94	3.00	3.14
Germany	3.57	3.88	4.04	4.27	4.38	4.16	4.14	4.15	3.88	3.99	3.84	3.99	3.97	3.97	3.95	3.80	3.88	3.97
Lithuania	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Ireland	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Belarus	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Romania	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Turkey	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
United States of America	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Portugal	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	NO	NO	NO	NO	NO	NO
Slovakia	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	NO	NO	NO	NO	NO	NO	NO	NO
Slovenia	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	NO	NO	NO	NO	NO	NO
Netherlands	IE	IE	IE	IE	IE	0.10	0.10	0.10	0.10	0.10	NO	NO	NO	NO	NO	NO	NO	NO
Austria	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Croatia	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Denmark	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Denmark (Denmark (mainland) and Greenland)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Estonia	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Greece	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Iceland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Liechtenstein	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Luxembourg	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Monaco	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
New Zealand	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Norway	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Switzerland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B.10

1.AA.1.C-Manufacture of Solid Fuels and Other Energy Industries,,Solid Fuels,Implied emission factor,CH4,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Japan	0.05	0.06	0.07	0.08	0.05	0.05	0.12	0.06	0.07	0.10	0.11	0.11	0.08	0.10	0.09	0.09	0.12	0.16
Czech Republic	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Finland	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sweden	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Hungary	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	1.00	1.00
Russian Federation	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	1.00
Poland	1.00	1.00	1.00	1.14	1.07	1.05	1.05	1.04	1.05	1.06	1.00	1.11	1.33	1.18	1.06	1.08	1.02	1.03
Australia	1.06	1.05	1.07	1.05	1.06	1.06	1.10	1.07	1.07	1.05	1.06	1.07	1.09	1.13	1.13	1.14	1.12	1.12
Germany	1.56	1.55	1.57	1.57	1.55	1.56	1.56	1.55	1.57	1.56	1.52	1.50	1.53	1.55	1.55	1.59	1.53	1.53
Ukraine	IE	NE	NE	NE	NE	NE	NE	NE	3.56	3.49	3.56	3.55	3.56	3.52	3.67	3.59	1.81	1.77
Bulgaria	1.51	1.61	1.62	1.60	1.61	1.54	1.52	1.54	1.69	1.64	1.65	1.60	1.58	1.54	1.52	1.53	1.54	2.05
Canada	2.95	2.92	3.05	2.98	3.00	2.96	2.96	2.97	3.01	2.95	2.96	2.80	2.89	2.83	2.90	3.03	3.09	3.07
Latvia	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	28.60	27.64	28.13	24.46	8.57	9.04	9.04	13.58	30.00	9.04
France	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
France (KP)	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
European Community (15)	13.72	13.78	14.14	14.43	16.98	16.73	18.71	22.34	24.35	24.46	20.90	17.34	15.85	15.42	15.77	15.65	16.23	16.18
Italy	93.79	91.93	88.21	83.07	93.09	85.57	87.48	79.33	74.17	75.79	49.20	26.24	22.08	20.29	21.69	18.98	21.47	23.50
Belgium	13.26	12.01	11.30	11.22	15.03	15.03	11.45	11.12	10.92	11.24	11.04	10.39	13.62	11.35	8.03	0.58	0.58	25.75
Lithuania	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00
Ireland	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
United Kingdom of Great Britain and Northern Ireland	63.72	63.45	65.71	68.61	71.33	73.41	72.59	70.98	69.28	69.80	67.78	65.63	66.20	67.59	66.06	66.21	69.06	70.51
Spain	123.35	107.22	106.62	118.65	138.04	158.12	156.13	161.83	159.13	143.22	128.88	120.91	121.90	122.54	138.32	174.97	164.39	150.71
Belarus	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Romania	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Turkey	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
United States of America	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Slovakia	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NO	NO	NO	NO	NO	NO	NO	NO
Portugal	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	NO	NO	NO	NO	NO	NO
Slovenia	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	NO	NO	NO	NO	NO	NO
Netherlands	IE	IE	IE	IE	IE	2.80	2.80	2.80	2.80	2.80	NO	NO	NO	NO	NO	NO	NO	NO
Austria	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Croatia	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Denmark	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Denmark (Denmark (mainland) and Greenland)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Estonia	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Greece	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Iceland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Liechtenstein	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Luxembourg	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Monaco	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
New Zealand	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Norway	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Switzerland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Appendix C. CH_4 and N_2O implied emission factors in Manufacturing Industries and Construction (Annex 1 Parties)
Table C.1

1.AA.2-Manufacturing Industries and Construction,,Liquid Fuels,Implied emission factor,N2O,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Netherlands	0.22	0.27	0.27	0.26	0.26	0.27	0.25	0.24	0.25	0.25	0.24	0.22	0.21	0.21	0.20	0.21	0.19	0.18
New Zealand	0.39	0.39	0.39	0.40	0.40	0.39	0.39	0.40	0.41	0.41	0.42	0.43	0.43	0.44	0.44	0.44	0.44	0.43
Bulgaria	0.47	0.38	0.39	0.37	0.38	0.33	0.32	0.34	0.43	0.41	0.46	0.50	0.52	0.50	0.49	0.50	0.50	0.46
Australia	0.56	0.54	0.56	0.55	0.56	0.56	0.53	0.56	0.54	0.56	0.55	0.54	0.55	0.54	0.55	0.54	0.55	0.56
Slovakia	0.63	0.63	0.62	0.62	0.62	0.61	0.61	0.61	0.60	0.60	0.59	0.58	0.58	0.58	0.60	0.59	0.59	0.58
Estonia	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.58	0.59	0.59	0.58	0.58	0.58
Ukraine	0.60	NE	NE	NE	NE	NE	NE	NE	0.58	0.58	0.59	0.58	0.58	0.57	0.57	0.51	0.60	0.60
Belarus	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Croatia	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Czech Republic	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Liechtenstein	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Norway	0.64	0.52	0.87	1.13	1.52	1.73	1.32	1.30	0.59	0.55	0.53	0.54	0.53	0.54	0.53	0.52	0.59	0.60
Romania	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Russian Federation	0.60	0.60	0.66	0.70	0.70	0.70	0.66	0.64	0.65	0.63	0.64	0.65	0.66	0.64	0.60	0.52	0.60	0.60
Switzerland	0.69	0.68	0.67	0.67	0.67	0.66	0.66	0.65	0.65	0.64	0.64	0.64	0.63	0.63	0.63	0.63	0.63	0.63
Latvia	0.64	0.62	0.62	0.62	0.61	0.60	0.61	0.61	0.61	0.61	0.61	0.61	0.63	0.61	0.63	0.63	0.63	0.63
Greece	0.60	0.66	0.71	0.75	0.80	0.79	0.76	0.81	0.86	0.84	0.77	0.78	0.77	0.76	0.74	0.69	0.67	0.71
Japan	0.64	0.65	0.76	0.63	0.63	0.62	0.66	0.68	0.68	0.72	0.71	0.71	0.70	0.70	0.71	0.71	0.72	0.72
Portugal	0.79	0.78	0.79	0.79	0.80	0.81	0.79	0.79	0.76	0.75	0.75	0.74	0.74	0.75	0.77	0.77	0.79	0.81
Turkey	0.60	0.60	0.63	0.67	0.69	0.66	0.74	0.70	0.70	0.76	0.75	0.74	0.77	0.76	0.78	0.84	0.86	0.91
Hungary	5.27	4.76	4.64	4.65	4.95	3.73	3.81	2.68	2.08	2.50	1.67	2.20	1.61	2.42	1.98	1.04	1.11	0.92
Germany	1.59	1.53	1.52	1.51	1.52	1.30	1.29	1.30	1.32	1.32	1.34	1.28	1.29	1.20	1.25	1.26	1.25	1.32
Slovenia	3.86	3.67	3.03	2.89	2.92	3.71	4.36	5.56	6.12	5.25	6.42	6.07	6.04	6.19	7.46	6.38	6.91	1.33
United States of America	1.29	1.35	1.31	1.39	1.38	1.44	1.38	1.41	1.50	1.48	1.47	1.47	1.52	1.50	1.48	1.45	1.41	1.40
Canada	1.56	1.56	1.57	1.56	1.52	1.52	1.51	1.52	1.51	1.51	1.51	1.51	1.50	1.51	1.50	1.50	1.50	1.49
Lithuania	2.00	2.00	2.00	2.00	2.00	2.00	2.00	1.99	1.99	1.99	1.98	1.98	1.97	1.96	1.96	1.95	1.89	1.78
Finland	2.00	1.98	1.97	1.92	1.96	1.91	1.95	1.92	1.90	1.90	1.86	1.85	1.85	1.84	1.85	1.84	1.80	1.79
Spain	1.80	1.81	1.82	1.80	1.80	1.82	1.87	1.90	1.89	1.89	1.90	1.93	1.92	1.92	1.92	1.94	1.96	1.97
Belgium	0.87	0.85	0.88	0.82	0.82	0.94	0.95	0.92	0.93	1.03	1.19	1.09	0.89	0.75	0.64	0.75	1.09	2.23
France	2.20	2.14	2.13	2.10	2.12	2.12	2.09	2.08	2.08	2.10	2.16	2.15	2.19	2.22	2.23	2.42	2.67	2.52
France (KP)	2.21	2.15	2.14	2.11	2.13	2.14	2.10	2.09	2.09	2.12	2.18	2.16	2.21	2.25	2.25	2.46	2.73	2.57
Poland	7.00	6.99	6.46	6.19	5.48	4.98	4.59	4.14	2.86	2.38	2.36	2.24	2.20	2.07	2.31	2.38	2.40	2.66
Denmark	2.40	2.37	2.38	2.44	2.46	2.48	2.50	2.54	2.54	2.59	2.62	2.64	2.64	2.66	2.67	2.71	2.69	2.77
Denmark (Denmark (mainland) and Greenland)	2.40	2.37	2.38	2.44	2.46	2.48	2.50	2.54	2.54	2.59	2.62	2.64	2.64	2.66	2.67	2.71	2.69	2.77
Austria	3.08	3.08	3.80	3.47	3.73	4.12	5.19	4.19	5.08	6.43	7.42	7.12	8.00	7.70	6.94	6.55	5.55	5.35
European Community (15)	4.17	4.05	4.16	4.11	4.18	4.32	4.39	4.43	4.50	4.64	4.94	4.86	5.06	5.01	5.09	5.20	5.27	5.40
Sweden	8.33	8.62	9.00	9.25	8.90	8.93	8.80	8.65	8.69	9.02	8.78	8.60	8.62	8.63	8.71	9.23	9.14	9.41
Ireland	9.53	9.60	9.60	9.58	9.70	9.73	9.61	9.77	9.75	9.78	9.90	9.99	9.98	10.01	10.02	9.98	9.96	10.07
Italy	8.23	8.84	9.57	9.16	8.94	9.39	9.57	9.42	9.97	9.35	10.22	10.46	11.23	10.32	10.49	11.25	11.22	11.87
United Kingdom of Great Britain and Northern Ireland	8.81	7.96	8.09	8.07	8.60	9.65	9.90	10.70	10.88	11.33	11.36	10.50	12.21	12.40	12.02	11.25	12.23	12.47
Luxembourg	5.71	4.30	5.21	4.51	4.28	4.95	5.33	7.55	9.15	11.01	13.78	11.23	11.28	11.25	12.45	14.05	15.12	14.78
Iceland	12.16	14.86	11.04	11.09	12.00	13.82	11.92	12.43	13.41	13.79	15.74	14.11	12.82	12.93	14.72	16.81	16.38	17.79
Monaco	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO

Table C.2

1.AA.2-Manufacturing Industries and Construction,,Solid Fuels,Implied emission factor,N2O,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Netherlands	0.57	0.52	0.48	0.48	0.27	0.51	0.24	0.28	0.28	0.31	0.27	0.25	0.25	0.22	0.20	0.19	0.21	0.26
Belgium	0.38	0.34	0.35	0.34	0.31	0.27	0.23	0.29	0.26	0.30	0.31	0.30	0.28	0.31	0.30	0.30	0.34	0.55
Estonia	0.39	0.40	0.27	0.12	0.04	0.06	0.10	0.15	0.14	0.20	0.49	0.76	0.45	0.51	0.56	0.37	0.65	0.65
Portugal	0.76	0.76	0.79	0.80	0.78	0.76	0.77	0.80	0.83	0.85	0.83	0.88	0.70	0.70	0.70	0.70	0.70	0.70
Canada	0.71	0.72	0.71	0.71	0.71	0.71	0.71	0.72	0.71	0.71	0.72	0.71	0.71	0.71	0.71	0.71	0.71	0.71
Australia	0.70	0.70	0.70	0.70	0.70	0.70	0.69	0.70	0.70	0.71	0.72	0.72	0.72	0.73	0.72	0.73	0.72	0.72
Ukraine	1.40	NE	NE	NE	NE	NE	NE	NE	0.71	0.81	0.74	0.73	0.79	0.83	0.84	0.91	0.89	0.84
Norway	0.78	0.75	0.75	0.56	0.53	0.54	0.59	0.66	0.62	0.52	0.77	0.52	0.37	0.50	0.85	0.79	0.94	0.84
Slovakia	1.17	1.18	1.19	1.19	1.19	1.18	1.17	1.16	1.14	1.12	1.14	1.13	1.08	1.07	1.08	1.06	1.04	1.01
Austria	1.05	1.14	1.16	1.12	1.13	1.19	1.17	1.18	1.34	1.29	1.33	1.27	1.20	1.18	1.17	1.13	1.22	1.25
Bulgaria	1.51	1.43	1.41	1.34	1.33	1.32	1.35	1.36	1.37	1.22	1.07	1.14	1.19	1.20	1.19	1.19	1.16	1.26
Belarus	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Croatia	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Czech Republic	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Iceland	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Latvia	1.40	1.45	1.42	1.40	1.42	1.45	1.45	1.49	1.50	1.46	1.40	1.40	1.40	1.40	1.46	1.40	1.40	1.40
Romania	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Russian Federation	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Slovenia	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Finland	3.47	3.31	3.14	3.47	3.34	3.46	3.55	3.78	3.52	3.64	3.59	4.04	3.77	3.67	3.71	3.76	1.43	1.43
Turkey	1.57	1.58	1.58	1.58	1.55	1.55	1.52	2.22	1.52	1.52	1.51	1.55	1.51	1.50	1.48	1.50	1.49	1.48
Poland	1.33	1.44	1.44	1.46	1.48	1.45	1.42	1.42	1.39	1.32	1.40	1.43	1.46	1.47	1.44	1.50	1.54	1.49
Luxembourg	0.83	0.81	0.82	0.82	0.86	1.01	1.03	1.12	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
United States of America	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Greece	1.40	1.43	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.49	1.61	1.53
New Zealand	1.55	1.55	1.55	1.55	1.55	1.54	1.54	1.54	1.54	1.53	1.53	1.54	1.54	1.55	1.53	1.53	1.54	1.54
Switzerland	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
Germany	2.55	2.46	2.48	2.42	2.35	2.47	2.29	2.37	2.16	2.23	1.87	2.00	1.92	1.92	1.78	1.85	1.87	1.90
France (KP)	2.21	2.24	2.27	2.13	2.21	2.14	2.14	2.07	2.00	1.95	1.96	2.06	1.86	1.89	1.93	2.00	2.08	2.13
France	2.22	2.24	2.27	2.14	2.21	2.15	2.16	2.08	2.02	1.97	1.98	2.08	1.89	1.92	1.95	2.02	2.10	2.15
Spain	2.51	2.38	2.27	2.29	2.39	2.40	2.38	2.29	2.25	2.29	2.21	2.20	2.25	2.27	2.19	2.13	2.11	2.20
European Community (15)	2.78	2.78	2.81	2.70	2.61	2.58	2.51	2.46	2.33	2.40	2.22	2.29	2.22	2.25	2.23	2.32	2.26	2.28
Italy	2.95	2.96	3.03	2.68	2.64	2.24	2.34	2.11	2.14	2.40	2.10	2.01	2.01	2.37	2.60	2.71	2.53	2.48
Denmark	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Denmark (Denmark (mainland) and Greenland)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Hungary	3.00	3.00	3.00	3.00	3.03	3.02	3.02	3.02	3.00	3.00	3.01	3.00	3.01	3.02	3.02	3.01	3.00	3.00
Ireland	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Lithuania	3.09	3.04	3.07	3.05	3.09	3.24	3.15	3.12	3.07	3.05	3.08	3.08	3.01	3.01	3.00	3.00	3.00	3.01
Japan	1.58	1.74	1.83	1.98	2.19	2.25	2.35	2.57	2.70	2.78	2.68	2.96	2.87	2.85	2.83	3.26	3.18	3.11
United Kingdom of Great Britain and Northern Ireland	5.37	5.42	5.58	5.14	4.95	4.75	4.77	4.37	4.23	4.45	4.42	4.46	4.53	4.45	4.44	4.43	4.34	4.20
Sweden	16.68	16.53	15.43	15.45	15.32	15.72	15.17	15.31	15.39	14.42	15.15	14.60	14.33	14.39	14.35	14.28	14.13	14.25
Monaco	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Liechtenstein	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table C.3

1.AA.2-Manufacturing Industries and Construction,,Gaseous Fuels,Implied emission factor,N2O,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Austria	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Belarus	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Belgium	0.10	0.11	0.11	0.11	0.11	0.13	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.08	0.10
Bulgaria	0.08	0.08	0.08	0.08	0.08	0.09	0.08	0.08	0.09	0.08	0.07	0.07	0.07	0.08	0.07	0.07	0.10	0.10
Croatia	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Czech Republic	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Estonia	0.10	0.13	0.15	0.10	0.07	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Latvia	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Liechtenstein	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Luxembourg	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Netherlands	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Poland	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Romania	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Russian Federation	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Slovakia	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Slovenia	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Switzerland	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Ukraine	0.10	NE	NE	NE	NE	NE	NE	NE	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
United States of America	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Turkey	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.87	0.10	0.10	0.11	0.11	0.11	0.10	0.10	0.10	0.11	0.11
Australia	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
United Kingdom of Great Britain and Northern Ireland	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	1.32	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
New Zealand	0.12	0.14	0.13	0.14	0.15	0.17	0.19	0.18	0.16	0.18	0.21	0.20	0.20	0.14	0.14	0.11	0.11	0.11
Norway	NO	NO	NO	NO	0.49	0.41	0.39	0.39	0.38	0.37	0.35	0.38	0.38	0.40	0.37	0.36	0.36	0.35
Greece	0.18	0.17	0.16	0.24	1.27	1.56	1.44	0.46	0.28	0.52	0.59	0.48	0.51	0.58	0.58	0.63	0.62	0.54
Japan	0.91	0.89	0.89	0.90	0.89	0.87	0.86	0.83	0.82	0.80	0.79	0.78	0.78	0.78	0.77	0.76	0.75	0.73
Germany	0.79	0.78	0.79	0.79	0.78	0.92	0.90	0.89	0.87	0.85	0.83	0.83	0.83	0.81	0.80	0.80	0.78	0.77
Lithuania	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
European Community (15)	0.87	0.89	0.90	0.90	0.89	0.93	0.92	0.92	0.94	0.92	0.94	0.97	1.00	1.00	1.00	1.01	1.03	1.02
Italy	0.95	1.01	1.00	0.97	0.97	0.96	0.94	0.92	0.99	0.97	0.97	1.00	1.02	1.02	1.03	1.04	1.06	1.04
Denmark	1.02	1.02	1.03	1.03	1.02	1.03	1.09	1.11	1.16	1.19	1.21	1.18	1.21	1.21	1.22	1.19	1.16	1.15
Denmark (Denmark (mainland) and Greenland)	1.02	1.02	1.03	1.03	1.02	1.03	1.09	1.11	1.16	1.19	1.21	1.18	1.21	1.21	1.22	1.19	1.16	1.15
Canada	1.11	1.12	1.13	1.13	1.08	1.11	1.09	1.09	1.10	1.09	1.12	1.16	1.13	1.11	1.11	1.20	1.19	1.18
Finland	1.23	1.24	1.24	1.22	1.22	1.18	1.28	1.29	1.30	1.32	1.37	1.31	1.30	1.29	1.30	1.29	1.27	1.25
Portugal	NO	NO	NO	NO	NO	NO	IE,NO	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Spain	1.43	1.44	1.47	1.49	1.58	1.50	1.52	1.53	1.54	1.53	1.50	1.50	1.51	1.45	1.44	1.44	1.46	1.47
Sweden	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
France	2.46	2.46	2.47	2.46	2.47	2.47	2.46	2.46	2.46	2.46	2.48	2.49	2.49	2.50	2.49	2.58	2.70	2.61
France (KP)	2.46	2.46	2.47	2.46	2.47	2.47	2.46	2.46	2.46	2.46	2.48	2.49	2.49	2.50	2.49	2.58	2.70	2.61
Hungary	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Ireland	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Iceland	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Monaco	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO

Table C.4

1.AA.2-Manufacturing Industries and Construction,,Biomass,Implied emission factor,N2O,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Japan	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.18	0.18	0.18	0.17	0.17	0.17	0.17	0.17	0.16	0.16
Switzerland	0.93	0.96	1.00	1.03	1.05	1.07	1.08	1.05	1.03	1.00	1.03	1.05	1.03	1.02	1.01	1.01	1.03	1.10
Canada	1.42	1.42	1.41	1.41	1.40	1.41	1.40	1.40	1.39	1.39	1.39	1.39	1.37	1.37	1.36	1.35	1.33	1.34
Finland	1.40	1.34	1.28	1.33	1.36	1.38	1.49	1.52	1.52	1.52	1.55	1.58	1.44	1.42	1.46	1.46	1.41	1.37
Bulgaria	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.52	1.40	1.40
Belgium	1.55	1.61	1.57	1.11	1.14	1.12	1.03	1.17	1.56	1.56	1.35	1.04	1.19	0.81	0.92	0.94	1.11	1.78
Portugal	2.49	2.38	2.40	2.48	2.44	2.45	2.47	2.40	2.40	2.42	2.34	2.33	2.34	2.42	2.34	2.32	2.31	2.34
Germany	2.69	2.49	2.48	2.29	2.21	2.00	1.77	1.98	1.89	1.89	1.96	1.91	1.82	1.67	2.30	2.34	2.36	2.40
European Community (15)	2.92	2.90	2.93	2.85	2.87	2.80	2.86	2.82	2.79	2.73	2.67	2.72	2.66	2.62	2.64	2.67	2.67	2.70
Austria	2.35	2.37	2.38	2.49	2.47	2.34	2.29	2.31	2.13	2.62	2.42	2.45	2.38	2.44	2.38	2.42	2.66	2.71
France	3.38	3.40	3.41	3.42	3.35	3.04	3.36	3.39	3.29	2.98	2.96	2.61	3.11	3.04	3.03	3.04	3.10	3.14
France (KP)	3.38	3.40	3.41	3.42	3.35	3.04	3.36	3.39	3.29	2.98	2.96	2.61	3.11	3.04	3.03	3.04	3.10	3.14
Netherlands	3.53	2.91	2.89	2.90	2.82	2.75	2.78	2.89	2.94	2.98	2.97	3.03	3.10	3.04	3.14	3.31	3.41	3.38
Czech Republic	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	3.32	3.35	3.20	3.49	3.73
United States of America	3.79	3.79	3.79	3.79	3.79	3.79	3.79	3.79	3.79	3.79	3.79	3.78	3.78	3.78	3.77	3.77	3.77	3.76
Spain	3.86	3.87	3.87	3.86	3.87	3.90	3.87	3.88	3.88	3.88	3.88	3.88	3.89	3.90	3.90	3.89	3.90	3.90
Denmark	4.00	4.00	4.00	4.00	3.99	3.94	3.95	3.94	3.96	3.98	3.98	3.96	3.95	3.94	3.94	3.94	3.88	3.92
Denmark (Denmark (mainland) and Greenland)	4.00	4.00	4.00	4.00	3.99	3.94	3.95	3.94	3.96	3.98	3.98	3.96	3.95	3.94	3.94	3.94	3.88	3.92
Italy	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	3.91	3.92	3.92	3.92	3.93	3.93
New Zealand	4.00	4.00	4.00	4.00	3.91	3.91	3.94	3.94	3.94	3.97	3.97	3.97	3.97	3.97	3.98	3.97	3.96	3.96
Belarus	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	3.99
Lithuania	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	1.32	4.00	4.00	4.00	4.00	4.00	4.00	4.00	3.99
Poland	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	3.99	3.99	4.00	3.99	3.99	3.99	3.99	3.99
Latvia	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Croatia	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Estonia	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Greece	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.13	4.03	4.01	4.01	4.00	4.00	4.00	4.00	4.00
Ireland	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Luxembourg	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	4.00	4.00	4.00	4.00	4.00	4.00
Romania	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Russian Federation	13.25	13.24	NE	NE	NE	NE	NE	NE	516.91	599.46	11.09	9.50	11.00	5.76	11.63	12.66	17.12	4.00
Slovakia	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Slovenia	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Ukraine	4.00	NE	NE	NE	NE	NE	NE	NE	4.00	3.99	4.00	4.00	4.00	4.00	4.00	4.00	3.99	4.00
Australia	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.31	4.31	4.31	4.31	4.30	4.30	4.30
United Kingdom of Great Britain and Northern Ireland	3.11	3.11	3.11	3.11	3.11	3.11	3.21	3.23	3.23	3.23	3.23	3.23	3.23	3.23	4.49	4.49	4.49	4.49
Sweden	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	4.99	4.98	5.00	4.98	5.00	5.00	5.00	4.99	4.98
Norway	7.89	8.04	7.81	7.48	7.60	7.75	8.16	7.92	8.69	6.54	6.53	7.22	7.22	7.21	7.19	6.00	6.34	6.17
Hungary	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	78.68	61.44
Monaco	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Iceland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Liechtenstein	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Turkey	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table C.5

1.AA.2-Manufacturing Industries and Construction,,Liquid Fuels,Implied emission factor,CH4,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Hungary	1.24	1.25	1.16	1.15	1.17	1.01	1.08	0.81	0.58	0.75	0.52	0.67	0.51	0.68	0.57	0.34	0.34	0.28
New Zealand	0.92	0.96	0.96	0.94	0.96	1.02	1.07	1.07	0.90	0.92	0.96	0.90	0.90	0.81	0.61	0.60	0.59	0.56
Liechtenstein	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Greece	1.71	1.73	1.72	1.65	1.58	1.43	1.45	1.44	1.40	1.31	1.30	1.25	1.25	1.19	1.25	1.04	1.14	1.12
Switzerland	2.10	1.88	1.73	1.72	1.63	1.61	1.47	1.41	1.37	1.35	1.39	1.41	1.35	1.35	1.36	1.38	1.43	1.39
Austria	1.47	1.50	1.52	1.43	1.48	1.40	1.42	1.33	1.36	1.44	1.50	1.41	1.57	1.63	1.61	1.62	1.52	1.51
Japan	1.76	1.80	1.89	1.93	1.87	1.87	2.00	1.87	1.74	1.66	1.62	1.64	1.58	1.56	1.55	1.61	1.68	1.72
Bulgaria	2.51	2.75	2.78	2.67	2.70	2.45	2.41	2.50	2.17	2.49	2.20	2.40	2.14	2.11	2.05	1.78	2.06	1.94
Belarus	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Croatia	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Czech Republic	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Romania	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Russian Federation	2.00	2.00	2.21	2.32	2.32	2.33	2.20	2.15	2.16	2.11	2.15	2.17	2.19	2.12	2.00	1.74	2.00	2.00
Spain	2.51	2.48	2.48	2.51	2.43	2.38	2.23	2.11	2.14	2.14	2.05	1.99	2.04	2.03	2.01	2.00	2.00	2.05
Slovakia	2.32	2.30	2.29	2.27	2.25	2.23	2.21	2.19	2.18	2.17	2.06	2.13	2.12	2.12	2.06	2.09	2.04	2.12
Finland	2.02	1.99	1.94	1.99	2.00	2.06	2.08	2.02	1.99	1.99	2.04	2.05	2.08	2.06	2.03	2.05	2.07	2.14
Poland	3.19	3.02	2.95	2.98	2.99	3.08	2.95	2.88	2.68	2.58	2.38	2.36	2.31	2.24	2.27	2.45	2.20	2.16
Sweden	2.10	2.12	2.15	2.18	2.16	2.16	2.15	2.15	2.15	2.19	2.17	2.15	2.15	2.13	2.13	2.20	2.18	2.19
Ukraine	2.00	NE	NE	NE	NE	NE	NE	NE	2.92	2.90	2.79	2.78	2.80	2.82	2.76	2.01	2.62	2.54
Canada	2.82	2.85	2.88	2.83	2.71	2.67	2.67	2.70	2.70	2.70	2.68	2.71	2.67	2.70	2.66	2.64	2.65	2.64
Belgium	2.25	2.15	2.32	2.47	2.51	2.70	2.87	4.26	3.00	2.73	2.51	2.92	2.90	3.26	2.17	2.60	2.10	2.64
Germany	3.41	3.37	3.37	3.31	3.17	2.58	2.60	2.54	2.54	1.32	2.61	2.49	2.54	2.51	2.61	2.69	2.60	2.73
Latvia	3.46	2.56	2.66	2.64	2.40	2.13	2.40	2.27	2.33	2.19	2.28	2.43	2.92	2.45	2.94	3.16	2.99	3.05
Iceland	2.77	2.93	2.70	2.71	2.77	2.87	2.76	2.79	2.84	2.85	2.96	2.88	2.81	2.92	2.99	3.08	3.02	3.19
Australia	4.22	4.12	4.26	4.29	4.44	4.34	4.10	4.14	4.01	4.07	3.79	3.61	3.67	3.65	3.75	3.64	3.70	3.44
Lithuania	3.73	3.78	4.56	4.04	4.37	4.15	4.68	4.19	4.01	4.62	4.38	3.66	3.75	4.30	4.03	4.31	4.06	3.55
Norway	3.47	3.12	3.55	3.59	3.49	3.59	3.32	3.54	3.10	3.14	3.16	3.20	3.32	3.34	3.35	3.53	3.61	3.63
Italy	4.13	4.06	4.13	4.35	4.16	4.60	4.60	4.62	4.58	3.73	3.88	4.19	4.68	4.02	3.90	4.15	3.93	3.66
European Community (15)	3.48	3.45	3.48	3.44	3.41	3.40	3.40	3.49	3.45	3.40	3.45	3.52	3.66	3.63	3.63	3.66	3.62	3.67
Slovenia	6.23	3.41	3.10	3.42	3.28	3.09	3.42	4.06	4.53	4.19	4.39	4.70	5.11	5.08	3.61	3.63	3.92	3.75
Netherlands	3.42	3.65	3.66	3.68	3.67	3.54	3.56	3.63	3.66	3.70	3.70	3.68	3.72	3.74	4.09	4.16	4.06	3.89
Luxembourg	3.02	3.04	3.08	3.05	3.01	3.55	4.14	4.43	4.36	4.16	4.30	4.37	3.90	3.85	3.92	3.86	3.98	3.93
France	4.00	3.97	3.83	3.36	3.42	3.44	3.38	3.45	3.42	3.46	3.59	3.45	3.62	4.07	4.06	3.85	3.91	3.96
France (KP)	4.08	4.07	3.92	3.44	3.50	3.53	3.46	3.54	3.51	3.55	3.70	3.55	3.76	4.25	4.23	4.03	4.11	4.16
United Kingdom of Great Britain and Northern Ireland	3.98	3.78	3.82	3.80	3.93	4.16	4.21	4.39	4.43	4.53	4.54	4.32	4.72	4.73	4.65	4.47	4.68	4.70
Estonia	2.49	2.42	2.63	2.39	2.26	2.95	2.50	2.53	3.49	4.33	4.31	4.12	4.28	4.31	4.03	4.38	4.74	4.81
United States of America	4.81	4.97	4.86	5.07	5.07	5.22	5.07	5.14	5.38	5.31	5.28	5.25	5.38	5.32	5.30	5.22	5.13	5.11
Turkey	2.34	2.30	2.62	2.98	3.19	2.91	3.60	3.50	3.26	3.76	3.68	3.59	3.88	3.75	3.95	4.49	4.67	5.30
Denmark	4.57	4.40	4.46	4.66	4.71	4.79	5.10	5.30	5.12	5.64	5.81	6.06	6.02	6.07	6.16	6.14	5.97	6.24
Denmark (Denmark (mainland) and Greenland)	4.57	4.40	4.46	4.66	4.71	4.79	5.10	5.30	5.12	5.64	5.81	6.06	6.02	6.07	6.16	6.14	5.97	6.24
Portugal	5.51	5.87	6.54	6.67	6.70	6.89	7.08	6.98	7.15	7.50	6.71	7.22	7.21	7.33	7.26	7.01	6.85	7.13
Ireland	4.99	6.68	4.87	4.51	5.02	5.63	3.64	6.47	5.95	6.01	8.55	11.39	11.22	12.01	12.29	12.52	13.40	15.54
Monaco	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO

Table C.6

1.AA.2-Manufacturing Industries and Construction,,Solid Fuels,Implied emission factor,CH4,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
New Zealand	0.77	0.77	0.78	0.77	0.77	0.79	0.79	0.79	0.79	0.80	0.80	0.79	0.79	0.77	0.81	0.80	0.80	0.79
Iceland	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Finland	1.50	1.47	1.44	1.33	1.29	1.28	1.32	1.30	1.25	1.20	1.06	1.08	1.08	1.05	1.05	1.05	1.07	1.06
Australia	1.24	1.25	1.25	1.26	1.26	1.26	1.26	1.26	1.24	1.25	1.25	1.25	1.24	1.24	1.24	1.24	1.24	1.25
Greece	0.93	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	1.62	1.35
Canada	1.26	1.22	1.26	1.29	1.32	1.29	1.29	1.27	1.27	1.27	1.25	1.28	1.31	1.32	1.35	1.38	1.40	1.41
Bulgaria	1.31	1.05	1.09	1.02	1.01	0.92	0.93	1.00	1.19	1.44	1.36	1.35	1.31	1.41	1.46	1.58	1.68	1.64
Switzerland	1.78	1.89	2.06	1.91	1.67	1.44	2.21	2.19	2.19	2.30	1.24	1.37	2.02	1.89	1.75	1.76	1.67	1.74
Sweden	2.11	2.49	2.25	2.66	2.44	2.83	2.59	2.34	2.35	2.18	2.02	2.77	2.14	2.25	2.21	2.03	1.91	2.18
Austria	1.53	1.68	1.93	1.74	1.56	1.55	1.65	1.65	1.88	1.64	1.76	1.67	1.50	1.91	2.02	2.05	2.28	2.23
Norway	3.17	3.36	3.06	2.52	2.56	2.61	2.79	2.78	2.69	2.37	2.90	2.42	2.15	2.40	3.11	3.07	3.30	3.17
Netherlands	3.80	1.57	1.54	1.48	1.76	3.85	3.72	3.86	3.86	3.84	3.78	3.48	3.75	3.47	2.01	1.61	2.39	3.18
Japan	4.33	4.34	4.28	4.28	4.39	4.33	4.38	4.08	3.90	3.85	3.95	3.89	3.86	3.84	3.82	3.61	3.66	3.60
Estonia	2.84	2.84	1.95	0.88	0.32	0.43	0.70	1.09	1.03	1.45	3.51	5.44	3.28	3.73	4.33	3.11	4.87	4.76
Germany	6.18	5.83	5.97	6.10	6.13	4.35	4.68	4.50	4.87	4.75	4.83	4.97	4.68	4.51	4.94	4.73	4.80	5.50
Ukraine	10.00	NE	NE	NE	NE	NE	NE	NE	5.83	5.91	5.89	6.38	6.83	7.10	7.25	7.56	7.13	6.99
Slovakia	9.12	9.16	9.18	9.19	9.19	9.16	9.12	9.06	8.99	8.90	8.99	8.97	8.76	8.72	8.77	8.61	8.57	8.48
Belarus	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Croatia	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.01	10.00	10.00	10.00	10.00	10.00	10.00
Czech Republic	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Latvia	10.00	10.40	10.18	10.00	10.19	10.38	10.40	10.69	10.75	10.44	10.00	10.00	10.00	10.00	10.49	10.00	10.00	10.00
Luxembourg	5.70	5.53	5.60	5.61	5.88	6.84	6.97	7.57	10.00	1.32	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Romania	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Russian Federation	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	9.99	10.00	10.00
Slovenia	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
United States of America	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Poland	9.18	9.95	9.98	9.96	10.18	9.90	9.63	9.61	9.41	9.10	9.56	9.77	9.97	10.07	9.86	10.28	10.68	10.24
Turkey	11.20	11.26	11.30	11.26	11.06	11.06	10.82	15.82	10.88	10.87	10.80	11.07	10.81	10.72	10.58	10.74	10.65	10.60
Portugal	8.63	7.70	8.73	9.14	8.45	9.40	9.71	10.36	10.18	10.61	9.96	10.63	12.52	12.30	20.71	93.52	69.12	11.60
Belgium	13.84	12.53	11.70	10.91	10.45	10.52	9.62	9.57	10.27	10.53	12.80	14.30	13.49	13.96	14.17	12.34	14.82	13.66
Denmark	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Denmark (Denmark (mainland) and Greenland)	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Lithuania	16.46	15.66	16.16	15.80	16.50	19.12	17.52	17.01	16.27	15.86	16.34	16.29	15.10	15.08	15.07	15.07	15.05	15.08
European Community (15)	13.12	13.41	13.25	13.95	14.14	14.02	14.65	14.71	15.16	15.23	15.29	14.99	14.87	15.05	16.36	15.81	14.61	16.36
Italy	15.97	16.13	15.59	16.87	16.77	18.26	17.86	17.60	17.41	16.44	16.40	15.36	15.69	15.32	14.67	17.61	16.36	17.90
Spain	6.52	6.39	6.45	7.79	6.87	7.39	8.00	6.57	6.90	9.88	12.37	11.56	11.83	19.16	22.36	24.12	24.37	20.67
France	29.13	28.41	26.06	28.41	28.43	29.04	27.67	29.94	31.54	32.25	31.50	28.93	35.93	29.47	37.59	27.78	18.27	30.38
France (KP)	29.37	28.66	26.28	28.79	28.75	29.49	28.12	30.45	32.15	32.85	32.07	29.50	36.89	30.15	38.26	28.27	18.62	31.02
United Kingdom of Great Britain and Northern Ireland	31.08	30.76	29.62	31.38	33.55	36.62	41.36	44.00	45.07	45.09	45.34	41.64	40.12	43.54	44.76	44.77	45.97	44.88
Hungary	99.50	99.50	99.50	99.50	99.50	99.50	99.50	99.50	99.50	99.50	99.50	99.50	99.50	99.50	99.50	99.50	99.50	99.50
Ireland	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.90
Monaco	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Liechtenstein	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table C.7

1.AA.2-Manufacturing Industries and Construction,,Gaseous Fuels,Implied emission factor,CH4,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Greece	0.36	0.35	0.31	0.49	2.54	3.12	2.62	0.64	0.53	0.92	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00
Italy	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Luxembourg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Poland	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sweden	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
United States of America	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Canada	1.13	1.13	1.12	1.12	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.10	1.11	1.10
Australia	1.19	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.21	1.20	1.20
Finland	1.20	1.22	1.24	1.27	1.22	1.24	1.19	1.31	1.27	1.24	1.27	1.23	1.20	1.23	1.22	1.22	1.18	1.21
Bulgaria	1.14	1.31	1.37	1.52	1.46	1.50	1.47	1.33	1.45	1.43	1.13	1.04	1.12	1.13	1.08	1.13	1.28	1.21
Austria	1.36	1.37	1.37	1.37	1.39	1.38	1.38	1.37	1.36	1.35	1.38	1.37	1.39	1.45	1.45	1.47	1.48	1.47
Germany	1.55	1.52	1.54	1.51	1.50	1.46	1.47	1.50	1.50	1.49	1.48	1.47	1.48	1.43	1.46	1.47	1.47	1.48
Hungary	1.50	1.50	1.47	1.48	1.50	1.46	1.48	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Ireland	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
New Zealand	1.70	2.01	1.86	1.96	2.28	2.66	2.99	3.07	2.93	3.00	3.57	3.43	3.51	2.64	2.63	2.21	2.16	2.11
Norway	NO	NO	NO	NO	1.75	2.48	2.75	2.96	3.14	3.19	3.42	2.81	2.98	2.91	3.15	3.22	3.19	3.41
Ukraine	5.00	NE	NE	NE	NE	NE	NE	NE	3.14	3.28	3.39	3.47	3.55	3.59	3.66	3.72	3.68	3.86
France	4.35	4.35	3.76	3.79	3.80	3.89	3.89	3.85	3.89	3.84	3.87	4.04	3.98	4.02	3.95	3.91	3.85	3.87
France (KP)	4.35	4.35	3.76	3.79	3.80	3.89	3.89	3.85	3.89	3.84	3.87	4.04	3.98	4.02	3.95	3.91	3.85	3.87
Lithuania	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
European Community (15)	3.20	3.22	3.15	3.18	3.24	3.33	3.61	3.68	3.90	3.94	4.07	4.11	4.07	4.18	4.12	4.18	4.14	4.12
Japan	6.22	6.47	6.75	6.77	6.50	6.20	6.40	6.28	6.36	1.32	5.83	5.84	5.60	5.32	5.09	4.92	4.69	4.45
Belgium	4.81	4.93	4.87	4.92	4.74	4.58	4.70	4.70	4.67	4.58	4.66	4.56	4.53	4.49	4.43	4.36	4.49	4.50
Slovakia	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	4.80	5.00
Belarus	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Croatia	4.76	4.90	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Czech Republic	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Estonia	5.00	6.33	7.28	5.19	3.56	5.00	5.00	5.00	5.01	5.01	5.00	5.01	5.01	5.00	5.00	5.00	5.00	5.00
Latvia	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Romania	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Russian Federation	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Slovenia	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Turkey	5.00	5.00	5.00	5.00	5.00	5.00	5.00	43.24	5.00	5.00	5.64	5.41	5.42	5.15	5.22	5.14	5.27	5.32
United Kingdom of Great Britain and Northern Ireland	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56
Switzerland	5.89	6.00	5.98	5.99	5.99	5.96	5.99	6.00	5.99	5.98	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Liechtenstein	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Netherlands	6.23	6.43	6.69	7.08	7.57	8.17	9.03	9.49	10.44	10.33	10.44	9.75	8.80	9.11	7.13	7.22	7.30	7.24
Spain	2.96	3.38	3.73	4.06	4.36	4.73	5.11	5.54	6.00	6.43	6.81	7.11	7.29	7.83	8.13	8.50	8.63	8.92
Portugal	NO	NO	NO	NO	NO	NO	NO	10.08	6.16	8.95	9.69	9.14	8.34	8.16	8.52	9.07	10.04	9.64
Denmark	5.91	5.86	5.85	5.86	6.43	8.99	20.56	19.26	20.94	19.54	25.21	25.46	25.58	25.62	25.67	21.00	17.23	11.24
Denmark (Denmark (mainland) and Greenland)	5.91	5.86	5.85	5.86	6.43	8.99	20.56	19.26	20.94	19.54	25.21	25.46	25.58	25.62	25.67	21.00	17.23	11.24
Iceland	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Monaco	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO

Table C.8

1.AA.2-Manufacturing Industries and Construction,,Biomass,Implied emission factor,CH4,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Austria	2.00	2.00	2.00	2.00	2.00	2.00	2.00	1.99	1.99	1.99	1.99	1.99	1.97	1.99	1.99	2.00	2.00	2.00
Germany	15.16	12.35	11.65	11.65	11.94	3.23	2.79	2.86	2.55	2.45	2.15	2.16	2.17	2.20	2.02	2.02	2.01	2.00
Finland	2.49	2.54	2.59	2.61	2.67	2.79	2.71	2.57	2.46	2.41	2.53	2.55	2.36	2.40	2.37	2.51	2.39	2.13
Canada	3.54	3.54	3.53	3.52	3.51	3.52	3.50	3.50	3.47	3.47	3.46	3.47	3.44	3.42	3.40	3.38	3.32	3.35
France	3.94	3.93	3.91	3.90	3.98	4.35	3.96	3.92	3.90	4.18	4.09	4.27	3.65	3.71	3.77	3.79	3.75	3.73
France (KP)	3.94	3.93	3.91	3.90	3.98	4.35	3.96	3.92	3.90	4.18	4.09	4.27	3.65	3.71	3.77	3.79	3.75	3.73
Japan	4.33	4.31	4.30	4.31	4.34	4.35	4.34	4.37	4.41	4.44	4.41	4.39	4.36	4.35	4.22	4.16	4.07	4.02
Australia	8.60	8.54	8.37	8.53	8.51	8.57	8.67	8.72	8.75	8.72	8.70	8.67	8.59	8.63	8.68	8.65	8.73	8.70
Belgium	12.96	13.24	13.30	14.10	12.63	11.69	10.78	11.16	12.40	12.63	12.19	10.38	10.73	8.90	11.97	11.24	9.95	9.36
European Community (15)	13.20	12.91	13.38	12.81	13.19	12.65	12.64	11.97	11.70	11.21	10.65	11.76	11.09	10.79	10.03	9.96	9.69	9.66
Spain	18.56	18.56	18.10	18.39	17.91	17.74	17.78	17.05	15.69	15.42	15.43	16.19	15.58	14.76	14.23	14.30	14.24	14.11
New Zealand	15.00	15.00	15.00	15.00	14.31	14.30	14.51	14.53	14.56	14.76	14.80	14.79	14.77	14.75	14.86	14.74	14.69	14.67
Bulgaria	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	16.29	15.00	15.00
Switzerland	17.86	18.32	18.66	19.04	19.26	19.36	19.20	18.87	18.57	18.21	20.07	20.85	19.62	18.83	18.61	18.35	18.24	18.51
Norway	25.62	25.07	23.78	23.50	24.09	24.02	22.72	21.79	25.23	23.75	23.61	23.03	22.89	22.76	22.77	21.56	22.75	21.64
Portugal	21.69	21.49	21.56	21.54	22.05	22.91	22.06	22.19	22.36	22.40	22.19	22.42	23.83	23.15	22.02	22.52	22.70	22.98
Sweden	28.37	26.37	28.48	28.53	29.05	29.36	29.40	29.00	28.34	28.47	27.56	28.42	27.71	28.24	28.56	28.21	27.72	27.87
United States of America	28.40	28.40	28.40	28.40	28.40	28.39	28.40	28.40	28.40	28.40	28.40	28.37	28.36	28.33	28.30	28.29	28.25	28.19
Czech Republic	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	25.64	25.80	24.86	26.72	28.25
Denmark	31.88	31.87	31.83	31.83	31.75	31.02	31.20	31.08	31.34	31.54	29.25	27.00	23.96	25.08	23.37	23.17	28.63	28.36
Denmark (Denmark (mainland) and Greenland)	31.88	31.87	31.83	31.83	31.75	31.02	31.20	31.08	31.34	31.54	29.25	27.00	23.96	25.08	23.37	23.17	28.63	28.36
Netherlands	30.30	25.59	25.42	25.53	24.95	24.30	24.49	25.23	25.56	1.32	25.59	25.92	26.19	25.56	28.49	29.83	28.78	28.79
Romania	29.60	29.60	29.60	29.60	29.60	29.60	29.60	29.60	29.60	29.60	29.60	29.60	29.60	29.60	29.60	29.60	29.60	29.60
Slovakia	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	29.74	29.66	29.64	29.49	29.42	29.42	29.37	29.67
Poland	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	29.99	29.98	29.93	29.95	29.96	29.94	29.93	29.93	29.95	29.95
Latvia	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	29.99	30.00
Belarus	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	29.83	30.00	30.00	30.00	30.00	30.00	30.00
Croatia	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	29.99	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Estonia	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.02	30.00	30.00	30.00	30.00
Greece	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	29.71	29.94	29.97	29.98	30.00	30.00	30.00	30.00	30.00
Ireland	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Luxembourg	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	30.00	30.00	30.00	30.00	30.00	30.00
Russian Federation	99.28	99.27	NE	NE	NE	NE	NE	NE	3,876.82	4,495.91	83.16	71.23	82.50	43.20	87.32	94.98	128.41	30.00
Slovenia	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Hungary	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	39.35	31.15
Lithuania	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	31.95	31.90
United Kingdom of Great Britain and Northern Ireland	23.29	23.29	23.29	23.29	23.29	23.29	24.07	24.24	24.24	24.24	24.24	24.24	24.24	24.24	33.68	33.68	33.68	33.68
Italy	27.65	27.63	27.62	27.63	28.01	28.02	28.05	28.01	28.19	28.04	28.09	28.30	39.22	38.38	37.29	38.01	36.71	36.42
Ukraine	30.00	NE	NE	NE	NE	NE	NE	NE	79.68	71.67	73.95	67.06	76.99	90.54	86.33	99.71	94.01	84.09
Monaco	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Iceland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Liechtenstein	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Turkey	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Appendix D. CH_4 and N_2O implied emission factors in Transport, railways (Annex 1 Parties)

Table D.1

1.AA.3.C-Railways,,Liquid Fuels,Implied emission factor,N2O,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Belarus	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Croatia	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Estonia	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Netherlands	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.59	0.60
Poland	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Romania	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Russian Federation	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.57	0.56	0.60	0.54	0.60	0.60	0.60	0.60	0.60
Ukraine	0.60	NE	NE	NE	NE	NE	NE	NE	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Germany	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
France	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
France (KP)	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
United States of America	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84
Bulgaria	1.83	1.83	1.83	1.81	1.82	1.82	1.84	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91
Finland	1.89	1.88	1.88	1.89	1.90	1.92	1.92	1.93	1.93	1.92	1.93	1.93	1.92	1.92	1.92	1.95	1.96	1.98
Spain	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Denmark	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04
Denmark (Denmark (mainland) and Greenland)	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04
Australia	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11
Lithuania	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Switzerland	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.13	3.12	3.11	3.10	3.10	3.09
Turkey	1.59	1.55	1.54	1.63	1.67	1.65	1.65	1.63	1.79	1.84	1.38	1.32	1.27	1.29	1.22	1.06	1.84	3.84
New Zealand	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90
Czech Republic	3.00	2.99	3.00	3.00	3.00	3.00	3.06	4.00	4.10	4.22	4.22	4.22	4.22	4.21	4.22	4.22	3.64	4.19
Hungary	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.02	6.00	6.00	6.00	6.00	6.00
Austria	9.37	9.42	9.27	9.13	8.99	8.83	8.70	8.56	8.43	8.28	8.15	8.03	7.91	7.79	9.48	6.85	6.42	6.32
Belgium	13.58	14.28	14.43	14.31	14.28	14.10	14.75	14.59	15.01	14.25	14.63	14.86	15.03	14.61	14.33	13.69	14.63	14.76
European Community (15)	10.78	11.25	11.08	10.93	11.18	11.43	11.91	12.14	12.69	12.87	12.76	13.35	13.58	13.75	14.20	14.34	14.91	15.16
Portugal	15.24	15.24	15.24	15.24	15.24	15.24	15.24	15.24	15.24	15.24	15.24	15.24	15.24	15.24	15.24	15.24	15.24	15.24
United Kingdom of Great Britain and Northern Ireland	27.82	27.82	27.82	27.82	27.82	27.82	27.82	27.82	27.76	27.70	27.70	27.70	27.70	27.70	27.70	27.64	27.70	27.76
Norway	27.84	27.84	27.84	27.84	27.84	27.84	27.84	27.84	27.84	27.84	27.84	27.84	27.84	27.84	27.84	27.84	27.84	27.84
Sweden	29.07	29.18	29.33	29.38	29.44	29.44	29.49	29.43	29.49	29.45	29.53	29.50	29.49	29.52	29.52	29.52	27.86	27.86
Greece	28.62	28.62	28.62	28.62	28.62	28.62	28.62	28.62	28.62	27.97	27.97	27.97	27.97	27.97	27.97	28.21	28.22	28.15
Luxembourg	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60
Latvia	28.60	28.67	28.63	28.64	28.60	28.61	28.61	28.60	28.60	28.62	28.60	28.59	28.61	28.60	28.59	28.70	28.60	29.00
Italy	29.06	29.06	29.06	29.06	29.06	29.06	29.06	29.06	29.06	29.06	29.06	29.06	29.06	29.06	29.06	29.06	29.06	29.06
Japan	30.31	30.32	30.32	30.31	30.31	30.33	30.32	30.28	30.31	30.30	30.01	30.00	30.13	30.16	30.35	29.95	29.88	29.80
Ireland	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Slovenia	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Canada	29.99	29.99	29.99	29.99	29.99	29.99	29.99	29.99	30.29	30.29	30.29	30.29	30.29	30.29	30.29	30.29	30.29	30.29
Slovakia	32.24	32.24	32.24	32.24	32.22	32.24	32.25	32.25	32.24	32.23	32.22	32.23	32.22	32.21	32.24	32.37	32.24	32.24
Iceland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Liechtenstein	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Monaco	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table D.2

1.AA.3.C-Railways,,Liquid Fuels,Implied emission factor,CH4,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Switzerland	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.81	0.81	0.81	0.81	0.80	0.80	0.80
Germany	2.64	2.42	2.52	2.51	2.40	2.40	2.30	2.20	2.30	2.10	2.20	1.90	1.70	1.70	1.60	1.60	1.60	1.60
Austria	3.03	3.00	2.92	2.85	2.78	2.71	2.64	2.58	2.52	2.45	2.39	2.33	2.28	2.22	2.68	1.92	1.78	1.74
Denmark	3.07	3.07	3.07	3.07	3.07	3.07	3.07	3.07	3.07	3.38	3.16	3.34	3.28	2.91	2.86	2.88	2.88	2.88
Denmark (Denmark (mainland) and Greenland)	3.07	3.07	3.07	3.07	3.07	3.07	3.07	3.07	3.07	3.38	3.16	3.34	3.28	2.91	2.86	2.88	2.88	2.88
Sweden	3.25	3.27	3.26	3.31	3.31	3.30	3.30	3.30	3.32	3.29	3.36	3.32	3.35	3.37	3.32	3.32	3.14	3.14
Australia	3.15	3.15	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16
Hungary	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.51	3.50	3.50	3.50	3.50	3.50
Turkey	4.97	4.85	4.81	5.10	5.22	5.16	5.16	5.10	5.60	5.74	4.30	4.12	3.97	4.02	3.81	3.32	5.77	3.84
Finland	4.26	4.24	4.24	4.20	4.16	4.14	4.13	4.13	4.10	4.11	4.05	4.13	4.18	4.12	4.10	4.07	4.05	3.91
Japan	4.04	4.04	4.04	4.04	4.04	4.04	4.04	4.04	4.04	4.04	4.00	4.00	4.02	4.02	4.05	3.99	3.98	3.97
Latvia	4.15	4.15	4.15	4.14	4.16	4.15	4.15	4.15	4.16	4.15	4.16	4.15	4.14	4.15	4.16	4.02	4.15	4.00
New Zealand	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Slovenia	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Canada	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.04	4.04	4.04	4.04	4.04	4.04	4.04	4.04	4.04	4.04
Luxembourg	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15
Spain	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17
Norway	4.18	4.18	4.18	4.18	4.18	4.18	4.18	4.18	4.18	4.18	4.18	4.18	4.18	4.18	4.18	4.18	4.18	4.18
Italy	4.22	4.22	4.22	4.22	4.22	4.22	4.22	4.22	4.22	4.22	4.22	4.22	4.22	4.22	4.22	4.22	4.22	4.22
France	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30
France (KP)	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30
Slovakia	5.87	5.88	5.87	5.87	4.47	4.48	4.46	4.47	4.48	4.46	4.48	4.49	4.47	4.47	4.47	4.22	4.47	4.47
Belgium	4.66	4.64	4.64	4.64	4.64	4.53	4.63	4.63	4.62	4.53	4.63	4.62	4.62	4.63	4.64	4.65	4.63	4.63
Czech Republic	4.99	4.96	4.95	5.00	5.00	5.00	5.00	5.00	5.00	5.00	4.61	4.61	4.61	4.61	4.61	4.61	3.98	4.68
European Community (15)	4.97	4.73	4.75	4.78	4.85	4.78	4.85	4.82	5.05	4.96	5.20	5.22	4.93	4.78	4.83	4.85	4.92	4.85
Portugal	4.97	4.97	4.97	4.97	4.97	4.97	4.97	4.97	4.97	4.97	4.97	4.97	4.97	4.97	4.97	4.97	4.97	4.97
Belarus	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Croatia	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Estonia	5.02	4.99	5.00	5.03	4.98	4.98	5.01	5.03	5.00	5.01	5.00	5.00	5.00	5.02	4.97	5.00	5.00	5.00
Ireland	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Lithuania	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Netherlands	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	4.90	5.00
Poland	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Romania	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Russian Federation	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Ukraine	5.00	NE	NE	NE	NE	NE	NE	NE	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
United Kingdom of Great Britain and Northern Ireland	6.12	5.81	5.93	6.10	6.03	6.23	6.20	6.17	6.33	6.49	7.27	7.23	6.27	5.76	5.73	5.69	5.67	5.64
United States of America	5.74	5.74	5.74	5.74	5.74	5.74	5.74	5.74	5.74	5.74	5.74	5.74	5.74	5.74	5.74	5.74	5.74	5.74
Bulgaria	5.70	5.68	5.68	5.61	5.64	5.63	5.64	5.97	5.97	5.97	5.97	5.97	5.97	5.97	5.97	5.97	5.97	5.97
Greece	41.54	41.54	41.54	41.54	41.54	41.54	41.54	41.54	41.54	40.60	40.60	40.60	40.60	40.60	40.60	40.95	40.97	40.87
Iceland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Liechtenstein	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Monaco	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Appendix D. CH_4 and N_2O implied emission factors in Transport, navigation (Annex 1 Parties)

Table D.3

1.AA.3.D-Navigation,,Residual Oil,Implied emission factor,N2O,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Romania	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	NA	0.60	NA	0.60	0.60	0.60	0.60
Ukraine	0.60	NE	NE	NE	NE	NE	NE	NE	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Russian Federation	C	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	0.60
Turkey	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	0.60	0.60	0.66
France	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75
France (KP)	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75
United Kingdom of Great Britain and Northern Ireland	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.94	1.94	1.93	1.94	1.94	1.95	1.93
Italy	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95
Canada	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96
United States of America	1.96	1.98	1.95	1.95	1.95	1.95	1.97	2.04	2.11	2.01	1.95	2.02	1.99	2.10	2.01	1.98	1.97	1.97
Norway	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97
Greece	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99
Spain	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99
Portugal	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99
Iceland	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
New Zealand	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Poland	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
European Community (15)	2.49	2.41	2.42	2.41	2.45	2.43	2.37	2.39	2.35	2.35	2.46	2.35	2.33	2.32	2.29	2.28	2.03	2.02
Finland	2.05	2.05	2.06	2.05	2.03	2.04	2.04	2.05	2.05	2.12	2.06	2.07	2.02	2.02	1.88	2.01	2.01	2.03
Australia	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11
Lithuania	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	3.00	3.00	NO	3.00	3.00	3.00	3.00	3.00
Sweden	3.86	3.86	3.86	3.86	3.86	3.86	3.86	3.86	3.86	3.86	3.86	3.86	3.86	3.86	3.86	3.90	3.90	3.90
Denmark	4.89	4.89	4.89	4.89	4.89	4.89	4.89	4.89	4.89	4.89	4.89	4.89	4.89	4.89	4.89	4.89	4.89	4.89
Denmark (Denmark (mainland) and Greenland)	4.89	4.89	4.89	4.89	4.89	4.89	4.89	4.89	4.89	4.89	4.89	4.89	4.89	4.89	4.89	4.89	4.89	4.89
Japan	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Belarus	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Ireland	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	NO	NO
Austria	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Belgium	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Bulgaria	NO	NO	NO	2.00	2.01	2.01	1.98	NO	1.91	2.01	NO	NO	NO	NO	NO	NO	NO	NO
Croatia	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	NO	NO	NO	NO
Czech Republic	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Estonia	0.60	0.59	0.60	0.60	0.61	NO	NO	NO	NO	0.60	0.63	NO	0.60	NO	NO	NO	NO	NO
Germany	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Hungary	5.00	5.00	5.00	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Latvia	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Liechtenstein	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Luxembourg	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Monaco	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Netherlands	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Slovakia	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Slovenia	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Switzerland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table D.4

1.AA.3.D-Navigation,,Gas/Diesel Oil,Implied emission factor,N2O,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Turkey	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.58	0.58	0.58	0.58	0.58	0.59	0.60	0.60	0.60
Belarus	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	0.60	NE	0.60	0.60	0.60
Croatia	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Estonia	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.61	0.60	0.60	0.60	0.60
Netherlands	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.58	0.60
Romania	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Russian Federation	0.88	0.88	0.95	0.99	1.06	1.09	1.10	1.14	1.14	1.16	2.26	1.75	1.90	1.91	1.10	1.15	1.15	0.60
Ukraine	0.60	NE	NE	NE	NE	NE	NE	NE	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Germany	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Norway	1.35	1.39	1.37	1.29	1.37	1.38	1.38	1.35	1.35	1.33	1.31	1.43	1.48	1.40	1.39	1.46	1.39	1.40
France	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
France (KP)	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Portugal	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85
United Kingdom of Great Britain and Northern Ireland	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.84	1.85	1.85
Spain	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85
Italy	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86
Greece	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.86	1.86	1.86
Monaco	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89
Iceland	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Luxembourg	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Finland	2.00	2.00	2.00	2.00	2.00	2.01	2.00	2.00	2.01	2.03	2.00	2.00	2.00	1.99	1.98	1.99	1.99	2.02
Japan	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.01	2.02	2.02	2.01	2.01	2.02	2.02	2.04	2.04	2.03	2.02
European Community (15)	2.15	2.13	2.12	2.11	2.13	2.26	2.31	2.37	2.38	2.42	2.48	2.49	2.38	2.29	2.32	2.28	2.06	2.09
Australia	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11
United States of America	2.01	1.94	3.07	2.73	2.80	1.92	1.91	1.93	1.92	3.77	2.16	1.90	1.91	2.06	2.05	2.20	2.21	2.21
Switzerland	2.63	2.62	2.61	2.60	2.59	2.59	2.59	2.59	2.60	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61
Lithuania	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Czech Republic	3.01	3.03	3.00	3.00	3.00	3.00	3.06	3.49	4.05	4.22	4.22	4.22	4.22	4.22	4.22	4.22	4.21	4.22
Denmark	4.57	4.57	4.58	4.57	4.56	4.56	4.57	4.57	4.53	4.49	4.43	4.41	4.38	4.37	4.36	4.36	4.35	4.35
Denmark (Denmark (mainland) and Greenland)	4.57	4.57	4.58	4.57	4.56	4.56	4.57	4.57	4.53	4.49	4.43	4.41	4.38	4.37	4.36	4.36	4.35	4.35
Sweden	4.81	4.81	4.81	4.81	4.81	4.81	4.81	4.81	4.81	4.81	4.81	4.81	4.81	4.81	4.81	4.80	4.80	4.80
Hungary	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Belgium	9.20	9.11	8.81	8.63	8.42	9.05	8.90	9.08	9.14	9.18	9.21	9.14	9.15	9.46	9.57	9.53	5.78	5.49
Austria	25.82	25.85	25.87	25.90	26.01	26.06	26.17	26.29	26.40	26.47	26.62	26.76	26.77	26.63	26.49	26.09	25.61	25.16
Poland	27.28	24.90	25.82	25.91	24.22	27.04	27.64	28.61	28.47	29.20	27.80	25.18	26.70	21.43	23.00	25.04	26.88	25.75
Ireland	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Latvia	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Canada	29.99	29.99	29.99	29.99	29.99	29.99	29.99	29.99	30.29	30.29	30.29	30.29	30.29	30.29	30.29	30.29	30.29	30.29
Slovenia	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Bulgaria	1.88	1.88	1.83	1.73	1.79	1.86	1.93	1.89	1.91	NO	NO	NO	NO	NO	NO	NO	NO	NO
Liechtenstein	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
New Zealand	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	NO
Slovakia	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table D.5

1.AA.3.D-Navigation,,Residual Oil,Implied emission factor,CH4,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Sweden	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
United Kingdom of Great Britain and Northern Ireland	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.21	1.21	1.21	1.21	1.21	1.22	1.21
Greece	7.47	7.47	7.47	7.47	7.47	7.47	7.47	7.47	7.47	7.47	7.47	7.47	7.47	7.47	7.47	1.24	1.24	1.24
Portugal	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
France	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
France (KP)	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Denmark	1.65	1.64	1.63	1.63	1.63	1.63	1.65	1.67	1.67	1.67	1.68	1.70	1.71	1.72	1.72	1.83	1.90	1.91
Denmark (Denmark (mainland) and Greenland)	1.65	1.64	1.63	1.63	1.63	1.63	1.65	1.67	1.67	1.67	1.68	1.70	1.71	1.72	1.72	1.83	1.90	1.91
Lithuania	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	2.00	2.00	NO	2.00	2.00	2.00	2.00	2.00
Australia	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16
European Community (15)	5.56	5.62	5.62	5.47	5.38	5.37	5.63	5.87	6.13	6.17	5.97	5.97	5.81	5.73	5.31	4.25	4.01	3.93
Spain	4.36	4.36	4.36	4.36	4.36	4.36	4.36	4.36	4.36	4.36	4.36	4.36	4.36	4.36	4.36	4.36	4.36	4.36
Romania	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	NA	5.00	NA	5.00	5.00	5.00	5.00
Russian Federation	C	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	5.00
Ukraine	5.00	NE	NE	NE	NE	NE	NE	NE	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Turkey	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	5.00	5.00	5.08
United States of America	5.63	5.68	5.59	5.61	5.62	5.61	5.65	5.87	6.08	5.78	5.60	5.82	5.72	6.04	5.78	5.70	5.66	5.65
Norway	12.28	15.32	8.64	13.46	11.82	10.03	5.67	5.67	5.67	5.67	5.67	5.67	5.67	5.67	5.67	5.67	5.67	5.67
Finland	6.16	6.17	6.13	6.14	6.15	6.12	6.16	6.20	6.21	6.41	6.24	6.24	6.08	6.14	5.70	6.01	5.94	5.97
Canada	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	6.87	6.87	6.87	6.87	6.87	6.87	6.87	6.87	6.87	6.87
Iceland	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
New Zealand	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Poland	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Italy	7.29	7.29	7.29	7.29	7.29	7.29	7.29	7.29	7.29	7.29	7.29	7.29	7.29	7.29	7.29	7.29	7.29	7.29
Japan	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Belarus	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Austria	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Belgium	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Bulgaria	NO	NO	NO	6.24	6.29	6.29	6.19	NO	5.95	6.28	NO	NO	NO	NO	NO	NO	NO	NO
Croatia	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	NO	NO	NO	NO
Czech Republic	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Estonia	5.01	5.00	5.00	5.01	5.00	NO	NO	NO	NO	5.00	5.00	NO	5.01	NO	NO	NO	NO	NO
Germany	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Hungary	5.00	5.00	5.00	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Ireland	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	NO	NO
Latvia	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Liechtenstein	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Luxembourg	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Monaco	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Netherlands	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Slovakia	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Slovenia	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Switzerland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table D.6

1.AA.3.D-Navigation,,Gas/Diesel Oil,Implied emission factor,CH4,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Sweden	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Portugal	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16
United Kingdom of Great Britain and Northern Ireland	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.16
Greece	6.92	6.92	6.92	6.92	6.92	6.92	6.92	6.92	6.92	6.92	6.92	6.92	6.92	6.92	6.92	1.16	1.16	1.16
Denmark	1.65	1.66	1.66	1.67	1.68	1.69	1.67	1.59	1.60	1.60	1.65	1.69	1.74	1.74	1.74	1.74	1.72	1.72
Denmark (Denmark (mainland) and Greenland)	1.65	1.66	1.66	1.67	1.68	1.69	1.67	1.59	1.60	1.60	1.65	1.69	1.74	1.74	1.74	1.74	1.72	1.72
Spain	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20
Belgium	3.28	3.23	3.18	3.09	3.08	3.06	3.02	2.99	2.96	2.92	2.87	2.83	2.79	2.77	2.74	2.70	2.41	2.35
Germany	2.88	2.84	2.74	2.72	2.70	2.70	2.60	2.60	2.60	2.50	2.50	2.50	2.50	2.40	2.40	2.40	2.40	2.40
Lithuania	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Austria	3.66	3.65	3.64	3.63	3.61	3.58	3.56	3.54	3.52	3.49	3.46	3.44	3.34	3.28	3.21	3.15	3.07	3.01
European Community (15)	3.58	3.61	3.61	3.61	3.69	3.69	3.55	3.64	3.81	3.78	3.76	3.97	4.05	3.66	3.84	3.27	3.09	3.24
Latvia	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Canada	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.04	4.04	4.04	4.04	4.04	4.04	4.04	4.04	4.04	4.04
France	3.81	3.77	3.81	3.97	4.01	3.98	3.97	3.92	3.91	3.89	3.83	3.90	3.95	3.98	3.99	4.03	4.05	4.08
Australia	5.55	5.62	5.49	5.48	4.88	4.55	4.39	4.50	4.41	4.21	4.21	4.21	4.21	4.21	4.21	4.21	4.21	4.21
France (KP)	4.18	4.15	4.15	4.16	4.16	4.15	4.13	4.12	4.11	4.10	4.09	4.12	4.17	4.18	4.19	4.20	4.21	4.21
Poland	4.29	4.55	4.45	4.44	4.62	4.32	4.25	4.15	4.16	4.09	4.24	4.52	4.35	4.92	4.75	4.53	4.34	4.46
Czech Republic	5.24	5.28	5.41	5.46	5.00	5.00	5.00	5.00	5.00	5.00	4.59	4.60	4.63	4.63	4.61	4.59	4.60	4.59
Finland	4.23	4.26	4.18	4.22	4.26	4.20	4.31	4.31	4.28	4.59	4.39	4.37	4.34	4.35	4.38	4.53	4.62	4.66
Belarus	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	5.00	NE	5.00	5.00	5.00
Croatia	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Estonia	4.99	5.02	5.00	5.00	5.00	5.00	5.03	5.06	5.16	5.02	5.06	5.03	5.11	5.09	5.07	5.02	5.00	5.00
Hungary	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Ireland	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Netherlands	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	4.83	5.00
Romania	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Russian Federation	7.35	7.37	7.94	8.26	8.79	9.05	9.18	9.48	9.47	9.64	18.81	14.57	15.80	15.90	9.43	9.58	9.59	5.00
Ukraine	5.00	NE	NE	NE	NE	NE	NE	NE	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Turkey	4.74	4.74	4.73	4.74	4.76	4.74	4.76	4.76	4.77	4.79	4.81	4.83	4.84	4.85	4.88	5.00	5.00	5.03
Monaco	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43
United States of America	5.78	5.57	8.84	7.85	8.03	5.53	5.50	5.54	5.53	10.84	6.22	5.46	5.48	5.91	5.90	6.32	6.35	6.36
Norway	10.18	9.76	10.00	10.69	9.97	9.90	9.86	10.17	10.14	10.30	10.57	9.37	8.94	9.70	9.74	5.54	6.49	6.62
Japan	7.18	7.18	7.18	7.18	7.18	7.19	7.18	7.17	7.18	7.18	6.89	6.89	6.92	6.93	6.97	6.97	6.95	6.93
Italy	6.95	6.95	6.96	6.95	6.95	6.94	6.95	6.96	6.96	6.95	6.96	6.94	6.95	6.95	6.94	6.94	6.94	6.93
Iceland	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Luxembourg	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Switzerland	18.71	18.54	18.36	18.19	18.01	17.83	17.54	17.26	16.98	16.71	16.44	16.36	16.28	16.21	16.13	16.06	15.99	15.92
Slovenia	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Bulgaria	5.41	5.41	5.35	5.25	5.33	5.35	5.55	5.43	5.50	NO	NO	NO	NO	NO	NO	NO	NO	NO
Liechtenstein	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
New Zealand	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	NO
Slovakia	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Appendix E. CH_4 and N_2O implied emission factors in Other Sectors, commercial/institutional (Annex 1 Parties)

Table E.1

1.AA.4.A-Commercial/Institutional,,Liquid Fuels,Implied emission factor,N2O,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Iceland	0.37	0.58	0.46	0.58	0.26	0.47	0.49	0.47	0.47	0.47	0.46	0.40	0.44	0.38	0.38	0.35	0.12	0.21
Slovakia	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.49	0.49	0.51	0.50	1.22	0.49	0.37	0.30
Netherlands	0.56	0.60	0.60	0.60	0.60	0.46	0.47	0.46	0.46	0.39	0.24	0.41	0.31	0.33	0.39	0.40	0.30	0.37
New Zealand	0.39	0.39	0.38	0.39	0.40	0.40	0.40	0.37	0.40	0.41	0.41	0.41	0.42	0.41	0.42	0.42	0.44	0.44
Poland	NO	NO	NO	NO	0.10	0.10	0.38	0.46	0.50	0.51	0.53	0.53	0.60	0.51	0.51	0.50	0.42	0.49
Germany	0.55	0.55	0.55	0.55	0.56	0.56	0.56	0.55	0.56	0.55	0.55	0.55	0.55	0.55	0.54	0.54	0.54	0.53
Greece	0.59	0.55	0.54	0.54	0.54	0.52	0.52	0.52	0.52	0.53	0.54	0.56	0.57	0.57	0.53	0.55	0.55	0.54
Japan	0.30	0.32	0.33	0.38	0.42	0.43	0.33	0.37	0.42	0.47	0.48	0.47	0.47	0.48	0.48	0.48	0.52	0.55
Estonia	0.60	0.60	0.56	0.58	0.59	0.58	0.59	0.59	0.60	0.59	0.59	0.60	0.59	0.59	0.59	0.59	0.59	0.57
Belgium	0.60	0.59	0.59	0.59	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.59	0.59	0.59	0.58
Liechtenstein	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.59
Ukraine	0.60	NE	NE	NE	NE	NE	NE	NE	0.56	0.60	0.60	0.60	0.60	0.60	0.60	0.33	0.60	0.60
Belarus	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.62	0.62	0.64	0.64	0.62	0.62	0.65	0.60
Bulgaria	0.60	0.60	0.60	0.60	0.60	0.62	0.62	0.71	0.60	0.61	0.61	0.62	0.61	0.61	0.61	0.61	0.60	0.60
Croatia	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Czech Republic	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Romania	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Russian Federation	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.63	0.60	0.60	0.60
Slovenia	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Switzerland	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
United States of America	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Australia	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63
Latvia	0.60	0.60	0.61	0.61	0.65	0.60	0.64	0.65	0.63	0.65	0.67	0.66	0.63	0.63	0.63	0.63	0.63	0.63
United Kingdom of Great Britain and Northern Ireland	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63
Norway	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Portugal	0.73	0.73	0.73	0.75	0.73	0.70	0.76	0.77	0.74	0.74	0.74	0.72	0.71	0.70	0.70	0.69	0.72	0.73
Austria	0.80	0.87	0.87	0.89	0.87	0.82	0.82	0.98	0.98	0.92	0.91	0.91	0.92	0.94	0.94	0.87	0.93	0.93
Spain	1.19	1.24	1.21	1.14	1.16	1.25	1.17	1.16	1.18	1.16	1.11	1.08	1.09	1.06	1.04	1.03	1.04	1.02
Canada	0.97	0.97	0.98	0.97	0.99	0.94	0.95	0.98	1.04	1.04	1.03	1.06	1.04	1.14	1.10	1.14	1.11	1.12
European Community (15)	1.33	1.27	1.26	1.25	1.27	1.27	1.20	1.29	1.28	1.35	1.37	1.30	1.33	1.34	1.34	1.34	1.34	1.46
France (KP)	1.56	1.57	1.57	1.56	1.56	1.57	1.56	1.57	1.59	1.57	1.58	1.57	1.57	1.57	1.57	1.58	1.57	1.57
France	1.56	1.58	1.57	1.56	1.56	1.57	1.56	1.57	1.59	1.57	1.58	1.57	1.57	1.57	1.57	1.58	1.57	1.57
Luxembourg	0.58	0.58	0.58	0.58	0.58	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.60	0.60	2.41	0.59	1.06	1.81
Italy	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Sweden	2.84	2.77	2.55	2.56	2.35	2.26	2.25	2.24	2.09	2.13	2.14	2.03	2.06	2.10	2.05	2.01	2.01	2.01
Denmark	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.00	2.00	2.00	2.00	2.00	2.02	2.00	2.01
Denmark (Denmark (mainland) and Greenland)	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.00	2.00	2.00	2.00	2.00	2.02	2.00	2.01
Finland	2.07	2.00	2.07	2.07	2.08	2.08	2.06	2.05	2.05	2.05	2.04	2.04	2.03	2.02	2.02	2.02	2.02	2.02
Lithuania	2.37	2.40	2.23	2.29	2.27	2.13	2.19	2.22	2.27	2.33	2.18	2.13	2.17	2.23	2.06	1.99	1.97	2.02
Hungary	9.35	8.90	8.92	8.43	8.96	9.03	7.72	7.37	4.61	4.35	4.93	5.00	3.85	3.39	4.49	3.20	2.19	4.71
Ireland	9.89	9.86	9.87	9.87	9.87	9.85	9.87	9.88	9.86	9.85	9.85	9.85	9.85	9.90	9.84	9.85	9.84	9.84
Monaco	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Turkey	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE

Table E.2

1.AA.4.A-Commercial/Institutional,,Solid Fuels,Implied emission factor,N2O,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Australia	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
Japan	0.88	0.80	0.21	0.64	0.65	0.80	0.71	0.77	0.79	0.80	0.80	0.82	0.82	0.84	0.87	0.88	0.91	0.91
Slovakia	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.49	1.34	1.33	1.33
Ukraine	1.40	NE	NE	NE	NE	NE	NE	NE	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Belarus	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Bulgaria	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Croatia	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Czech Republic	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Netherlands	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
New Zealand	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Romania	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Russian Federation	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Hungary	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.53	1.50	1.50	1.50	1.50	1.50	1.50
Luxembourg	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
United States of America	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Poland	1.51	1.50	1.49	1.51	1.50	1.50	1.51	1.50	1.50	1.50	1.50	1.51	1.51	1.51	1.50	1.50	1.50	1.50
Latvia	1.51	1.51	1.54	1.49	1.58	1.50	1.58	1.55	1.47	1.42	1.45	1.43	1.40	1.42	1.40	1.45	1.49	1.55
Belgium	1.42	1.40	1.41	1.39	1.37	1.42	1.36	1.42	1.38	1.27	1.38	1.47	1.37	1.43	1.43	1.43	NO	1.67
Spain	2.04	1.91	1.80	2.06	2.12	2.06	1.99	1.80	1.83	1.85	2.06	2.05	1.78	1.81	1.84	1.85	1.83	1.91
Estonia	2.08	1.90	2.52	1.71	3.58	2.88	2.67	3.23	3.58	2.32	2.43	1.43	3.17	3.41	2.63	1.62	2.49	2.04
Austria	2.54	2.66	2.54	2.60	2.77	2.54	2.43	2.90	2.69	2.49	3.16	3.24	2.68	3.07	2.88	2.21	2.23	2.23
France	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
France (KP)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Lithuania	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
United Kingdom of Great Britain and Northern Ireland	5.66	5.61	5.61	5.41	5.41	5.39	5.12	5.31	5.33	6.15	5.33	5.33	5.17	5.26	5.23	5.35	5.26	5.31
European Community (15)	1.41	1.84	2.00	2.15	2.98	2.32	2.65	3.22	2.96	3.82	3.83	4.43	4.59	5.19	5.42	5.94	6.13	5.96
Germany	0.67	0.98	0.90	1.04	1.65	1.42	1.60	2.39	1.63	2.78	3.69	4.55	5.01	5.67	6.34	6.92	6.82	6.58
Ireland	5.14	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	11.77	11.88	11.88	11.90	12.00
Turkey	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Canada	0.74	0.74	0.74	NO	0.69	0.69	NO	NO	0.81	0.81	0.81	0.81	0.81	NO	NO	NO	NO	NO
Denmark	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	NO	NO	NO	NO	NO	3.00	NO	NO	NO
Denmark (Denmark (mainland) and Greenland)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	NO	NO	NO	NO	NO	3.00	NO	NO	NO
Finland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Greece	1.50	1.50	1.50	1.50	1.50	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	1.50	NO	NO
Iceland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Italy	1.13	1.14	1.13	1.12	1.12	1.12	1.12	1.46	1.44	1.43	1.43	1.50	1.50	1.50	NO	NO	NO	NO
Liechtenstein	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Monaco	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Norway	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Portugal	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Slovenia	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	NO	NO	NO
Sweden	NO	NO	20.00	20.00	NO	NO	NO	20.00	20.00	NO	NO	NO	NO	NO	NO	NO	NO	NO
Switzerland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table E.3

1.AA.4.A-Commercial/Institutional,,Gaseous Fuels,Implied emission factor,N2O,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Belarus	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Belgium	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Croatia	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Czech Republic	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Greece	2.50	2.50	2.50	2.50	2.50	2.50	2.50	0.15	0.10	0.12	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Latvia	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Liechtenstein	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Luxembourg	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Netherlands	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Poland	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Romania	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Russian Federation	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.63	0.10	0.10	0.10
Slovakia	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Slovenia	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Switzerland	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Ukraine	0.10	NE	NE	NE	NE	NE	NE	NE	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
United States of America	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
United Kingdom of Great Britain and Northern Ireland	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Norway	NO	NO	NO	NO	0.11	0.11	0.11	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Australia	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Germany	0.33	0.33	0.33	0.33	0.33	0.35	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.33	0.33	0.33
Japan	0.28	0.30	0.32	0.36	0.39	0.42	0.43	0.41	0.40	0.39	0.39	0.38	0.37	0.37	0.36	0.36	0.35	0.35
Estonia	0.60	0.60	NO	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
European Community (15)	0.71	0.67	0.70	0.69	0.68	0.66	0.65	0.67	0.68	0.69	0.70	0.70	0.69	0.70	0.71	0.77	0.73	0.74
Austria	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Italy	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Lithuania	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Spain	0.90	0.90	0.90	0.90	0.91	0.92	0.92	0.93	0.93	0.95	0.94	0.95	0.95	0.96	0.97	0.98	1.00	1.00
Denmark	1.00	1.00	1.01	1.01	1.02	1.02	1.02	1.03	1.03	1.04	1.04	1.04	1.04	1.03	1.03	1.03	1.03	1.03
Denmark (Denmark (mainland) and Greenland)	1.00	1.00	1.01	1.01	1.02	1.02	1.02	1.03	1.03	1.04	1.04	1.04	1.04	1.03	1.03	1.03	1.03	1.03
Finland	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.02	1.00	1.00	1.08	1.08	1.07	1.09
Canada	1.18	1.19	1.18	1.21	1.28	1.35	1.28	1.31	1.26	1.29	1.27	1.28	1.26	1.24	1.25	1.20	1.23	1.25
Bulgaria	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Portugal	NO	NO	NO	NO	NO	NO	NO	1.40	1.40	1.40	1.40	1.40	1.41	1.41	1.41	1.41	1.40	1.40
Ireland	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Sweden	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
New Zealand	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30
France	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
France (KP)	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Hungary	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Monaco	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Turkey	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Iceland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table E.4

1.AA.4.A-Commercial/Institutional,,Biomass,Implied emission factor,N2O,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Greece	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.10	0.10	0.10
United Kingdom of Great Britain and Northern Ireland	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Germany	0.93	0.96	0.96	0.96	0.96	0.98	0.90	0.81	0.73	0.64	0.56	0.48	0.39	0.31	0.22	0.14	0.14	0.14
Belgium	NO	NO	NO	NO	NO	NO	NO	NO	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.19
Portugal	NO	NO	NO	NO	NO	NO	NO	NO	NO	1.40	1.40	1.40	1.40	1.40	1.40	1.40	0.96	0.79
Netherlands	0.41	0.33	0.31	0.30	0.30	0.26	0.32	0.33	0.32	0.30	0.24	0.28	0.28	0.28	0.46	0.54	0.50	0.87
Norway	0.49	0.25	0.13	0.51	0.81	0.59	0.53	0.67	0.53	0.48	0.57	0.37	0.25	1.10	1.39	1.07	1.37	1.40
Switzerland	1.58	1.58	1.58	1.58	1.58	1.59	1.59	1.59	1.59	1.59	1.58	1.58	1.58	1.58	1.57	1.57	1.56	1.52
Liechtenstein	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
Finland	1.97	2.00	1.98	1.98	1.98	1.99	2.00	2.00	2.00	2.00	1.99	1.99	1.98	1.97	1.99	1.98	1.98	1.98
Czech Republic	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	2.06
New Zealand	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18
Spain	2.80	2.80	2.75	2.76	2.72	2.45	2.46	2.45	2.44	2.41	2.70	2.70	2.73	2.68	2.80	2.80	2.80	2.66
Denmark	3.15	3.18	3.13	3.13	3.24	3.16	3.23	3.14	2.91	3.23	2.59	2.37	2.34	3.11	2.50	2.63	2.97	2.67
Denmark (Denmark (mainland) and Greenland)	3.15	3.18	3.13	3.13	3.24	3.16	3.23	3.14	2.91	3.23	2.59	2.37	2.34	3.11	2.50	2.63	2.97	2.67
Ireland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.22	1.28	2.77
Austria	3.00	3.00	3.00	2.46	2.44	2.51	2.47	2.56	2.54	2.75	2.77	2.76	2.83	2.87	2.83	2.87	2.87	2.90
Lithuania	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	2.98	2.97	2.99	2.98	2.98	2.98
United States of America	3.76	3.77	3.77	3.78	3.78	3.78	3.78	3.77	3.77	3.78	3.77	3.77	3.76	3.75	3.75	3.74	3.72	3.70
France	3.77	3.77	3.76	3.78	3.78	3.76	3.75	3.77	3.82	3.85	3.80	3.85	3.77	3.78	3.86	3.79	3.81	3.80
France (KP)	3.77	3.77	3.76	3.78	3.78	3.76	3.75	3.77	3.82	3.85	3.80	3.85	3.77	3.78	3.86	3.79	3.81	3.80
Poland	0.10	0.10	0.10	3.91	0.10	3.86	3.79	3.76	3.72	3.72	3.71	3.49	3.59	3.58	3.65	3.80	3.61	3.82
Latvia	4.00	4.00	4.00	3.93	3.94	3.96	3.96	3.96	3.94	3.95	3.93	3.95	3.92	3.85	3.83	3.82	3.83	3.84
Ukraine	4.00	NE	NE	NE	NE	NE	NE	NE	3.99	4.00	4.00	4.00	4.00	3.98	4.00	3.99	3.98	4.00
Belarus	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Croatia	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	4.00
Estonia	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Luxembourg	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Romania	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Russian Federation	4.15	4.15	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.04	4.04	4.04	4.20	4.08	5.17	6.11	4.00
Slovakia	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
European Community (15)	2.44	2.61	2.54	2.84	2.87	2.99	3.10	3.13	3.27	3.40	3.60	3.79	3.82	3.89	3.92	3.97	4.00	4.04
Bulgaria	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30
Hungary	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30
Australia	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32
Sweden	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Italy	11.04	10.87	10.79	10.82	10.64	9.96	9.22	8.35	8.07	8.00	8.31	8.29	7.98	7.92	7.71	7.76	7.59	7.50
Canada	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Iceland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Japan	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Monaco	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Slovenia	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	NO	NO	NO
Turkey	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table E.5

1.AA.4.A-Commercial/Institutional,,Liquid Fuels,Implied emission factor,CH4,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Germany	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.03	0.04
Austria	0.93	0.95	0.96	0.88	0.89	0.74	0.48	0.41	0.45	0.46	0.54	0.40	0.51	0.57	0.79	0.49	0.40	0.66
Australia	0.69	0.68	0.68	0.68	0.68	0.68	0.70	0.70	0.70	0.69	0.68	0.71	0.70	0.69	0.70	0.69	0.68	0.69
Iceland	3.08	5.46	3.74	5.40	0.44	0.73	0.82	0.79	0.80	0.81	0.80	0.73	0.80	0.75	0.82	0.76	0.55	0.97
Canada	0.82	0.83	0.83	0.83	0.85	0.80	0.80	0.83	0.89	0.89	0.88	0.92	0.90	0.99	0.95	0.99	0.96	0.97
New Zealand	0.83	0.81	0.87	0.80	0.73	0.74	0.78	0.67	0.80	0.94	0.95	0.99	0.99	1.02	0.92	1.00	0.98	0.98
Switzerland	2.00	1.81	1.61	1.41	1.22	1.03	1.03	1.04	1.04	1.04	1.05	1.04	1.04	1.03	1.03	1.02	1.02	1.02
Liechtenstein	1.03	1.02	1.04	1.03	1.02	1.02	1.02	1.02	1.02	1.01	1.02	1.01	1.01	1.01	1.01	1.01	1.01	1.04
Bulgaria	0.83	0.75	0.69	1.06	0.95	1.79	2.08	2.65	1.08	1.17	1.06	0.78	0.91	1.12	1.46	1.54	2.16	1.34
Japan	0.55	0.61	0.79	1.44	1.39	2.00	0.92	1.33	2.07	2.71	2.25	2.46	2.48	1.59	1.78	1.48	3.23	1.44
Sweden	2.25	2.23	2.12	2.13	2.05	2.02	2.02	2.02	1.96	1.95	1.94	1.87	1.88	1.91	1.89	1.80	1.66	1.53
Denmark	1.91	1.82	1.82	1.81	1.88	1.85	1.86	1.90	1.85	1.80	1.67	1.66	1.73	1.65	1.60	1.85	1.70	1.74
Denmark (Denmark (mainland) and Greenland)	1.91	1.82	1.82	1.81	1.88	1.85	1.86	1.90	1.85	1.80	1.67	1.66	1.73	1.65	1.60	1.85	1.70	1.74
Netherlands	2.42	3.40	3.40	3.40	3.40	2.28	2.36	2.32	2.34	1.72	1.18	1.98	1.43	1.54	1.89	2.11	1.56	1.76
Greece	2.95	2.77	2.76	2.75	2.76	2.69	2.66	2.68	2.66	2.72	2.77	2.82	2.87	2.86	2.70	2.79	2.79	2.78
Italy	5.64	5.71	5.56	5.55	5.51	5.54	5.56	5.48	5.46	4.19	4.21	4.30	4.25	4.13	4.10	4.04	4.05	3.83
Spain	4.75	4.77	4.98	4.60	4.58	5.14	4.88	5.33	4.67	4.65	4.38	4.32	4.21	4.26	4.17	4.13	4.16	3.95
European Community (15)	3.99	3.89	3.95	3.95	3.99	3.98	3.68	3.99	3.78	3.89	3.88	3.77	3.69	3.81	3.78	3.80	3.59	4.06
Portugal	3.92	4.08	4.15	4.06	3.98	3.97	4.05	4.63	4.61	4.53	4.37	4.52	4.51	4.59	4.60	4.55	4.21	4.20
Ireland	3.78	3.89	4.01	4.12	4.30	4.34	4.48	4.63	4.74	4.76	4.76	4.78	4.79	5.49	4.80	4.82	4.82	4.81
Hungary	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Lithuania	4.29	4.09	4.36	5.11	3.84	2.79	4.32	4.00	6.49	5.01	7.67	6.88	5.94	4.24	5.33	5.99	5.80	5.08
Slovakia	9.97	9.97	9.97	9.97	9.97	9.97	9.97	9.97	9.97	9.97	8.30	8.38	8.71	8.52	6.91	8.48	6.72	5.70
France	6.48	6.47	6.50	6.57	6.57	6.55	6.60	6.57	6.25	6.49	6.34	6.52	6.61	6.63	6.54	6.49	6.58	6.58
France (KP)	6.49	6.47	6.51	6.58	6.57	6.56	6.61	6.57	6.25	6.49	6.34	6.53	6.61	6.63	6.54	6.50	6.59	6.58
Ukraine	10.00	NE	NE	NE	NE	NE	NE	NE	4.54	6.10	5.65	5.48	6.59	6.65	6.82	3.28	6.60	6.73
Poland	NO	NO	NO	NO	5.00	5.00	7.78	8.56	8.99	9.05	9.34	9.33	10.00	9.13	9.14	8.95	8.23	8.93
Norway	9.25	9.24	9.21	9.21	9.21	9.20	9.22	9.20	9.20	9.22	9.19	9.19	9.15	9.15	9.13	9.15	9.15	9.14
Luxembourg	9.79	9.84	9.82	9.83	9.84	9.85	9.85	9.92	9.90	9.91	9.91	9.92	9.96	9.98	9.58	9.93	9.84	9.72
Estonia	11.03	10.97	9.59	11.03	10.18	10.16	10.60	10.97	10.52	10.90	10.67	10.79	11.58	10.70	10.28	10.08	10.06	9.79
Finland	9.31	10.00	9.36	9.33	9.26	9.26	9.40	9.46	9.52	9.47	9.58	9.62	9.66	9.77	9.78	9.81	9.90	9.83
Belgium	9.96	9.92	9.92	9.92	9.99	9.98	9.98	9.96	10.14	9.95	9.95	9.98	9.98	9.96	9.91	9.94	9.87	9.83
Belarus	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.38	10.33	10.59	10.60	10.36	10.40	10.82	10.00
Croatia	9.96	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Czech Republic	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Romania	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Russian Federation	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.43	10.00	10.00	10.00
Slovenia	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
United States of America	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
United Kingdom of Great Britain and Northern Ireland	10.55	10.55	10.55	10.55	10.55	10.55	10.55	10.54	10.54	10.53	10.53	10.49	10.51	10.47	10.49	10.48	10.52	10.49
Latvia	10.12	10.10	10.13	10.16	11.51	10.00	11.14	11.35	10.79	11.43	11.96	11.71	10.91	10.78	10.76	10.93	10.71	10.92
Monaco	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Turkey	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE

Table E.6

1.AA.4.A-Commercial/Institutional,,Solid Fuels,Implied emission factor,CH4,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
United Kingdom of Great Britain and Northern Ireland	0.42	0.42	0.42	0.40	0.40	0.40	0.38	0.40	0.40	0.46	0.40	0.40	0.39	0.39	0.39	0.40	0.39	0.40
Japan	6.65	6.09	0.03	4.10	2.62	1.12	0.11	0.67	0.92	1.05	1.03	1.05	1.07	1.11	1.17	1.22	1.30	1.31
Australia	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37
Netherlands	1.26	0.44	0.44	0.44	0.44	1.31	1.24	1.58	1.52	1.74	1.65	1.61	1.62	1.42	1.86	NO	8.27	4.40
Ukraine	10.00	NE	NE	NE	NE	NE	NE	NE	8.08	8.12	7.74	7.44	5.93	6.76	6.79	5.77	6.00	5.84
Slovakia	10.01	10.01	10.01	10.01	10.01	10.01	10.01	10.01	10.01	10.01	10.00	10.06	10.00	10.00	9.99	9.60	9.50	9.50
Belarus	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Belgium	10.02	12.92	11.73	16.54	13.96	19.86	10.00	10.02	9.95	14.25	12.42	10.04	9.90	10.03	10.03	10.03	NO	10.00
Croatia	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Czech Republic	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Luxembourg	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
New Zealand	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Romania	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Russian Federation	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
United States of America	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Poland	11.22	10.15	10.00	11.02	10.39	10.00	10.70	9.99	10.02	10.04	10.29	11.42	10.93	10.67	10.02	10.23	10.00	10.14
Bulgaria	10.69	10.78	10.93	10.73	10.64	10.55	10.62	10.47	11.00	10.97	10.96	10.97	10.97	10.71	10.60	10.47	10.40	10.61
Latvia	22.50	22.57	25.65	20.26	30.43	20.79	30.58	26.36	18.29	12.18	15.63	12.89	10.00	12.16	10.00	15.45	20.21	26.15
Hungary	82.79	91.66	95.07	92.87	97.87	96.40	84.03	81.52	78.98	75.44	85.67	89.55	84.14	84.93	90.80	90.48	71.60	66.77
Estonia	85.85	66.02	134.29	51.43	254.21	173.13	155.00	210.77	254.21	114.40	123.93	10.00	203.33	233.08	147.75	34.51	131.82	79.60
France	67.58	67.78	60.17	50.00	36.27	59.39	58.46	61.57	52.59	12.43	2.47	1.35	12.74	85.00	85.00	85.00	85.00	85.00
France (KP)	67.58	67.78	60.17	50.00	36.27	59.39	58.46	61.57	52.59	12.43	2.47	1.35	12.74	85.00	85.00	85.00	85.00	85.00
Austria	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00
Ireland	50.99	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	96.64	98.26	97.83	97.95	98.67
European Community (15)	199.62	169.18	150.65	128.45	95.67	119.68	105.32	123.48	104.72	87.17	89.85	75.79	95.43	91.97	87.27	92.06	103.33	110.07
Lithuania	114.24	114.26	114.82	114.26	114.26	114.45	114.38	114.54	114.16	114.49	114.01	114.05	114.03	114.00	114.59	114.59	114.48	114.65
Germany	239.90	213.01	200.75	181.99	173.56	169.22	168.17	181.55	173.25	147.58	127.68	114.69	117.24	118.42	112.61	118.08	125.15	133.66
Spain	191.83	245.29	287.08	183.54	158.63	182.21	211.68	288.22	275.22	268.30	184.43	186.58	297.99	284.10	272.93	267.51	275.22	244.59
Turkey	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Canada	147.74	148.31	147.74	NO	138.29	138.05	NO	NO	161.82	161.82	161.82	161.82	161.82	NO	NO	NO	NO	NO
Denmark	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	NO	NO	NO	NO	NO	15.00	NO	NO	NO
Denmark (Denmark (mainland) and Greenland)	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	NO	NO	NO	NO	NO	15.00	NO	NO	NO
Finland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Greece	1.00	1.00	1.00	1.00	1.00	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	1.00	NO	NO
Iceland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Italy	28.30	28.42	26.98	26.59	27.40	29.32	28.67	92.94	18.85	18.91	18.92	20.45	22.85	22.85	NO	NO	NO	NO
Liechtenstein	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Monaco	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Norway	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Portugal	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Slovenia	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	NO	NO	NO
Sweden	NO	NO	4.00	4.00	NO	NO	NO	4.00	4.00	NO	NO	NO	NO	NO	NO	NO	NO	NO
Switzerland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table E.7

1.AA.4.A-Commercial/Institutional,,Gaseous Fuels,Implied emission factor,CH4,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Germany	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.13	0.14	0.14	0.14	0.14	0.14
Austria	2.80	2.40	2.00	1.60	1.20	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Greece	5.00	5.00	5.00	5.00	5.00	5.00	5.00	1.54	1.00	1.16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Slovakia	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	1.00
Sweden	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Canada	1.09	1.09	1.08	1.08	1.07	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.07	1.07	1.07
Bulgaria	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
New Zealand	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
Portugal	NO	NO	NO	NO	NO	NO	NO	1.20	1.20	1.20	1.20	1.20	1.21	1.21	1.21	1.21	1.20	1.20
Australia	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.25	1.25	1.25	1.25	1.25	1.25	1.25
France	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
France (KP)	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Italy	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Ukraine	5.00	NE	NE	NE	NE	NE	NE	NE	3.95	3.57	3.21	3.16	2.91	2.81	2.55	3.58	3.19	2.88
Finland	2.68	3.00	2.48	2.19	2.22	2.18	2.16	2.18	2.03	2.09	2.10	2.08	2.17	2.11	2.28	3.53	3.32	3.87
Japan	1.53	2.45	3.18	3.76	4.22	4.66	4.63	4.95	5.28	5.58	5.52	5.43	5.36	5.24	5.17	5.10	4.98	4.97
Belarus	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Belgium	5.02	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Croatia	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Czech Republic	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Estonia	5.00	5.00	NO	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Hungary	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Ireland	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Latvia	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Lithuania	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Luxembourg	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Poland	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Romania	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Russian Federation	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	31.77	5.00	5.00	5.00
Slovenia	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
United States of America	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
United Kingdom of Great Britain and Northern Ireland	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56
Norway	NO	NO	NO	NO	5.36	5.32	5.37	5.44	5.50	5.52	5.51	5.53	5.58	5.57	5.62	5.55	5.57	5.60
European Community (15)	3.99	4.19	4.48	4.85	5.35	5.74	6.19	6.65	6.48	6.46	6.65	5.89	5.88	5.76	5.34	5.89	5.60	5.92
Liechtenstein	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Spain	2.56	2.56	2.57	2.61	2.93	3.25	3.28	3.66	3.85	4.47	4.22	4.54	4.81	5.23	5.60	5.85	6.83	6.92
Switzerland	6.55	6.76	7.01	7.04	7.46	7.90	8.15	8.33	8.32	8.29	8.24	8.00	8.04	7.78	7.57	7.40	7.34	7.36
Netherlands	12.35	12.58	16.10	17.99	24.14	26.12	30.00	36.88	35.80	41.58	41.01	31.04	29.34	28.06	25.40	28.91	24.48	28.70
Denmark	7.86	9.83	18.82	27.04	43.33	48.04	40.75	53.19	59.07	67.66	71.86	71.59	70.48	58.83	56.85	45.08	43.01	40.44
Denmark (Denmark (mainland) and Greenland)	7.86	9.83	18.82	27.04	43.33	48.04	40.75	53.19	59.07	67.66	71.86	71.59	70.48	58.83	56.85	45.08	43.01	40.44
Monaco	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Turkey	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Iceland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table E.8

1.AA.4.A-Commercial/Institutional,,Biomass,Implied emission factor,CH4,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Greece	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	1.00	1.00	1.00
New Zealand	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14
France	3.13	3.13	3.13	3.13	3.13	3.13	3.12	3.13	3.14	3.15	3.14	3.15	3.13	3.13	3.16	3.14	3.14	3.14
France (KP)	3.13	3.13	3.13	3.13	3.13	3.13	3.12	3.13	3.14	3.15	3.14	3.15	3.13	3.13	3.16	3.14	3.14	3.14
Australia	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.89	3.88	3.89	3.89
Portugal	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.72	0.72	0.72	0.72	0.72	0.72	0.72	3.09	3.98
United Kingdom of Great Britain and Northern Ireland	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56
Liechtenstein	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Belgium	NO	NO	NO	NO	NO	NO	NO	NO	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	12.55
Norway	5.75	5.15	4.85	24.14	38.88	28.01	25.75	32.58	25.90	23.32	27.66	17.81	11.84	12.85	13.45	12.00	12.41	12.78
Ireland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	1.64	9.58	20.80
Germany	91.09	95.33	95.33	95.40	95.47	94.10	89.69	85.09	80.56	76.03	72.24	67.71	63.14	58.61	54.09	49.56	49.56	49.56
Finland	49.12	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	51.42	51.35	51.08	50.40	51.36	50.20
Netherlands	28.72	22.03	20.49	19.82	20.37	18.53	21.41	22.12	21.54	19.95	16.71	18.49	18.39	18.62	32.44	37.89	34.97	60.26
European Community (15)	71.74	72.07	72.94	70.99	69.95	69.65	69.19	75.40	74.95	74.53	73.44	70.08	70.12	68.15	70.10	65.96	67.88	70.05
Italy	23.90	25.96	30.25	23.06	27.84	37.00	47.55	63.10	66.77	67.99	60.84	61.97	66.13	67.14	68.00	66.86	70.00	72.37
Hungary	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	100.00	100.00	100.00	80.00	80.00
Austria	21.00	21.00	21.00	15.75	15.52	16.18	15.81	116.96	115.44	131.64	133.22	123.33	117.41	117.00	105.01	98.41	101.68	95.08
Switzerland	118.07	118.57	118.56	118.72	118.64	118.97	119.15	119.00	118.99	118.85	118.46	118.49	118.23	118.26	117.91	117.86	116.73	113.82
Denmark	70.42	71.56	85.76	90.09	80.30	85.47	96.02	96.03	124.32	94.98	176.87	183.62	179.37	106.21	160.33	132.80	117.15	152.44
Denmark (Denmark (mainland) and Greenland)	70.42	71.56	85.76	90.09	80.30	85.47	96.02	96.03	124.32	94.98	176.87	183.62	179.37	106.21	160.33	132.80	117.15	152.44
Czech Republic	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	152.85
Lithuania	196.00	196.00	196.00	196.00	196.00	196.00	196.00	196.00	196.00	196.00	196.00	196.00	192.03	190.74	194.09	193.05	192.13	191.35
Slovakia	279.66	279.66	279.66	279.66	279.66	279.66	279.66	279.66	279.66	279.66	135.92	147.77	156.57	194.14	217.17	220.55	227.51	200.88
Ukraine	300.00	NE	NE	NE	NE	NE	NE	NE	267.52	262.29	255.65	259.11	248.04	247.92	252.58	247.52	222.36	218.34
Sweden	250.00	250.00	250.00	250.00	250.00	250.00	250.00	250.00	250.00	250.00	250.00	250.00	250.00	250.00	250.00	250.00	250.00	250.00
United States of America	282.04	282.35	282.36	283.46	283.46	283.65	283.66	283.07	282.93	283.30	282.69	282.79	282.28	280.91	280.87	280.60	278.99	277.72
Poland	5.00	5.00	5.00	292.99	5.00	289.59	283.92	281.65	278.96	278.78	278.29	261.54	268.71	268.05	273.86	284.47	270.70	286.04
Latvia	300.00	300.00	300.00	294.93	295.13	296.72	296.66	296.53	295.34	295.80	294.75	296.42	293.71	288.81	286.59	286.07	286.58	287.88
Belarus	300.00	299.99	299.99	299.99	299.99	299.99	299.99	299.99	299.99	299.99	299.99	299.99	299.99	300.00	300.00	300.00	300.00	300.00
Croatia	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	300.00
Estonia	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Luxembourg	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Romania	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Russian Federation	311.11	311.11	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	303.28	303.19	302.98	315.18	304.05	387.39	458.33	300.00
Spain	371.89	371.89	354.27	355.03	341.47	248.77	250.10	249.40	245.20	232.91	335.91	334.42	346.41	329.80	371.89	371.89	371.89	322.05
Bulgaria	370.00	370.00	370.00	370.00	370.00	370.00	370.00	370.00	370.00	370.00	370.00	370.00	370.00	370.00	370.00	370.00	370.00	370.00
Canada	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Iceland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Japan	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Monaco	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Slovenia	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	NO	NO	NO
Turkey	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Appendix F. CH_4 and N_2O implied emission factors in Other Sectors, residential (Annex 1 Parties)

Table F.1

1.AA.4.B-Residential,,Liquid Fuels,Implied emission factor,N2O,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Canada	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.17	0.17	0.17	0.17	0.17	0.17	0.18	0.17	0.18
Poland	0.10	0.10	0.10	0.10	0.10	0.10	0.16	0.23	0.26	0.27	0.33	0.35	0.36	0.34	0.34	0.32	0.29	0.34
Bulgaria	1.46	1.41	1.33	0.62	0.65	0.60	0.60	0.60	0.98	0.85	0.81	0.76	0.74	0.72	0.70	0.66	0.38	0.36
Iceland	0.57	0.56	0.56	0.56	0.55	0.56	0.56	0.54	0.55	0.55	0.53	0.52	0.50	0.44	0.47	0.46	0.40	0.40
Japan	0.37	0.37	0.38	0.38	0.37	0.38	0.38	0.39	0.38	0.39	0.40	0.40	0.41	0.39	0.41	0.42	0.41	0.40
Estonia	0.52	0.49	0.42	0.47	0.39	0.20	0.37	0.35	0.37	0.45	0.45	0.34	0.49	0.46	0.42	0.45	0.46	0.44
Netherlands	0.50	0.60	0.60	0.60	0.60	0.49	0.46	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
Germany	0.62	0.62	0.61	0.61	0.60	0.60	0.60	0.59	0.59	0.58	0.57	0.57	0.56	0.56	0.55	0.55	0.55	0.55
Belgium	0.58	0.58	0.58	0.60	0.58	0.58	0.59	0.58	0.58	0.58	0.59	0.59	0.60	0.60	0.59	0.59	0.58	0.58
Greece	0.56	0.56	0.56	0.56	0.56	0.57	0.58	0.58	0.58	0.58	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Luxembourg	0.58	0.58	0.58	0.58	0.58	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.60	0.60	0.60	0.59	0.59	0.60
New Zealand	0.53	0.55	0.51	0.51	0.53	0.53	0.59	0.59	0.59	0.58	0.59	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Belarus	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Croatia	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Czech Republic	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Liechtenstein	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Monaco	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Romania	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Russian Federation	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Slovenia	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Switzerland	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Ukraine	0.60	NE	NE	NE	NE	NE	NE	NE	0.60	0.61	0.60	0.57	0.60	0.60	0.60	0.60	0.60	0.60
United States of America	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Turkey	0.60	0.60	0.60	0.61	0.61	0.61	0.62	0.62	0.63	0.63	0.63	0.63	0.63	0.63	0.64	0.64	0.64	0.64
Norway	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.69	0.69	0.69	0.69	0.69
United Kingdom of Great Britain and Northern Ireland	0.67	0.65	0.66	0.66	0.66	0.67	0.66	0.67	0.67	0.68	0.68	0.67	0.68	0.67	0.67	0.68	0.68	0.70
Australia	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.70	0.70	0.70	0.70	0.70	0.70	0.71	0.71	0.72
Latvia	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.73	0.73	0.73	0.73	0.73	0.80	0.83	0.86
Lithuania	1.23	1.18	1.21	1.12	1.22	1.07	1.08	1.02	1.00	1.00	1.00	1.00	1.00	1.01	1.00	1.02	1.02	1.01
Austria	1.19	1.19	1.22	1.24	1.29	1.27	1.24	1.29	1.27	1.26	1.27	1.27	1.23	1.18	1.17	1.20	1.22	1.23
European Community (15)	1.30	1.27	1.24	1.21	1.21	1.23	1.20	1.19	1.22	1.28	1.27	1.24	1.26	1.25	1.29	1.29	1.26	1.37
Portugal	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.41	1.40
Spain	1.84	1.83	1.78	1.73	1.74	1.66	1.66	1.61	1.62	1.61	1.54	1.50	1.51	1.45	1.45	1.45	1.46	1.47
France	1.68	1.68	1.68	1.69	1.69	1.69	1.69	1.69	1.69	1.70	1.70	1.67	1.69	1.69	1.69	1.69	1.68	1.69
France (KP)	1.68	1.68	1.68	1.69	1.69	1.69	1.69	1.69	1.69	1.70	1.70	1.67	1.68	1.69	1.69	1.69	1.68	1.69
Denmark	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.98	1.98	1.97	1.96	1.95	1.95	1.95	1.95	1.94	1.94
Denmark (Denmark (mainland) and Greenland)	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.98	1.98	1.97	1.96	1.95	1.95	1.95	1.95	1.94	1.94
Italy	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Finland	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Hungary	7.77	7.81	8.22	7.86	7.96	5.44	3.84	3.08	2.15	2.16	2.02	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Sweden	2.48	2.51	2.45	2.45	2.49	2.43	2.45	2.56	2.62	2.72	2.78	2.89	2.94	3.16	3.36	3.62	3.93	4.28
Ireland	8.68	8.76	8.76	8.77	9.07	9.29	9.33	9.50	9.44	9.51	9.48	9.54	9.54	9.56	9.53	9.51	9.50	9.51
Slovakia	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table F.2

1.AA.4.B-Residential,,Solid Fuels,Implied emission factor,N2O,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Australia	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
Belarus	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Belgium	1.40	1.40	1.40	1.47	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Bulgaria	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Croatia	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Czech Republic	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Latvia	1.56	1.51	1.60	1.53	1.48	1.72	1.69	1.65	1.91	1.58	1.45	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Netherlands	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
New Zealand	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Romania	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Russian Federation	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Slovakia	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Ukraine	1.40	NE	NE	NE	NE	NE	NE	NE	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Canada	0.97	0.96	0.95	0.95	0.98	0.98	1.02	1.11	1.11	1.15	1.11	1.18	1.37	1.37	1.38	1.19	1.32	1.40
Norway	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.41	1.41	1.41	1.42	1.41	1.41	1.41
Poland	1.41	1.44	1.46	1.48	1.49	1.49	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Greece	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Hungary	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Italy	1.18	1.19	1.21	1.20	1.20	1.21	1.21	1.48	1.48	1.48	1.48	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Luxembourg	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
United States of America	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Liechtenstein	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
Switzerland	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
Spain	1.86	1.74	1.66	1.64	1.58	1.56	1.48	1.47	1.53	1.51	1.90	1.68	1.68	1.62	1.64	1.66	1.65	1.64
Turkey	12.47	12.19	11.71	12.44	17.32	14.49	15.52	13.49	18.35	21.40	19.75	26.44	20.29	16.29	14.32	2.04	1.96	1.97
Austria	2.35	2.34	2.35	2.34	2.32	2.32	2.31	2.30	2.28	2.32	2.27	2.27	2.24	2.22	2.25	2.30	2.35	2.35
Estonia	2.69	2.60	3.17	3.33	3.78	3.36	3.05	2.64	2.40	2.28	2.34	2.14	2.08	2.26	1.85	1.94	1.89	2.42
Denmark	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Denmark (Denmark (mainland) and Greenland)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
France	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
France (KP)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Finland	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Lithuania	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
United Kingdom of Great Britain and Northern Ireland	4.20	4.20	4.18	4.21	4.21	4.10	4.04	4.06	3.99	4.31	4.23	4.34	4.37	4.42	4.45	4.50	4.51	4.57
European Community (15)	4.14	4.16	4.10	4.24	4.29	4.32	4.43	4.52	4.48	4.80	5.17	5.31	5.75	5.58	5.56	5.90	6.14	5.99
Germany	4.12	4.17	4.25	4.50	4.72	5.25	5.34	5.86	5.43	6.11	6.90	7.08	7.82	7.38	7.39	7.65	8.01	7.83
Ireland	8.24	8.71	7.98	8.06	7.49	7.02	8.02	7.63	7.86	8.14	8.42	8.35	8.25	8.28	8.25	8.32	8.05	8.04
Iceland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Japan	0.31	0.33	0.43	0.39	0.38	0.32	0.43	0.44	0.34	NO	NO	NO	NO	NO	NO	NO	NO	NO
Monaco	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Portugal	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Slovenia	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	NO	NO
Sweden	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table F.3

1.AA.4.B-Residential,,Gaseous Fuels,Implied emission factor,N2O,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Belarus	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Belgium	0.11	0.10	0.10	0.10	0.11	0.11	0.10	0.11	0.10	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Croatia	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Czech Republic	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Greece	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Hungary	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Latvia	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Luxembourg	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Monaco	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Netherlands	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
New Zealand	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Poland	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Romania	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Russian Federation	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Slovakia	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Slovenia	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Switzerland	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Ukraine	0.10	NE	NE	NE	NE	NE	NE	NE	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
United States of America	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Japan	0.13	0.13	0.13	0.13	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.11	0.11	0.11	0.11	0.11	0.10	0.10
Turkey	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.11	0.11	0.12	0.11	0.11	0.10	0.11	0.11
Australia	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
United Kingdom of Great Britain and Northern Ireland	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Norway	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Germany	0.31	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.29	0.29	0.28	0.28	0.27	0.26	0.26	0.25	0.25	0.25
Estonia	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Liechtenstein	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
European Community (15)	0.62	0.64	0.64	0.63	0.63	0.63	0.61	0.63	0.65	0.65	0.65	0.66	0.64	0.65	0.67	0.69	0.69	0.69
Spain	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Austria	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Finland	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Italy	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Lithuania	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Denmark	1.00	1.00	1.01	1.01	1.01	1.01	1.01	1.02	1.02	1.02	1.02	1.01	1.01	1.01	1.01	1.01	1.02	1.01
Denmark (Denmark (mainland) and Greenland)	1.00	1.00	1.01	1.01	1.01	1.01	1.01	1.02	1.02	1.02	1.02	1.01	1.01	1.01	1.01	1.01	1.02	1.01
Canada	1.16	1.17	1.15	1.10	1.08	1.10	1.09	1.10	1.10	1.08	1.09	1.09	1.09	1.08	1.08	1.09	1.09	1.09
Ireland	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Sweden	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
France	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
France (KP)	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Bulgaria	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Iceland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Portugal	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table F.4

1.AA.4.B-Residential,,Biomass,Implied emission factor,N2O,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Germany	1.53	1.53	1.53	1.53	1.53	1.50	1.50	1.51	1.51	1.51	1.52	1.52	1.53	1.53	1.53	1.54	1.54	1.54
Norway	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.58	1.58	1.58	1.59
Liechtenstein	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
Switzerland	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
Australia	2.42	2.42	2.41	2.38	2.34	2.30	2.26	2.22	2.16	2.10	2.04	2.02	2.00	1.98	1.96	1.96	1.96	1.96
Finland	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Lithuania	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
United States of America	3.79	3.79	3.79	3.79	3.79	3.79	3.79	3.79	3.79	3.79	3.79	3.79	3.79	3.79	3.79	3.79	3.79	3.79
Spain	3.74	3.76	3.78	3.80	3.82	3.85	3.87	3.87	3.87	3.87	3.87	3.87	3.87	3.87	3.87	3.87	3.87	3.87
France	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
France (KP)	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Belarus	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Belgium	4.00	4.13	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Croatia	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Czech Republic	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Denmark	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Denmark (Denmark (mainland) and Greenland)	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Estonia	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Ireland	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Japan	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Latvia	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Luxembourg	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Netherlands	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
New Zealand	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Poland	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Romania	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Russian Federation	4.01	4.01	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.18	4.10	4.01	4.00	4.00	4.00
Slovakia	4.00	4.00	4.00	4.00	4.01	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Slovenia	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Turkey	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	4.00	4.00	4.00
Ukraine	4.00	NE	NE	NE	NE	NE	NE	NE	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Bulgaria	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30
Hungary	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30
Portugal	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30
European Community (15)	4.12	4.16	4.21	4.18	4.27	4.26	4.23	4.09	4.08	4.15	4.13	4.08	4.00	4.04	4.17	4.14	4.18	4.37
Austria	4.40	4.36	4.33	4.30	4.27	4.24	4.21	4.17	4.13	4.08	4.07	4.17	4.29	4.40	4.53	4.53	4.50	4.50
Sweden	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
United Kingdom of Great Britain and Northern Ireland	6.16	6.16	6.16	6.16	6.16	6.16	6.16	6.16	6.16	6.16	6.16	6.16	6.16	6.16	5.85	5.85	5.85	5.85
Greece	9.00	8.98	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
Canada	9.36	8.99	9.36	9.36	9.36	9.36	9.36	9.36	9.36	9.36	9.36	9.36	9.36	9.36	9.36	9.34	9.35	9.36
Italy	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	13.30	13.56	13.63	13.85	14.00	14.00
Iceland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Monaco	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table F.5

1.AA.4.B-Residential,,Liquid Fuels,Implied emission factor,CH4,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Germany	0.20	0.21	0.22	0.21	0.22	0.20	0.20	0.19	0.20	0.23	0.24	0.22	0.23	0.25	0.25	0.25	0.24	0.34
Canada	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
Iceland	0.72	0.73	0.72	0.73	0.73	0.73	0.73	0.74	0.73	0.73	0.75	0.76	0.76	0.81	0.79	0.79	0.83	0.83
Austria	1.12	1.05	1.13	1.11	1.16	1.06	0.96	1.09	1.03	0.99	0.98	0.96	0.94	0.84	0.88	0.88	0.89	0.96
Liechtenstein	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Switzerland	2.00	1.80	1.60	1.40	1.20	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Lithuania	1.14	1.09	1.17	1.06	1.11	1.03	1.09	1.03	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.01
New Zealand	1.04	1.06	1.02	1.02	1.03	1.07	1.09	1.09	1.09	1.08	1.09	1.10	1.10	1.10	1.10	1.10	1.10	1.10
Bulgaria	4.60	4.40	4.10	1.16	1.31	1.11	1.11	1.11	2.66	2.11	1.96	1.74	1.68	1.57	1.50	1.33	1.35	1.30
Portugal	1.64	1.64	1.62	1.59	1.59	1.57	1.57	1.60	1.60	1.59	1.55	1.53	1.54	1.57	1.60	1.58	1.69	1.58
Hungary	4.05	4.07	4.24	4.09	4.13	3.06	2.38	2.06	1.67	1.67	1.61	1.60	1.60	1.60	1.60	1.60	1.60	1.60
Netherlands	2.85	3.40	3.40	3.40	3.40	2.78	2.65	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.69	2.69	2.69	2.69
Spain	2.75	2.73	2.77	2.86	2.74	2.96	3.05	3.42	2.74	2.81	2.88	2.98	2.99	3.05	3.02	3.01	3.00	2.94
Greece	2.83	2.84	2.83	2.84	2.85	2.86	2.90	2.90	2.92	2.93	2.95	2.95	3.35	2.97	2.96	2.97	2.97	2.96
European Community (15)	4.23	4.07	4.08	3.87	3.83	3.92	3.95	3.82	3.91	4.07	4.03	4.00	4.06	4.06	4.22	4.22	4.10	4.65
Italy	5.99	6.00	5.89	5.75	5.67	5.78	5.77	5.79	5.77	5.60	5.45	5.44	5.32	5.17	5.11	5.04	4.97	4.70
Ireland	6.50	7.50	6.75	6.40	6.90	6.94	6.47	7.73	7.02	6.66	6.89	7.53	6.83	6.62	5.88	6.01	5.72	5.89
Sweden	2.69	2.72	2.75	2.77	2.79	2.81	2.82	2.95	2.99	3.12	3.16	3.41	3.57	3.74	3.88	4.61	5.61	6.10
France	7.00	6.92	6.94	6.93	6.99	6.97	6.91	6.97	6.95	6.93	6.97	7.00	7.01	7.01	6.99	7.01	7.12	7.19
France (KP)	7.01	6.93	6.95	6.93	6.99	6.98	6.92	6.97	6.96	6.94	6.98	7.01	7.01	7.01	7.00	7.02	7.12	7.20
Poland	5.00	5.00	5.00	5.00	5.00	5.00	5.58	6.29	6.58	6.67	7.29	7.54	7.58	7.37	7.40	7.16	6.91	7.36
Japan	7.20	7.13	7.26	7.31	7.29	7.40	7.40	7.47	7.45	7.54	7.66	7.64	7.77	7.62	7.84	7.99	7.96	7.87
Norway	8.36	8.34	8.19	8.12	8.00	8.07	8.15	8.03	8.07	8.09	8.05	8.11	8.21	8.16	8.03	7.92	7.97	7.99
Estonia	9.16	8.87	8.16	8.70	7.91	5.98	7.71	7.48	7.69	8.52	8.47	7.35	8.92	8.59	8.15	8.51	8.55	8.43
Belgium	9.65	9.83	9.83	9.89	9.65	9.67	9.71	9.67	9.67	9.83	9.92	9.94	9.97	9.95	9.89	9.90	9.84	9.78
Luxembourg	9.79	9.84	9.82	9.83	9.84	9.85	9.85	9.92	12.04	11.04	11.10	9.92	9.96	9.98	9.96	9.93	9.94	9.97
Belarus	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.05	10.05	10.05	10.05	10.00	10.00
Croatia	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Czech Republic	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Finland	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Monaco	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Romania	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Russian Federation	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Slovenia	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
United States of America	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Ukraine	10.00	NE	NE	NE	NE	NE	NE	NE	11.28	12.15	10.04	10.38	10.13	10.02	10.00	10.00	10.00	10.00
United Kingdom of Great Britain and Northern Ireland	11.60	11.23	11.29	11.28	11.38	11.56	11.21	11.27	11.12	11.06	10.97	10.70	10.72	10.58	10.51	10.47	10.33	10.42
Turkey	10.03	10.03	10.07	10.14	10.20	10.16	10.32	10.32	10.45	10.51	10.55	10.47	10.49	10.55	10.69	10.72	10.66	10.61
Denmark	4.87	4.41	4.88	4.36	4.63	4.61	4.51	4.87	4.96	5.17	5.75	5.92	6.68	7.61	8.63	9.51	10.72	11.89
Denmark (Denmark (mainland) and Greenland)	4.87	4.41	4.88	4.36	4.63	4.61	4.51	4.87	4.96	5.17	5.75	5.92	6.68	7.61	8.63	9.51	10.72	11.89
Latvia	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.06	20.08	20.08	20.38	20.05	25.34	27.90	30.17
Australia	77.17	76.55	75.11	72.43	78.16	79.74	81.72	81.79	83.54	87.94	86.16	85.29	87.05	85.35	95.80	102.04	108.54	108.79
Slovakia	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table F.6

1.AA.4.B-Residential,,Solid Fuels,Implied emission factor,CH4,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Netherlands	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44
Greece	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Luxembourg	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Denmark	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Denmark (Denmark (mainland) and Gree	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
France	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
France (KP)	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Ireland	72.50	75.22	70.11	70.92	66.75	63.19	70.46	67.56	68.97	70.78	72.97	72.05	70.88	71.62	71.75	71.42	71.42	71.09
Austria	105.49	102.77	98.46	106.89	109.39	112.41	115.65	95.83	95.74	95.83	95.61	95.63	95.64	95.74	95.86	95.86	95.86	95.86
Hungary	71.20	75.34	81.88	84.15	81.54	85.97	87.44	91.29	86.87	89.08	93.04	96.89	96.86	96.32	97.11	96.50	96.75	97.36
Germany	103.51	102.37	103.21	109.84	115.14	124.42	123.09	125.82	119.16	126.41	126.38	119.36	126.54	106.53	93.12	93.80	97.60	108.62
Australia	110.53	110.53	110.53	110.53	110.53	110.53	110.53	110.53	110.53	110.53	110.53	110.53	110.53	110.53	110.53	110.53	110.53	110.53
Estonia	154.34	143.93	207.09	226.51	276.72	228.66	194.04	147.84	121.61	108.91	115.77	92.51	86.02	105.65	60.58	70.21	64.94	123.79
European Community (15)	159.78	172.65	187.07	187.93	178.12	167.10	172.84	189.69	202.35	227.57	187.11	172.37	168.92	170.13	167.30	165.69	172.55	194.54
Italy	36.51	37.78	40.17	40.44	42.83	46.98	46.48	97.33	20.10	20.24	20.42	20.50	22.85	22.85	200.00	200.00	200.00	200.00
Canada	193.82	192.78	190.21	189.14	195.25	196.36	203.82	221.39	221.10	229.18	221.30	236.16	274.21	273.88	276.19	237.58	263.05	280.70
Norway	298.02	298.29	297.90	297.85	297.85	297.80	297.48	297.78	297.87	297.59	297.58	296.56	296.22	296.40	297.72	295.38	296.72	296.52
Poland	280.51	286.63	290.47	294.88	296.80	298.40	299.63	299.84	299.80	299.82	299.76	299.79	299.80	300.00	299.81	299.87	299.88	299.89
Belarus	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Belgium	300.00	300.00	300.00	314.48	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Croatia	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Czech Republic	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Finland	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Latvia	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Liechtenstein	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
New Zealand	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Romania	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Russian Federation	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Slovakia	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Switzerland	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Ukraine	300.00	NE	NE	NE	NE	NE	NE	NE	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
United States of America	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Lithuania	300.93	300.89	305.11	306.84	310.99	315.50	312.82	316.70	327.75	328.81	324.70	322.67	321.80	322.44	322.59	325.68	321.51	311.86
Spain	267.53	314.74	348.93	353.33	378.77	386.35	418.74	420.20	399.23	404.11	247.02	336.05	337.71	359.83	351.89	344.03	349.72	352.29
United Kingdom of Great Britain and Nortl	343.84	326.01	334.03	299.51	264.97	246.44	252.69	262.32	288.06	331.29	273.03	243.46	233.03	247.62	247.76	279.75	323.67	367.48
Turkey	1187.02	1173.28	1130.93	1181.14	1570.17	1340.19	1423.98	1262.64	1648.55	1886.33	1752.12	2243.95	1782.04	1476.23	1337.91	436.19	419.85	422.69
Bulgaria	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Iceland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Japan	68.98	73.83	95.31	86.11	84.80	70.57	95.00	98.69	75.27	NO	NO	NO	NO	NO	NO	NO	NO	NO
Monaco	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Portugal	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Slovenia	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	NO	NO
Sweden	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table F.7

1.AA.4.B-Residential,,Gaseous Fuels,Implied emission factor,CH4,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Austria	4.74	3.88	3.07	2.29	1.53	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Greece	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
New Zealand	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sweden	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Canada	1.09	1.09	1.09	1.08	1.07	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08
Bulgaria	NO	NO	NO	NO	NO	NO	NO	NO	NO	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
Australia	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78
Germany	1.10	1.10	1.10	1.10	1.10	1.10	1.22	1.35	1.47	1.59	1.71	1.83	1.96	2.08	2.20	2.32	2.32	2.32
Italy	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Portugal	NO	NO	NO	NO	NO	NO	NO	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Spain	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Finland	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Croatia	4.81	4.70	4.74	4.88	4.94	4.94	4.95	4.95	4.96	4.95	4.96	4.96	4.96	4.96	4.96	4.96	4.95	4.96
Belarus	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Belgium	5.29	5.00	5.00	5.25	5.25	5.24	5.21	5.24	5.23	5.00	5.00	5.00	5.00	5.00	5.07	5.06	5.00	5.00
Czech Republic	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Estonia	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
France	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
France (KP)	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Hungary	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Ireland	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Latvia	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Lithuania	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Luxembourg	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Monaco	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Poland	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Romania	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Russian Federation	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Slovakia	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Slovenia	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Ukraine	5.00	NE	NE	NE	NE	NE	NE	NE	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
United States of America	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Japan	6.60	6.50	6.41	6.32	6.20	6.18	6.04	5.91	5.84	5.81	5.74	5.65	5.57	5.45	5.38	5.30	5.18	5.16
Turkey	5.00	5.00	5.00	5.00	5.16	5.00	5.00	5.00	5.00	5.16	5.38	5.37	5.90	5.50	5.25	5.15	5.31	5.36
United Kingdom of Great Britain and Northern Ireland	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56
Norway	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	5.51	5.53	5.58	5.57	5.62	5.55	5.57	5.60
Liechtenstein	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Switzerland	6.07	6.10	6.13	6.14	6.17	6.18	6.19	6.20	6.21	6.21	6.23	6.22	6.21	6.21	6.18	6.17	6.18	6.19
European Community (15)	8.08	7.82	7.60	7.60	7.68	7.55	7.69	7.35	7.11	7.05	7.08	7.02	6.95	6.88	6.76	6.69	6.69	6.64
Denmark	6.00	6.12	14.03	22.81	30.50	30.44	33.71	33.16	33.49	33.22	32.31	31.04	31.07	30.45	29.85	28.85	28.89	26.63
Denmark (Denmark (mainland) and Greenland)	6.00	6.12	14.03	22.81	30.50	30.44	33.71	33.16	33.49	33.22	32.31	31.04	31.07	30.45	29.85	28.85	28.89	26.63
Netherlands	40.73	39.64	40.65	40.72	41.49	40.73	40.72	40.73	40.73	40.73	40.73	40.73	40.73	40.73	40.73	40.73	40.73	40.74
Iceland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table F.8

1.AA.4.B-Residential,,Biomass,Implied emission factor,CH4,,(kg/TJ)
Unit: kg/TJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Ireland	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Germany	122.95	122.95	122.95	122.95	122.95	123.00	120.67	118.34	116.01	113.67	111.34	109.01	106.68	104.35	102.02	99.68	99.68	99.68
Switzerland	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00
Austria	255.89	249.52	244.31	239.00	233.69	228.34	223.00	167.89	167.19	166.27	166.13	165.61	165.35	165.80	166.20	163.87	160.63	158.06
Denmark	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00
Denmark (Denmark (mainland) and Greenla	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00
Finland	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00
Bulgaria	210.00	210.00	210.00	210.00	210.00	210.00	210.00	210.00	210.00	210.00	210.00	210.00	210.00	210.00	210.00	210.00	210.00	210.00
European Community (15)	361.35	372.03	368.97	367.31	359.46	358.75	356.53	325.36	321.03	310.76	300.61	283.12	270.96	263.50	257.81	247.84	238.54	232.68
Sweden	279.44	277.67	275.10	271.86	274.51	274.31	278.63	281.61	283.96	274.65	274.89	269.35	263.99	242.07	249.95	245.60	250.32	250.32
Norway	259.51	259.60	259.62	259.51	259.45	259.47	259.43	259.40	259.43	259.42	259.40	259.37	259.40	258.76	258.55	258.19	258.57	257.70
France	494.57	495.95	497.38	498.75	500.18	501.50	491.46	478.63	463.86	446.96	426.90	404.35	384.03	363.38	340.74	315.18	291.37	268.33
France (KP)	494.57	495.95	497.38	498.75	500.18	501.50	491.46	478.63	463.86	446.96	426.90	404.35	384.03	363.38	340.74	315.18	291.37	268.33
United States of America	284.21	284.21	284.21	284.21	284.21	284.21	284.21	284.21	284.21	284.21	284.21	284.21	284.21	284.21	284.21	284.21	284.21	284.21
Portugal	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	299.92	299.97
Belarus	300.00	299.99	299.99	299.99	299.99	299.99	299.99	299.99	299.99	299.99	299.99	299.99	299.99	299.99	300.00	299.99	299.99	300.00
Belgium	300.00	300.00	300.00	300.01	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Croatia	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Czech Republic	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Estonia	300.00	300.00	300.00	300.00	300.45	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Latvia	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Luxembourg	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Netherlands	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
New Zealand	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Poland	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Romania	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Russian Federation	300.69	300.69	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	313.38	307.12	300.00	300.00	300.00	300.00
Slovakia	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Slovenia	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Turkey	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	300.00	300.00	300.00
Ukraine	300.00	NE	NE	NE	NE	NE	NE	NE	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Japan	305.26	305.26	305.26	305.26	305.26	305.26	305.26	305.26	305.26	305.26	305.26	305.26	305.26	305.26	305.26	305.26	305.26	305.26
Greece	320.00	319.33	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00
Italy	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	304.06	309.98	311.62	316.60	320.00	320.00
Spain	331.42	330.50	329.57	328.60	327.61	326.59	325.55	325.55	325.55	325.55	325.55	325.55	325.55	325.55	325.55	325.55	325.55	325.55
Liechtenstein	350.00	350.00	350.00	350.00	350.00	350.00	350.00	350.00	350.00	350.00	350.00	350.00	350.00	350.00	350.00	350.00	350.00	350.00
Lithuania	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00
United Kingdom of Great Britain and Northe	462.08	462.08	462.08	462.08	462.08	462.08	462.08	462.08	462.08	462.08	462.08	462.08	462.08	462.08	438.95	438.95	438.95	438.95
Hungary	470.00	470.00	470.00	470.00	470.00	470.00	470.00	470.00	470.00	470.00	470.00	470.00	470.00	470.00	470.00	470.00	470.00	470.00
Australia	1158.00	1155.18	1152.36	1126.04	1087.28	1050.93	1014.55	978.95	925.53	873.73	823.56	805.52	787.54	769.63	751.78	751.78	751.78	751.78
Canada	838.01	804.04	837.61	837.84	837.40	837.54	837.18	837.21	837.25	837.20	837.14	837.08	837.02	836.96	836.90	837.41	864.06	836.80
Iceland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Monaco	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Annex D

Calculation Sheets for Energy 2008

Comparison of Reference and Sectoral Approach

Time-Series of Implied Emission Factors in Categories 1.A.1 and 1.A.2

Table D.1 Calculation Sheet for Emissions from Fuel Combustion 2008 (continued on following page)

	Sectoral Disaggregation of Fuel Combustion from National Energy Balance			Emission Factors CO_2	CH_4	N_20	Emissions CO_2	CH_4	N_2O
	Sector/Fuel	**kTOE**	**TJ**	**kg/TJ**	**kg/TJ**	**kg/TJ**	**Gg**	**Mg**	**Mg**
	1A1a Public Electricity								
1	Coal	1046.47	43813.75	88424	0.7	0.5	3874.20	30.67	21.91
2	Peat	558.44	23380.70	117909	3.0	7.0	2756.79	70.14	163.66
3	Fuel Oil and Gas Oil	345.12	14449.54	79133	0.8	0.3	1143.44	11.56	4.33
4	Natural Gas	2577.36	107908.97	57739	2.1	2.3	6230.57	221.86	247.76
5	Biomass (LFG & Wood)	29.43	1231.97	60316	2.2	3.5	74.31	2.70	4.28
	Public Electricity Total	**4556.82**	**190784.92**				**14005.00**	**336.93**	**441.95**
	1A1b Refinery Fuel								
6	Refinery Gas	96.17	4026.41	55688	1.0	0.1	224.22	4.03	0.40
7	Fuel Oil	25.06	1049.41	89235	3.0	0.6	93.64	3.15	0.63
8	LPG	3.84	160.68	270511	1.0	0.1	43.47	0.16	0.02
9	Gasoil/Diesel/DERV	7.53	315.40	17617	3.0	0.6	5.56	0.95	0.19
	Refinery Total	**132.60**	**5551.91**				**366.89**	**8.28**	**1.24**
	1A1c Manufacture of Briquettes								
10	Peat	**29.45**	**1232.84**	100218	2.0	1.5	**123.55**	**2.47**	**1.85**
	1A2a-1A2f Industry Fuel								
11	Bituminous Coals	125.34	5247.86	94607	10.0	1.5	496.49	52.48	7.87
12	Briquettes	0.00	0.00	98860	2.0	1.5	0.00	0.00	0.00
13	Kerosene	139.00	5819.52	71400	3.0	0.6	415.51	17.46	3.49
14	Fuel Oil	330.84	13851.80	76000	3.0	0.6	1052.74	41.56	8.31
15	LPG	82.46	3452.55	63700	1.0	0.1	219.93	3.45	0.35
16	Gasoil/Diesel/DERV	177.66	7438.09	73300	3.0	0.6	545.21	22.31	4.46
17	Pet Coke	218.88	9164.12	92932	3.0	0.6	851.64	27.49	5.50
19	Natural Gas	815.34	34136.79	56873	1.0	0.1	1941.45	34.14	3.41
20	Biomass	138.72	5807.73	109447	30.0	4.0	635.64	172.55	23.00
	Industry Total	**2028.24**	**84918.46**				**5522.96**	**371.44**	**56.40**
	1A3a Aviation								
21	Civil Aviation Kerosene	40.89	1711.98	71363	1.1	2.5	122.17	1.91	4.19
	1A3b Road Transport Fuel								
22	Gasoline	1905.69	79787.47	69960	13.632	2.66	5581.93	1087.69	212.35
23	Gasoil/Diesel/DERV	2627.85	110022.68	73300	1.54	2.36	8064.66	169.64	259.84
24	LPG	1.21	50.77	63700	11.23	3.35	3.23	0.57	0.17
25	Liquid Biofuels	58.12	2433.21	70523	5.21	2.42	171.60	12.67	5.89
	Road Transport Total	**4592.87**	**192294.14**				**13649.83**	**1257.90**	**472.36**

Table D.1 Calculation Sheet for Emissions from Fuel Combustion 2008 (continued from previous page)

	Sectoral Disaggregation of Fuel Combustion from National Energy Balance			Emission Factors CO_2	Emission Factors CH_4	Emission Factors N_20	Emissions CO_2	Emissions CH_4	Emissions N_2O
	Sector/Fuel	**kTOE**	**TJ**	**kg/TJ**	**kg/TJ**	**kg/TJ**	**Gg**	**Mg**	**Mg**
	1A3c-1A3e Other Transport Fuel								
26	Railway Diesel	45.60	1909.08	73300	4.2	28.6	139.94	7.92	54.60
27	Navigation Fuel Oil	0.00	0.00	76000	7.0	2.0	0.00	0.00	0.00
28	Navigation Gasoil	1.38	57.95	73300	7.0	2.0	4.25	0.41	0.12
29	Gas Distribution Use (Natural Gas)	61.15	2560.35	56873	5.0	2.0	145.61	12.80	5.12
	Other Transport Total	**108.13**	**4527.38**				**289.80**	**21.13**	**59.84**
	1A4a Commercial/Institutional Fuel								
30	Bituminous Coal	24.49	1025.41	94600	10.0	1.5	97.00	10.25	1.54
31	Anthracite + Manufactured Ovoids	0.88	37.02	98260	10.0	1.5	3.64	0.37	0.06
32	Lignite	0.70	29.13	101200	10.0	1.5	2.95	0.29	0.04
33	Briquettes	0.00	0.00	98860	10.0	1.4	0.00	0.00	0.00
34	Fuel Oil	9.85	412.36	76000	10.0	0.6	31.34	4.12	0.25
35	LPG	13.34	558.50	63700	5.0	0.1	35.58	2.79	0.06
36	Gasoil / Diesel/ DERV	527.12	22069.59	73300	10.0	0.6	1617.70	220.70	13.24
37	Natural Gas	408.09	17085.93	56873	5.0	0.1	971.72	85.43	1.71
38	Biomass	10.11	423.34	110000	300.0	4.0	46.57	127.00	1.69
39	Biogas	2.94	122.96	54600	5.0	0.1	6.71	0.61	0.01
	Commercial/Institutional Total	**997.52**	**41764.24**				**2759.93**	**451.57**	**18.60**
	1A4b Residential Fuel								
40	Bituminous Coal	163.57	6848.38	94600	300.0	1.5	647.86	2054.51	10.27
41	Anthracite + Manufactured Ovoids	55.04	2304.21	98260	300.0	1.5	226.41	691.26	3.46
42	Lignite	9.74	407.60	101200	300.0	1.5	41.25	122.28	0.61
43	Sod Peat	173.87	7279.39	104000	300.0	1.4	757.06	2183.82	10.19
44	Briquettes	105.83	4430.84	98860	300.0	1.4	438.03	1329.25	6.20
45	Kerosene	887.44	37155.42	71400	10.0	0.6	2652.90	371.55	22.29
46	LPG	90.95	3807.96	63700	5.0	0.1	242.57	19.04	0.38
47	Gasoil / Diesel/ DERV	229.08	9591.22	73300	10.0	0.6	703.04	95.91	5.75
48	Petroleum Coke	23.38	979.01	92932	10.0	0.6	90.98	9.79	0.59
49	Natural Gas	668.83	28002.62	56873	5.0	0.1	1592.58	140.01	2.80
50	Biomass	23.04	964.58	110000	300.0	4.0	106.10	289.37	3.86
	Residential Total	**2430.76**	**101771.23**				**7392.67**	**7306.81**	**66.41**
	1A4c Agriculture Fuel								
51	Gasoil	251.29	10520.98	73300	4.7	25.8	771.19	49.82	271.44
	Total Energy	**15168.58**	**635078.08**				**45003.98**	**9808.26**	**1394.27**

Table D.2 Emissions from Fuel Combustion Allocated by IPCC Source Category

	GREENHOUSE GAS SOURCE AND SINK CATEGORIES	AGGREGATE ACTIVITY DATA	IMPLIED EMISSION FACTORS			EMISSIONS		
		Consumption	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
		(TJ)	(t/TJ)	(kg/TJ)	(kg/TJ)		(Gg)	
A	**1.A.1. Energy Industries**	**197,569.6720**				**14,495.4404**	**0.3477**	**0.4450**
B	Solid Fuels	68,427.2888	98.7113	1.5093	2.7390	6,754.5445	0.1033	0.1874
C	Liquid Fuels	20,001.4446	75.5110	0.9920	0.2786	1,510.3285	0.0198	0.0056
D	Gaseous Fuels	107,908.9722	57.7391	2.0560	2.2960	6,230.5674	0.2219	0.2478
E	Biomass	1,231.9664	60.3156	2.1930	3.4772	74.3068	0.0027	0.0043
F	**1.A.2 Manufacturing Industries and Construction**	**84,918.4572**				**5,522.9630**	**0.3714**	**0.0564**
G	Solid Fuels	5,247.8606	94.6074	10.0000	1.5000	496.4865	0.0525	0.0079
H	Liquid Fuels	39,726.0854	77.6576	2.8262	0.5565	3,085.0312	0.1123	0.0221
I	Gaseous Fuels	34,136.7857	56.8725	1.0000	0.1000	1,941.4453	0.0341	0.0034
J	Biomass	5,807.7254	109.4469	29.7105	3.9611	635.6375	0.1726	0.0230
K	**1.A.3 Transport**	**198,533.4996**				**14,061.7969**	**1.2936**	**0.5423**
L	Solid Fuels	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
M	Liquid Fuels	193,539.9429	71.9034	6.5523	2.7450	13,916.1834	1.2681	0.5313
N	Gaseous Fuels	2,560.3476	56.8725	5.0000	2.0000	145.6134	0.0128	0.0051
O	Biomass	2,433.2091	70.5232	5.2054	2.4216	171.5978	0.0127	0.0059
P	**1.A.4 Other Sectors**	**154,056.4529**				**10,923.7827**	**7.8082**	**0.3564**
Q	Solid Fuels	22,361.9833	99.0161	285.8441	1.4476	2,214.1966	6.3920	0.0324
R	Liquid Fuels	85,095.0417	72.2167	9.0925	3.6900	6,145.2866	0.7737	0.3140
S	Gaseous Fuels	45,088.5456	56.8725	5.0000	0.1000	2,564.2995	0.2254	0.0045
T	Biomass	1,510.8823	105.4913	275.9914	3.6826	159.3849	0.4170	0.0056
U	**1.A.5 Other** ***(Not specified elsewhere)*** (6)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
V	**1.A. Fuel Combustion**	**635,078.0816**				**45,003.9830**	**9.8209**	**1.4002**
	Memo Items							
W	Air Bunkers	38,974.5720	71.3672	0.9904	2.3451	2,781.5076	0.0386	0.0914
X	Marine Bunkers	2,943.0424	75.0212	NE,NO	NE,NO	220.7906	NE,NO	NE,NO
Y	CO_2 from Biomass	10,983.7851	94.7694			1,040.9270	NA	NA

Table D.3 Correspondence between National Disaggregation of Sources and IPCC Combustion Source Categories

IPCC Source Category/Fuel Groups from Table C.2		National Disaggregated Sources from Table C.1
A	**1.A.1 Energy Industries (A = B+C+D+E)**	
B	(a) Solid Fuels	1+2+10
C	(b) Liquid Fuels	3+6+7+8+9
D	(c) Gaseous Fuels	4
E	(d) Biomass	5
F	**1.A.2 Manufacturing Industries (F = G+H+I+J)**	
G	(a) Solid Fuels	11+12
H	(b) Liquid Fuels	13+14+15+16+17
I	(c) Gaseous Fuels	19
J	(d) Biomass	20
K	**1.A.3 Transport (K = L+M+N+O)**	
L	(a) Solid Fuels	NO
M	(b) Liquid Fuels	21+22+23+24+25+26+27+28
N	(c) Gaseous Fuels	29
O	(d) Biomass	25
P	**1.A.4 Other Sectors (P = Q+R+S+T)**	
Q	(a) Solid Fuels	30+31+32+33+40+41+42+43+44
R	(b) Liquid Fuels	34+35+36+45+46+47+48+51
S	(c) Gaseous Fuels	37+49
T	(d) Biomass	38+39+50
U	**1.A.5 Other**	**NO**
V	**1.A Fuel Combustion (V = A+F+K+P+U)**	

Table D.4 Emissions of CO_2 from the Reference Approach in 2008 [CRF 2008 Table 1.A(b)]

FUEL TYPES			Unit	Production	Imports	Exports	International bunkers	Stock change	Apparent consumption	Conversion factor (TJ/Unit)	NCV/ GCV [1]	Apparent consumption (TJ)	Carbon emission factor (t C/TJ)	Carbon content (Gg C)	Carbon stored (Gg C)	Net carbon emissions (Gg C)	Fraction of carbon oxidized	Actual CO_2 emissions (Gg CO_2)
Liquid Fossil	Primary Fuels	Crude Oil	kt	NO	3,194.761	NO		2.828	3,191.933	42.184	NCV	134,649.148	20.000	2,692.983	NA	2,692.983	1.000	9,874.271
		Orimulsion		NO	NO	NO		NO	NO	41.868	NCV	NO	NO	NO	NO	NO	NO	NO
		Natural Gas Liquids	kt	NO	NO	NO		NO	NO	NO	NCV	NO	NO	NO	NA	NA,NO	NO	NA,NO
	Secondary Fuels	Gasoline	kt		1,128.527	5.965	NO	-31.192	1,153.755	44.589	NCV	51,444.771	19.080	981.566	NA	981.566	1.000	3,599.076
		Jet Kerosene	kt		1,197.551	NO	882.251	-0.084	315.385	44.100	NCV	13,908.467	19.473	270.840	NA	270.840	1.000	993.078
		Other Kerosene	kt		435.760	NO	NO	-26.508	462.268	44.196	NCV	20,430.391	19.473	397.835	NA	397.835	1.000	1,458.728
		Shale Oil			NO	NO		NO	NO	NO	NCV	NO	NO	NO	NO	NO	NO	NO
		Gas / Diesel Oil	kt		2,649.139	19.953	24.635	-40.102	2,644.652	43.308	NCV	114,535.137	19.991	2,289.660	NA	2,289.660	1.000	8,395.422
		Residual Fuel Oil	kt		767.634	1,162.545	45.498	-53.753	-386.655	41.236	NCV	-15,944.004	20.727	-330.475	NA	-330.475	1.000	-1,211.740
		Liquefied Petroleum Gas (LPG)	kt		130.496	11.477		3.376	115.644	47.156	NCV	5,453.277	17.373	94.738	NA	94.738	1.000	347.373
		Ethane			NO	NO		NO	NO	NO	NCV	NO	NO	NO	NA	NA,NO	NO	NA,NO
		Naphtha	kt		NO	24.484		-0.061	-24.424	44.003	NCV	-1,074.713	20.000	-21.494	NO	-21.494	1.000	-78.812
		Bitumen	kt		271.000	NO		NO	271.000	37.698	NCV	10,216.131	22.000	224.755	224.755	0.000	1.000	0.000
		Lubricants	kt		38.000	5.000	NO	NO	33.000	42.287	NCV	1,395.461	20.000	27.909	13.955	13.955	0.500	25.583
		Petroleum Coke	kt		349.145	0.483		6.335	342.327	32.084	NCV	10,983.219	25.345	278.371	NO	278.371	1.000	1,020.694
		Refinery Feedstocks			NO	NO		NO	NO	NO	NCV	NO	NO	NO	NO	NO	NO	NO
		Other Oil			NO	NO		NO	NO	NO	NCV	NO	NO	NO	NO	NO	NO	NO
Other Liquid Fossil												88.006		1.760	NO	1.760		6.454
Other non-specified			kt	NO	2.000	NO	NO	NO	2.000	44.003	NCV	88.006	20.000	1.760	NO	1.760	1.000	6.454
Liquid Fossil Totals												346,085.291		6,908.449	238.709	6,669.739		24,430.127
Solid Fossil	Primary Fuels	Anthracite [2]	kt	NO	52.000	NO		6.000	46.000	27.842	NCV	1,280.741	26.798	34.322	NO	34.322	1.000	125.846
		Coking Coal	kt	NO	NO	NO		NO	NO	NO	NCV	NO	NO	NO	NA	NA,NO	NO	NA,NO
		Other Bituminous Coal	kt	NO	2,450.000	23.000	NO	237.000	2,190.000	27.842	NCV	60,974.418	25.800	1,573.140	NA	1,573.140	1.000	5,768.180
		Sub-bituminous Coal		NO	NO	NO	NO	NO	NO	NO	NCV	NO	NO	NO	NO	NO	NO	NO
		Lignite	kt	NO	26.000	1.000		NO	25.000	19.816	NCV	495.403	27.600	13.673	NO	13.673	1.000	50.135
		Oil Shale		NO	NO	NO		NO	NO	NO	NCV	NO	NO	NO	NO	NO	NO	NO
		Peat	kt	2,534.265	NO	NO		-1,050.781	3,585.046	7.787	NCV	27,918.187	29.863	833.721	NA	833.721	1.000	3,056.976
	Secondary Fuels	BKB [3] and Patent Fuel	kt		NO	21.952		-32.105	10.153	18.548	NCV	188.313	26.962	5.077	NA	5.077	1.000	18.617
		Coke Oven/Gas Coke			NO	NO		NO	NO	NO	NCV	NO	NO	NO	NO	NO	NO	NO
Other Solid Fossil												7,266.818		206.113	NO	206.113		755.748
Other non-specified				NO	NO	NO	NO	NO	NO	NO	NCV	NO	NO	NO	NO	NO	NO	NO
Sod Peat			kt	555.000	NO	NO	NO	0.480	554.520	13.105	NCV	7,266.818	28.364	206.113	NO	206.113	1.000	755.748
Solid Fossil Totals												98,123.880		2,666.046	NA,NO	2,666.046		9,775.501
Gaseous Fossil		Natural Gas (Dry)	TJ	14,859.525	173,139.594	NO		-44.648	188,043.767	1.000	NCV	188,043.767	15.511	2,916.688	NO	2,916.688	1.000	10,694.524
Other Gaseous Fossil												NO		NO	NO	NO		NO
	Other non-specified			NO	NO	NO	NO	NO	NO	NO	NCV	NO	NO	NO	NO	NO	NO	NO
Gaseous Fossil Totals												188,043.767		2,916.688	NO	2,916.688		10,694.524
Total												632,252.939		12,491.183	238.709	12,252.473		44,900.152
Biomass total												11,269.373		302.632	NO	302.632		1,109.649
		Solid Biomass	TJ	6,993.000	478.000	7.000		NO	7,464.000	1.000	NCV	7,464.000	30.000	223.920	NO	223.920	1.000	821.040
		Liquid Biomass	TJ	1,004.563	1,363.546	88.807		-43.071	2,322.373	1.000	NCV	2,322.373	19.229	44.657	NO	44.657	1.000	163.741
		Gas Biomass	TJ	1,483.000	NO	NO		NO	1,483.000	1.000	NCV	1,483.000	22.964	34.055	NO	34.055	1.000	124.868

Table D.5 Comparison of Results from Sectoral Approach and Reference Approach for 2008 (CRF 2008 Table 1.A(c)]

FUEL TYPES	REFERENCE APPROACH			SECTORAL APPROACH [(1)]		DIFFERENCE [(2)]	
	Apparent energy consumption [(3)] (PJ)	Apparent energy consumption (excluding non-energy use and feedstocks) [(4)] (PJ)	CO_2 emissions (Gg)	Energy consumption (PJ)	CO_2 emissions (Gg)	Energy consumption (%)	CO_2 emissions (%)
Liquid Fuels (excluding international bunkers)	346.085	335.171	24,430.127	338.363	24,656.830	-0.943	-0.919
Solid Fuels (excluding international bunkers) [(5)]	98.124	98.124	9,775.501	96.037	9,465.212	2.173	3.278
Gaseous Fuels	188.044	188.044	10,694.524	189.695	10,881.926	-0.870	-1.722
Other [(5)]	NO	NO	NO	NA,NO	NA,NO	0.000	0.000
Total [(5)]	***632.253***	***621.339***	***44,900.152***	***624.094***	***45,003.967***	***-0.441***	***-0.231***

Table D.6 (a) Implied emission factors (IEFs) for CO_2 – Liquid Fuels in Sector 1.A.1.a

Energy (TJ)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Heavy Fuel Oil	13978.93	23298.22	23793.05	23504.40	26473.38	25318.78	25772.37	33483.46	45689.26	57070.34	41771.86	50019.02	36436.44	23912.76	30201.29	29201.32	25573.39	15238.51	14014.68	**Energy balance data**
Gasoil	303.16	259.85	346.47	216.54	779.55	649.62	389.77	476.39	606.32	1082.71	1212.63	1082.71	822.86	1169.32	1645.71	2867.04	3130.66	1325.36	434.86	**Energy balance data**
total	**14282.09**	**23558.07**	**24139.52**	**23720.94**	**27252.93**	**25968.40**	**26162.15**	**33959.85**	**46295.57**	**58153.04**	**42984.49**	**51101.72**	**37259.30**	**25082.08**	**31847.00**	**32068.36**	**28704.05**	**16563.87**	**14449.54**	**Liquid Fuels CRFReporter**
Emission Factors (t CO_2/TJ)																				
Heavy Fuel Oil	76.00	76.00	76.00	76.00	76.00	76.00	76.00	76.00	76.00	76.00	76.00	76.00	76.00	76.00	76.00	76.00	76.00	76.00	76.00	
Gasoil	73.30	73.30	73.30	73.30	73.30	73.30	73.30	73.30	73.30	73.30	73.30	73.30	73.30	73.30	73.30	73.30	73.30	73.30	73.30	
CO_2 Emissions National Approach Tier 1)																				
Heavy Fuel Oil	1062.40	1770.66	1808.27	1786.33	2011.98	1924.23	1958.70	2544.74	3472.38	4337.35	3174.66	3801.45	2769.17	1817.37	2295.30	2219.30	1943.58	1158.13	1065.12	
Gasoil	22.22	19.05	25.40	15.87	57.14	47.62	28.57	34.92	44.44	79.36	88.89	79.36	60.32	85.71	120.63	210.15	229.48	97.15	31.88	
total	**1084.62**	**1789.71**	**1833.67**	**1802.21**	**2069.12**	**1971.84**	**1987.27**	**2579.66**	**3516.83**	**4416.71**	**3263.55**	**3880.81**	**2829.48**	**1903.08**	**2415.93**	**2429.45**	**2173.05**	**1255.28**	**1096.99**	
IEF calculated	**75.94**	**75.97**	**75.96**	**75.98**	**75.92**	**75.93**	**75.96**	**75.96**	**75.96**	**75.95**	**75.92**	**75.94**	**75.94**	**75.87**	**75.86**	**75.76**	**75.71**	**75.78**	**75.92**	**IEF National Approach**
CO_2 emissions from ETS (Tier 3 bottom up)	1086.52	1788.62	1834.97	1803.59	2067.85	1985.81	1986.13	2617.23	3519.32	4533.60	3484.39	3925.34	2905.74	1992.62	2539.76	2562.77	2222.00	1284.23	1143.44	**Gg CO_2 CRFReporter**
difference	**0.17%**	**-0.06%**	**0.07%**	**0.08%**	**-0.06%**	**0.70%**	**-0.06%**	**1.44%**	**0.07%**	**2.58%**	**6.34%**	**1.13%**	**2.62%**	**4.49%**	**4.88%**	**5.20%**	**2.20%**	**2.25%**	**4.06%**	
IEF reported	**76.08**	**75.92**	**76.02**	**76.03**	**75.88**	**76.47**	**75.92**	**77.07**	**76.02**	**77.96**	**81.06**	**76.81**	**77.99**	**79.44**	**79.75**	**79.92**	**77.41**	**77.53**	**79.13**	**IEF CRFReporter**
	76.08	75.92	76.02	76.03	75.88	76.47	75.92	77.07	76.02	77.96	81.06	76.81	77.99	79.44	79.75	79.92	77.41	77.53	79.13	

Table D.6 (b) Implied emission factors (IEFs) for CO_2 – Liquid Fuels in Sector 1.A.1.a

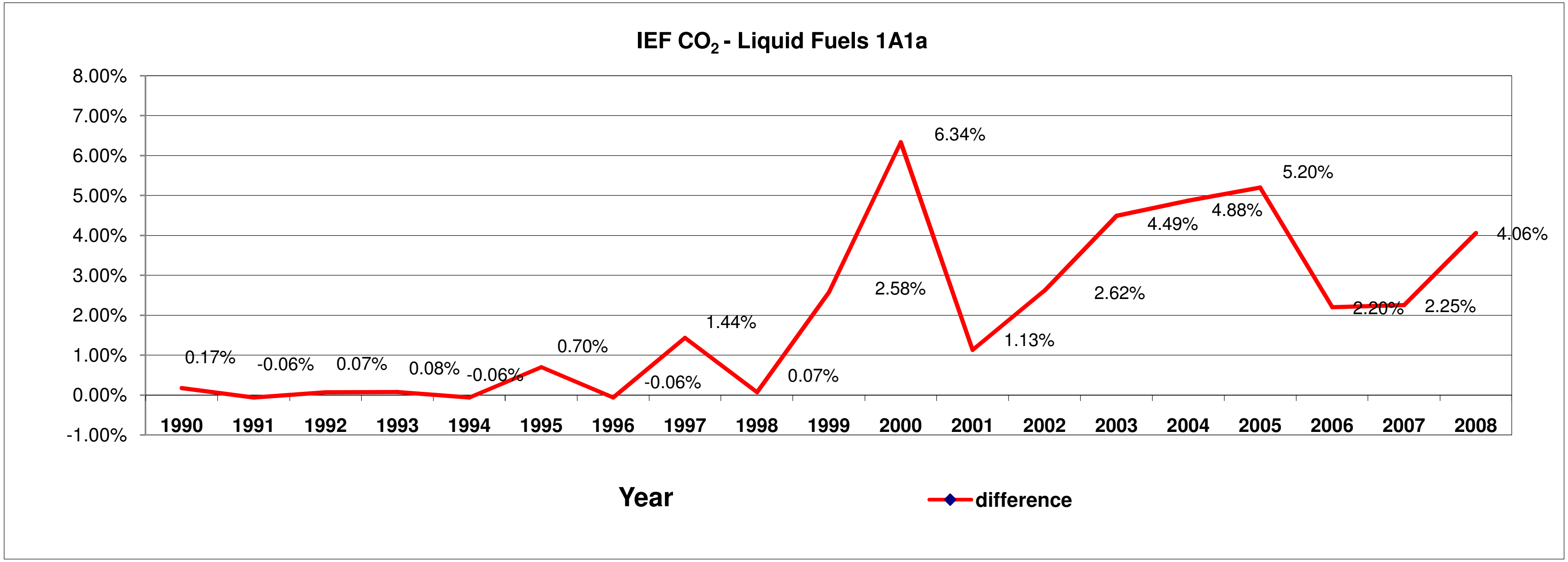

Table D.7 (a) Implied emission factors (IEFs) for CO_2 – Solid Fuels in Sector 1.A.1.a

Energy (TJ)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Coal	51972.08	51137.65	58287.50	56810.07	58544.91	62584.78	62177.52	60202.93	61174.75	52951.80	59728.50	63375.92	61343.32	55395.13	57925.06	59050.32	52968.76	47054.58	43813.75	**Energy balance data**
Milled Peat	23463.58	24374.71	25363.72	23222.17	23821.80	23385.71	22832.80	22871.73	21516.72	21516.72	20021.53	22466.79	22529.09	21010.53	12109.48	21092.90	18279.76	18036.97	23380.70	**Energy balance data**
Sod Peat	1323.57	1218.74	904.22	445.56	314.51	314.51	982.85	353.83	183.47	183.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**Energy balance data**
total	**76759.23**	**76731.10**	**84555.44**	**80477.79**	**82681.22**	**86285.00**	**85993.17**	**83428.49**	**82874.94**	**74651.99**	**79750.03**	**85842.71**	**83872.41**	**76405.67**	**70034.54**	**80143.22**	**71248.51**	**65091.55**	**67194.44**	**Solid Fuels CRFReporter**
Emission Factors (t CO_2/TJ)																				
Coal	94.60	94.60	94.60	94.60	94.60	94.60	94.60	94.60	94.60	94.60	94.60	94.60	94.60	94.60	94.60	94.60	94.60	94.60	94.60	
Milled Peat	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00	
Sod Peat	104.00	104.00	104.00	104.00	104.00	104.00	104.00	104.00	104.00	104.00	104.00	104.00	104.00	104.00	104.00	104.00	104.00	104.00	104.00	
CO_2 Emissions National Approach (Tier 1)																				
Coal	4916.56	4837.62	5514.00	5374.23	5538.35	5920.52	5881.99	5695.20	5787.13	5009.24	5650.32	5995.36	5803.08	5240.38	5479.71	5586.16	5010.84	4451.36	4144.78	
Milled Peat	2698.31	2803.09	2916.83	2670.55	2739.51	2689.36	2625.77	2630.25	2474.42	2474.42	2302.48	2583.68	2590.85	2416.21	1392.59	2425.68	2102.17	2074.25	2688.78	
Sod Peat	137.65	126.75	94.04	46.34	32.71	32.71	102.22	36.80	19.08	19.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
total	**7752.52**	**7767.46**	**8524.86**	**8091.12**	**8310.56**	**8642.59**	**8609.98**	**8362.24**	**8280.63**	**7502.74**	**7952.79**	**8579.04**	**8393.92**	**7656.59**	**6872.30**	**8011.84**	**7113.02**	**6525.61**	**6833.56**	
IEF calculated	**101.00**	**101.23**	**100.82**	**100.54**	**100.51**	**100.16**	**100.12**	**100.23**	**99.92**	**100.50**	**99.72**	**99.94**	**100.08**	**100.21**	**98.13**	**99.97**	**99.83**	**100.25**	**101.70**	**IEF National Approach**
CO_2 emissions from ETS (Tier 3 bottom up)	7909.31	7795.76	8477.38	7955.29	8205.33	8645.06	8857.12	8606.14	8145.16	7454.31	8084.48	8688.84	8397.65	7731.52	7078.28	7909.68	6966.22	6703.73	6630.99	**Gg CO_2 CRFReporter**
difference	**1.98%**	**0.36%**	**-0.56%**	**-1.71%**	**-1.28%**	**0.03%**	**2.79%**	**2.83%**	**-1.66%**	**-0.65%**	**1.63%**	**1.26%**	**0.04%**	**0.97%**	**2.91%**	**-1.29%**	**-2.11%**	**2.66%**	**-3.05%**	
IEF reported	**103.04**	**101.60**	**100.26**	**98.85**	**99.24**	**100.19**	**103.00**	**103.16**	**98.28**	**99.85**	**101.37**	**101.22**	**100.12**	**101.19**	**101.07**	**98.69**	**97.77**	**102.99**	**98.68**	**IEF CRFReporter**

Table D.7 (b) Implied emission factors (IEFs) for CO_2 – Solid Fuels in Sector 1.A.1.a

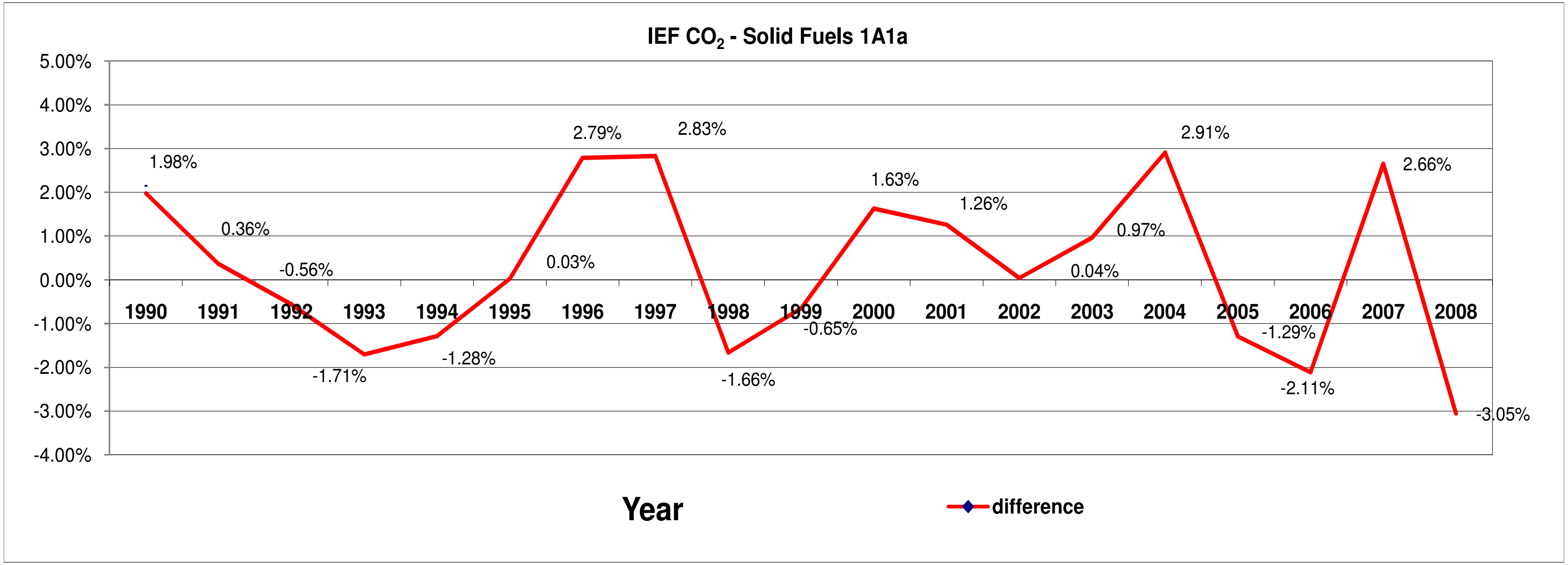

Table D.8 Implied emission factors (IEFs) for CO_2 – Liquid Fuels in Sector 1.A.2.f

Energy (TJ)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Kerosene	144.70	90.47	85.15	95.80	164.98	212.88	287.39	313.99	372.54	473.65	452.37	474.04	456.99	493.83	452.85	871.98	772.26	770.01	865.56	**Energy balance data**
Fuel Oil	3611.38	2007.31	2415.72	2466.61	3153.10	2935.85	2748.41	3012.82	2979.30	3180.05	3390.73	2668.90	2255.59	1951.78	1818.20	3306.59	2313.89	1835.17	1581.02	**Energy balance data**
LPG	1924.86	1569.13	1512.07	1540.60	1597.66	1540.60	1483.54	1597.66	1569.13	1569.13	1683.24	1537.94	1755.19	2049.33	2302.36	2092.88	2100.35	2063.97	2434.42	**Energy balance data**
Gasoil	3119.23	4336.97	4421.46	4336.97	5012.86	5716.92	4477.78	4674.92	4731.24	5041.02	5181.84	5461.59	5362.92	5288.70	4858.54	5767.26	5522.14	5182.80	5159.06	**Energy balance data**
Petroleum Coke	1971.87	1994.03	1462.29	1329.35	1971.87	2193.43	1019.17	2747.33	2414.99	2614.39	4608.42	5277.33	5951.78	7598.42	9083.54	9484.38	8950.54	10944.86	9164.12	**Energy balance data**
total	**10772.03**	**9997.91**	**9896.68**	**9769.33**	**11900.47**	**12599.68**	**10016.28**	**12346.72**	**12067.20**	**12878.25**	**15316.60**	**15419.80**	**15782.47**	**17382.07**	**18515.48**	**21523.09**	**19659.17**	**20796.81**	**19204.18**	**Energy balance data**
Emission Factors (t CO_2/TJ)																				
Kerosene	71.40	71.40	71.40	71.40	71.40	71.40	71.40	71.40	71.40	71.40	71.40	71.40	71.40	71.40	71.40	71.40	71.40	71.40	71.40	
Fuel Oil	76.00	76.00	76.00	76.00	76.00	76.00	76.00	76.00	76.00	76.00	76.00	76.00	76.00	76.00	76.00	76.00	76.00	76.00	76.00	
LPG	63.70	63.70	63.70	63.70	63.70	63.70	63.70	63.70	63.70	63.70	63.70	63.70	63.70	63.70	63.70	63.70	63.70	63.70	63.70	
Gasoil	73.30	73.30	73.30	73.30	73.30	73.30	73.30	73.30	73.30	73.30	73.30	73.30	73.30	73.30	73.30	73.30	73.30	73.30	73.30	
Petroleum Coke	93.68	93.68	93.68	93.68	93.68	93.68	93.68	93.68	93.68	93.68	93.68	93.68	93.68	93.68	93.68	95.13	93.43	93.21	92.93	
CO_2 Emissions National Approach (Tier 1)																				
Kerosene	10.33	6.46	6.08	6.84	11.78	15.20	20.52	22.42	26.60	33.82	32.30	33.85	32.63	35.26	32.33	62.26	55.14	54.98	61.80	
Fuel Oil	274.46	152.56	183.59	187.46	239.64	223.12	208.88	228.97	226.43	241.68	257.70	202.84	171.42	148.34	138.18	251.30	175.86	139.47	120.16	
LPG	122.61	99.95	96.32	98.14	101.77	98.14	94.50	101.77	99.95	99.95	107.22	97.97	111.81	130.54	146.66	133.32	133.79	131.48	155.07	
Gasoil	228.64	317.90	324.09	317.90	367.44	419.05	328.22	342.67	346.80	369.51	379.83	400.33	393.10	387.66	356.13	422.74	404.77	379.90	378.16	
Petroleum Coke	184.72	186.79	136.98	124.53	184.72	205.47	95.47	257.36	226.23	244.91	431.70	494.36	557.54	711.79	850.91	902.29	836.28	1020.13	851.64	
total	**820.77**	**763.66**	**747.07**	**734.87**	**905.35**	**960.98**	**747.59**	**953.20**	**926.01**	**989.87**	**1208.75**	**1229.35**	**1266.50**	**1413.59**	**1524.22**	**1771.91**	**1605.84**	**1725.95**	**1566.83**	
IEF calculated	**76.19**	**76.38**	**75.49**	**75.22**	**76.08**	**76.27**	**74.64**	**77.20**	**76.74**	**76.86**	**78.92**	**79.73**	**80.25**	**81.32**	**82.32**	**82.33**	**81.68**	**82.99**	**81.59**	**IEF National Approach**
CO_2 emissions	820.77	763.66	747.07	734.87	905.35	960.98	747.59	953.20	926.01	989.87	1208.75	1229.35	1266.50	1413.59	1524.22	1771.91	1605.84	1725.95	1566.83	**Gg CO_2 CRFReporter**
difference	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	
IEF reported	**76.19**	**76.38**	**75.49**	**75.22**	**76.08**	**76.27**	**74.64**	**77.20**	**76.74**	**76.86**	**78.92**	**79.73**	**80.25**	**81.32**	**82.32**	**82.33**	**81.68**	**82.99**	**81.59**	**IEF CRFReporter**
% Share of Fuels	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	
Kerosene	1.34%	0.90%	0.86%	0.98%	1.39%	1.69%	2.87%	2.54%	3.09%	3.68%	2.95%	3.07%	2.90%	2.84%	2.45%	4.05%	3.93%	3.70%	4.51%	
Fuel Oil	33.53%	20.08%	24.41%	25.25%	26.50%	23.30%	27.44%	24.40%	24.69%	24.69%	22.14%	17.31%	14.29%	11.23%	9.82%	15.36%	11.77%	8.82%	8.23%	
LPG	17.87%	15.69%	15.28%	15.77%	13.43%	12.23%	14.81%	12.94%	13.00%	12.18%	10.99%	9.97%	11.12%	11.79%	12.43%	9.72%	10.68%	9.92%	12.68%	
Gasoil	28.96%	43.38%	44.68%	44.39%	42.12%	45.37%	44.71%	37.86%	39.21%	39.14%	33.83%	35.42%	33.98%	30.43%	26.24%	26.80%	28.09%	24.92%	26.86%	
Petroleum Coke	**18.31%**	**19.94%**	**14.78%**	**13.61%**	**16.57%**	**17.41%**	**10.18%**	**22.25%**	**20.01%**	**20.30%**	**30.09%**	**34.22%**	**37.71%**	**43.71%**	**49.06%**	**44.07%**	**45.53%**	**52.63%**	**47.72%**	
	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	

Annex E

Animal Populations

Methane Emission Factors for Enteric Fermentation and Manure Management

Input Parameters used for the Calculation of Nitrous Oxide Emissions from Agricultural Soils

Table E.1 (a) Animal Populations 1990-2008

Housing and Storage (1000 head)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Cattle	5,969.10	6,100.40	6,147.30	6,236.40	6,263.90	6,343.80	6,450.70	6,661.00	6,881.60	6,951.80	6,557.70	6,330.10	6,408.10	6,332.90	6,223.50	6,211.50	6,191.80	6,001.70	5,902.20
Dairy Cows	1,341.60	1,322.20	1,288.00	1,246.20	1,248.30	1,233.00	1,220.80	1,215.60	1,201.40	1,198.80	1,173.80	1,152.80	1,148.00	1,128.70	1,135.70	1,121.80	1,101.10	1,087.10	1,087.50
All Other Cattle	4,627.50	4,778.20	4,859.30	4,990.20	5,015.60	5,110.80	5,229.90	5,445.40	5,680.20	5,753.00	5,383.90	5,177.30	5,260.10	5,204.20	5,087.80	5,089.70	5,090.70	4,914.60	4,814.70
Other Cows	659.20	729.40	784.00	916.70	936.60	968.70	1,004.60	1,083.40	1,163.80	1,196.20	1,166.80	1,155.20	1,159.70	1,150.80	1,144.20	1,150.80	1,150.00	1,128.80	1,117.40
Dairy Heifers	172.30	185.30	182.10	198.70	193.70	209.40	235.40	243.80	244.00	223.80	210.40	202.90	206.20	215.80	225.60	238.00	236.30	220.50	212.90
Other Heifers	100.00	91.30	91.70	117.30	121.40	107.20	129.20	139.00	154.00	128.80	125.20	140.40	147.50	141.60	140.90	143.60	146.30	144.40	147.50
Cattle < 1 yrs	1,436.20	1,477.00	1,491.00	1,472.30	1,564.90	1,556.50	1,631.40	1,735.00	1,828.60	1,789.60	1,648.90	1,689.90	1,879.40	1,805.70	1,751.10	1,746.00	1,693.30	1,635.80	1,633.40
Cattle < 1 yrs - male	775.30	794.80	796.10	799.40	849.60	842.20	888.10	952.90	1,012.80	983.10	892.20	927.10	1,007.40	1,001.10	948.60	924.20	885.60	835.50	830.80
Cattle < 1 yrs - female	660.90	682.20	694.90	672.90	715.30	714.30	743.30	782.10	815.80	806.50	756.70	762.80	872.00	804.60	802.50	821.80	807.70	800.30	802.60
Cattle 1 - 2 yrs	1,311.70	1,347.60	1,399.30	1,379.00	1,361.40	1,403.90	1,380.20	1,424.60	1,481.90	1,548.90	1,446.40	1,269.30	1,329.00	1,363.80	1,319.90	1,253.40	1,261.70	1,194.20	1,153.30
Cattle 1 - 2 yrs - male	813.80	824.00	846.00	857.50	841.20	850.60	853.00	894.70	943.60	976.10	904.80	798.10	841.40	885.60	856.20	782.00	762.00	703.40	662.80
Cattle 1 - 2 yrs - female	497.90	523.60	553.30	521.50	520.20	553.30	527.20	529.90	538.30	572.80	541.60	471.20	487.60	478.20	463.70	471.40	499.70	490.80	490.50
Cattle > 2 yrs	922.60	920.10	881.50	873.80	803.10	829.10	810.50	778.00	763.10	818.90	738.70	669.80	485.30	471.20	449.50	499.20	543.50	532.80	491.60
Cattle > 2 yrs - male	638.70	623.90	591.20	608.50	551.80	571.40	563.30	531.40	521.90	546.40	491.10	452.30	288.00	278.60	258.20	283.20	311.90	313.30	287.30
Cattle > 2 yrs - female	283.90	296.20	290.30	265.30	251.30	257.70	247.20	246.60	241.20	272.50	247.60	217.50	197.30	192.60	191.30	216.00	231.60	219.50	204.30
Bulls	25.50	27.50	29.70	32.40	34.50	36.00	38.60	41.60	44.80	46.80	47.50	49.80	53.00	55.30	56.60	58.70	59.60	58.10	58.60
Total Sheep	8,020.98	8,483.65	8,735.75	8,977.22	8,559.06	8,363.83	8,329.04	8,050.87	8,572.21	8,547.20	7,957.34	7,454.79	6,682.41	6,480.70	6,703.33	6,431.32	6,187.15	5,655.57	5,105.21
Ewes Lowland	2,396.60	2,542.54	2,621.99	2,576.45	2,511.11	2,426.99	2,369.07	2,389.75	3,056.41	2,936.15	2,814.25	2,704.31	2,637.25	2,552.34	2,463.79	2,626.72	2,414.32	2,206.84	2,056.56
Ewes Upland	1,960.85	2,080.26	2,145.26	2,108.00	2,054.54	1,985.72	1,938.33	1,955.25	1,309.89	1,258.35	1,206.11	1,158.99	1,130.25	1,093.86	1,055.91	656.68	603.58	551.71	514.14
Rams	116.85	122.55	126.45	125.05	122.05	120.00	113.15	115.50	115.70	113.25	110.65	106.55	104.65	102.35	100.00	96.25	92.70	85.75	78.70
Other Sheep>1	298.38	174.80	161.35	179.22	194.86	205.33	192.19	215.37	245.21	218.35	204.74	182.20	184.46	205.74	199.44	155.13	152.76	136.80	140.35
Lambs	3,248.30	3,563.50	3,680.70	3,988.50	3,676.50	3,625.80	3,716.30	3,375.00	3,845.00	4,021.10	3,621.60	3,302.74	2,625.80	2,526.41	2,884.19	2,896.54	2,923.79	2,674.47	2,315.46
Total Pigs	1,212.10	1,315.85	1,394.60	1,495.90	1,506.95	1,539.40	1,632.65	1,698.80	1,800.95	1,763.90	1,718.65	1,751.75	1,784.40	1,721.10	1,696.15	1,671.50	1,625.40	1,574.85	1,529.65
Gilts in Pig	21.10	21.85	25.45	23.20	21.65	23.70	24.50	26.85	25.60	24.85	21.25	22.65	20.05	20.00	21.55	19.75	21.65	21.90	21.75
Gilts not yet Served	12.10	13.90	14.55	14.35	14.70	17.55	16.85	17.70	18.70	16.20	17.85	18.95	19.55	17.80	19.00	19.55	18.65	16.50	16.60
Sows in Pig	83.45	90.25	96.15	100.75	99.40	100.30	103.20	107.95	109.10	108.60	109.65	107.30	110.00	103.95	102.25	99.80	96.40	94.55	90.70
Other Sows for Breeding	21.00	22.45	23.45	24.20	22.60	24.00	25.65	27.55	29.20	26.65	23.85	27.85	26.45	24.75	22.80	25.90	24.30	22.60	20.05
Boars	6.25	6.65	6.55	6.35	5.65	5.30	5.10	5.10	4.75	4.20	4.00	3.55	3.30	3.00	2.75	2.45	1.95	1.75	1.50
Pigs 20 Kg +	749.20	802.65	836.50	904.95	917.65	951.90	1,015.80	1,063.90	1,144.35	1,094.15	1,037.90	1,036.20	1,061.95	1,043.20	1,027.80	1,010.30	1,033.95	969.60	972.35
Pigs Under 20 Kg	319.00	358.10	391.95	422.10	425.30	416.65	441.55	449.75	469.25	489.25	504.15	535.25	543.10	508.40	500.00	493.75	428.50	447.95	406.70
Total Poultry	11,412.83	12,338.21	12,913.07	12,712.41	13,674.55	14,078.45	15,015.62	15,189.04	15,326.96	15,130.48	15,320.50	15,663.15	15,182.57	15,787.87	16,610.57	16,094.68	15,303.58	14,826.15	14,348.72
Layer	1,868.25	1,800.00	2,231.00	1,831.50	1,730.00	1,370.50	1,701.00	1,580.00	1,558.50	1,537.00	1,572.00	1,676.00	1,613.00	1,906.60	1,906.27	1,950.00	1,970.00	1,900.00	1,830.00
Broiler	8,035.13	8,904.90	9,066.82	9,522.47	10,392.54	11,092.18	11,729.88	12,096.34	12,286.79	12,200.11	12,426.10	12,628.89	12,321.96	12,672.21	13,242.90	12,817.70	12,236.93	12,029.20	11,821.47
Turkey	1,509.45	1,633.30	1,615.26	1,358.44	1,552.01	1,615.77	1,584.74	1,512.70	1,481.67	1,393.37	1,322.41	1,358.26	1,247.60	1,209.06	1,461.40	1,326.98	1,096.65	896.95	697.25
Horses	61.60	63.10	65.10	66.20	67.00	68.00	69.90	71.90	72.80	75.50	69.90	71.00	72.60	70.40	72.80	79.90	86.60	89.20	95.70
Mules	8.30	7.30	8.00	8.50	7.80	7.00	7.60	7.10	7.50	7.30	5.00	4.90	4.70	5.80	5.70	6.00	7.00	7.20	8.80
Goats	17.40	17.40	17.80	17.60	16.10	15.60	14.90	15.20	15.10	13.50	8.10	7.80	7.70	7.60	7.50	7.30	6.70	7.30	8.90
Fertiliser (tonnes N)	379,311	370,121	358,302	377,985	404,811	428,826	416,918	380,350	431,999	442,916	407,598	368,667	363,513	388,080	362,525	352,165	342,137	321,553	308,960

Table E.1 (b) Animal Populations 1990-2008

Pasture (1000 head)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Cattle	6,816.10	6,912.10	6,951.40	6,981.70	6,996.30	7,034.00	7,313.50	7,532.80	7,639.90	7,387.00	7,037.40	7,049.70	6,992.20	6,999.60	7,015.70	6,982.60	6,915.80	6,704.10	6,719.90
Dairy Cows	1,359.70	1,330.80	1,277.90	1,263.50	1,260.60	1,256.20	1,266.40	1,251.70	1,233.80	1,200.60	1,177.50	1,182.50	1,164.10	1,155.60	1,156.10	1,113.70	1,109.20	1,087.00	1,113.90
All Other Cattle	5,456.40	5,581.30	5,673.50	5,718.20	5,735.70	5,777.80	6,047.10	6,281.10	6,406.10	6,186.40	5,859.90	5,867.20	5,828.10	5,844.00	5,859.60	5,868.90	5,806.60	5,617.10	5,606.00
Other Cows	731.30	817.30	889.10	979.70	1,011.00	1,039.10	1,112.70	1,201.90	1,247.90	1,217.30	1,187.00	1,196.80	1,154.20	1,187.30	1,207.10	1,227.80	1,215.40	1,180.90	1,179.90
Dairy Heifers	158.60	129.70	174.50	187.90	203.90	224.10	231.40	243.90	228.80	213.60	206.50	198.30	230.70	215.80	229.60	230.20	228.70	217.80	225.40
Other Heifers	68.60	50.10	94.50	111.50	101.50	117.20	128.80	143.50	126.70	116.50	125.10	132.80	143.20	137.00	139.60	148.10	157.00	152.80	147.90
Cattle < 1 yrs	1,716.10	1,764.70	1,694.50	1,737.50	1,736.20	1,746.10	1,852.10	1,938.20	1,965.00	1,820.70	1,751.90	1,824.40	1,799.30	1,761.20	1,771.40	1,689.50	1,631.20	1,593.50	1,615.90
Cattle < 1 yrs - male	903.20	918.70	888.90	913.80	903.80	915.30	974.30	1,023.00	1,054.80	965.10	919.40	955.20	953.10	922.10	929.80	842.50	801.70	784.50	801.20
Cattle < 1 yrs - female	812.90	845.90	805.60	823.70	832.40	830.70	877.80	915.20	910.30	855.50	832.50	869.20	846.20	839.10	841.60	847.00	829.50	809.00	814.70
Cattle 1 - 2 yrs	1,663.10	1,692.00	1,637.60	1,587.00	1,585.70	1,586.10	1,639.40	1,717.00	1,782.60	1,706.00	1,517.10	1,515.00	1,593.20	1,577.10	1,534.80	1,575.60	1,553.80	1,475.80	1,466.30
Cattle 1 - 2 yrs - male	985.80	981.10	981.60	957.50	952.00	964.40	996.20	1,054.70	1,085.60	1,039.00	912.40	913.30	991.80	983.30	949.80	940.20	915.70	843.90	842.50
Cattle 1 - 2 yrs - female	677.30	710.90	656.10	629.50	633.70	621.70	643.20	662.30	697.00	667.10	604.70	601.70	601.40	593.90	585.00	635.30	638.10	631.90	623.80
Cattle > 2 yrs	1,092.60	1,098.80	1,151.80	1,077.90	1,057.70	1,022.90	1,036.20	985.70	1,002.10	1,057.70	1,016.20	941.10	844.70	901.50	910.60	929.40	951.20	928.30	902.10
Cattle > 2 yrs - male	826.40	797.50	829.60	773.20	739.80	711.60	732.20	690.20	708.10	736.70	721.60	642.10	560.40	598.70	605.40	619.30	639.70	614.50	589.00
Cattle > 2 yrs - female	266.20	301.30	322.20	304.70	318.00	311.30	304.00	295.60	294.00	321.00	294.70	299.00	284.30	302.80	305.20	310.20	311.50	313.80	313.10
Bulls	26.10	28.70	31.50	36.70	39.70	42.30	46.50	50.90	53.00	54.60	56.10	58.80	62.80	64.10	66.50	68.30	69.30	68.00	68.50
Total Sheep	8,020.98	8,483.65	8,735.75	8,977.22	8,559.06	8,363.83	8,329.04	8,050.87	8,572.21	8,547.20	7,957.34	7,454.79	6,682.41	6,480.70	6,703.33	6,431.32	6,187.15	5,655.57	5,105.21
Lowland Ewes	2,396.60	2,542.54	2,621.99	2,576.45	2,511.11	2,426.99	2,369.07	2,389.75	3,056.41	2,936.15	2,814.25	2,704.31	2,637.25	2,552.34	2,463.79	2,626.72	2,414.32	2,206.84	2,056.56
Upland Ewes	1,960.85	2,080.26	2,145.26	2,108.00	2,054.54	1,985.72	1,938.33	1,955.25	1,309.89	1,258.35	1,206.11	1,158.99	1,130.25	1,093.86	1,055.91	656.68	603.58	551.71	514.14
Rams	116.85	122.55	126.45	125.05	122.05	120.00	113.15	115.50	115.70	113.25	110.65	106.55	104.65	102.35	100.00	96.25	92.70	85.75	78.70
Other Sheep>1	298.38	174.80	161.35	179.22	194.86	205.33	192.19	215.37	245.21	218.35	204.74	182.20	184.46	205.74	199.44	155.13	152.76	136.80	140.35
Lambs	3,248.30	3,563.50	3,680.70	3,988.50	3,676.50	3,625.80	3,716.30	3,375.00	3,845.00	4,021.10	3,621.60	3,302.74	2,625.80	2,526.41	2,884.19	2,896.54	2,923.79	2,674.47	2,315.46
Total Pigs	1,212.10	1,315.85	1,394.60	1,495.90	1,506.95	1,539.40	1,632.65	1,698.80	1,800.95	1,763.90	1,718.65	1,751.75	1,784.40	1,721.10	1,696.15	1,671.50	1,625.40	1,574.85	1,529.65
Gilts in Pig	21.10	21.85	25.45	23.20	21.65	23.70	24.50	26.85	25.60	24.85	21.25	22.65	20.05	20.00	21.55	19.75	21.65	21.90	21.75
Gilts not yet Served	12.10	13.90	14.55	14.35	14.70	17.55	16.85	17.70	18.70	16.20	17.85	18.95	19.55	17.80	19.00	19.55	18.65	16.50	16.60
Sows in Pig	83.45	90.25	96.15	100.75	99.40	100.30	103.20	107.95	109.10	108.60	109.65	107.30	110.00	103.95	102.25	99.80	96.40	94.55	90.70
Other Sows for Breeding	21.00	22.45	23.45	24.20	22.60	24.00	25.65	27.55	29.20	26.65	23.85	27.85	26.45	24.75	22.80	25.90	24.30	22.60	20.05
Boars	6.25	6.65	6.55	6.35	5.65	5.30	5.10	5.10	4.75	4.20	4.00	3.55	3.30	3.00	2.75	2.45	1.95	1.75	1.50
Pigs 20 Kg +	749.20	802.65	836.50	904.95	917.65	951.90	1,015.80	1,063.90	1,144.35	1,094.15	1,037.90	1,036.20	1,061.95	1,043.20	1,027.80	1,010.30	1,033.95	969.60	972.35
Pigs Under 20 Kg	319.00	358.10	391.95	422.10	425.30	416.65	441.55	449.75	469.25	489.25	504.15	535.25	543.10	508.40	500.00	493.75	428.50	447.95	406.70
Total Poultry	11,412.83	12,338.21	12,913.07	12,712.41	13,674.55	14,078.45	15,015.62	15,189.04	15,326.96	15,130.48	15,320.50	15,663.15	15,182.57	15,787.87	16,610.57	16,094.68	15,303.58	14,826.15	14,348.72
Layer	1,868.25	1,800.00	2,231.00	1,831.50	1,730.00	1,370.50	1,701.00	1,580.00	1,558.50	1,537.00	1,572.00	1,676.00	1,613.00	1,906.60	1,906.27	1,950.00	1,970.00	1,900.00	1,830.00
Broiler	8,035.13	8,904.90	9,066.82	9,522.47	10,392.54	11,092.18	11,729.88	12,096.34	12,286.79	12,200.11	12,426.10	12,628.89	12,321.96	12,672.21	13,242.90	12,817.70	12,236.93	12,029.20	11,821.47
Turkey	1,509.45	1,633.30	1,615.26	1,358.44	1,552.01	1,615.77	1,584.74	1,512.70	1,481.67	1,393.37	1,322.41	1,358.26	1,247.60	1,209.06	1,461.40	1,326.98	1,096.65	896.95	697.25
Horses	61.60	63.10	65.10	66.20	67.00	68.00	69.90	71.90	72.80	75.50	69.90	71.00	72.60	70.40	72.80	79.90	86.60	89.20	95.70
Mules	8.30	7.30	8.00	8.50	7.80	7.00	7.60	7.10	7.50	7.30	5.00	4.90	4.70	5.80	5.70	6.00	7.00	7.20	8.80
Goats	17.40	17.40	17.80	17.60	16.10	15.60	14.90	15.20	15.10	13.50	8.10	7.80	7.70	7.60	7.50	7.30	6.70	7.30	8.90
Fertiliser (tonnes N)	379,311	370,121	358,302	377,985	404,811	428,826	416,918	380,350	431,999	442,916	407,598	368,667	363,513	388,080	362,525	352,165	342,137	321,553	308,960

Table E.2 (a) CH_4 Emission Factors for Enteric Fermentation (kg/head/year)

Animal Category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Cattle																			
Dairy cows	101.38	101.92	102.47	103.01	103.56	104.10	104.64	105.19	105.73	106.28	106.82	107.37	107.91	108.45	108.36	107.84	109.68	110.22	109.21
Beef cows(Suckler Cows)	74.03	74.04	74.06	74.07	74.08	74.10	74.11	74.12	74.14	74.15	74.16	74.18	74.19	74.20	74.47	74.15	74.28	73.87	75.92
Dairy heifers	51.82	51.69	51.56	51.44	51.31	51.18	51.05	50.93	50.80	50.67	50.54	50.42	50.29	50.16	50.16	50.16	50.16	50.16	50.16
Beef heifers	55.42	55.29	55.15	55.02	54.89	54.75	54.62	54.48	54.35	54.22	54.08	53.95	53.82	53.68	53.68	53.68	53.68	53.68	53.68
Bulls for breeding	86.38	86.01	85.61	85.23	84.86	84.49	84.12	83.75	83.37	83.00	82.63	82.26	81.89	81.55	81.55	81.55	81.55	81.55	81.55
Male cattle																			
< 1 year	30.46	30.39	30.31	30.24	30.17	30.09	30.02	29.95	29.87	29.80	29.73	29.65	29.58	29.51	29.70	29.74	29.61	29.69	29.71
1 - 2 years	62.22	62.09	61.95	61.82	61.69	61.55	61.42	61.29	61.16	61.02	60.89	60.76	60.62	60.49	59.27	58.94	59.88	59.19	59.07
> 2 years*	55.08	53.47	51.85	50.24	48.63	47.01	45.40	43.79	42.17	40.56	38.95	37.33	35.72	34.11	35.24	37.67	37.78	38.58	36.98
Female cattle																			
< 1 year	27.05	27.11	27.17	27.22	27.28	27.34	27.40	27.45	27.51	27.57	27.63	27.68	27.74	27.80	27.88	27.86	27.76	27.77	27.72
1 - 2 years	53.54	52.85	52.17	51.48	50.79	50.10	49.42	48.73	48.04	47.35	46.67	45.98	45.29	44.60	44.49	45.61	46.39	46.60	47.00
> 2 years*	21.65	21.71	21.77	21.84	21.90	21.96	22.02	22.08	22.15	22.21	22.27	22.33	22.40	22.46	22.46	22.43	22.38	22.42	22.55
Sheep																			
Lowland Ewes	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Upland Ewes	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Rams	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Sheep > 1 yrs	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Lambs	3.38	3.38	3.38	3.38	3.38	3.38	3.38	3.38	3.38	3.38	3.38	3.38	3.38	3.38	3.38	3.38	3.38	3.38	3.38
Horses	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00
Mules	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Goats	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Pigs																			
Gilts in Pig	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Gilts not yet Served	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Sows in Pig	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Other Sows for Breeding	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Boars	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Pigs > 20 Kg	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44
Pigs < 20 Kg	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Poultry	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

* Note: This value is low because this category of animal only live part of their third year.

Table E.2 (a) CH_4 Emission Factors for Manure Management (kg/head/year)

Animal Category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Cattle																			
Dairy cows	21.57	21.49	21.40	21.32	21.24	21.15	21.07	20.99	20.91	20.82	20.74	20.66	20.57	20.49	20.46	20.41	20.59	20.60	20.50
Beef cows(Suckler Cows)	14.02	14.01	13.99	13.98	13.97	13.96	13.94	13.93	13.92	13.91	13.89	13.88	13.87	13.85	13.89	13.86	13.88	13.85	14.25
Dairy heifers	13.40	13.21	13.02	12.83	12.64	12.45	12.26	12.07	11.88	11.69	11.50	11.31	11.12	10.93	10.93	10.93	10.93	10.93	10.93
Beef heifers	15.61	15.40	15.19	14.98	14.77	14.56	14.35	14.14	13.93	13.71	13.50	13.29	13.08	12.87	12.87	12.87	12.87	12.87	12.87
Bulls for breeding	23.79	23.42	23.05	22.67	22.30	21.93	21.56	21.18	20.81	20.44	20.07	19.70	19.32	18.95	18.95	18.95	18.95	18.95	18.95
Male cattle																			
< 1 year	9.73	9.64	9.54	9.45	9.35	9.26	9.17	9.07	8.98	8.88	8.79	8.70	8.60	8.51	8.58	8.59	8.55	8.59	8.63
1 - 2 years	16.68	16.49	16.29	16.10	15.90	15.71	15.52	15.32	15.13	14.93	14.74	14.55	14.35	14.16	13.75	13.82	14.08	13.85	13.78
> 2 years*	4.57	4.33	4.09	3.85	3.61	3.37	3.13	2.89	2.65	2.41	2.17	1.93	1.69	1.46	1.60	1.91	1.92	2.02	1.82
Female cattle																			
< 1 year	8.79	8.75	8.71	8.67	8.63	8.60	8.56	8.52	8.48	8.44	8.40	8.36	8.32	8.28	8.30	8.28	8.27	8.27	8.28
1 - 2 years	14.74	14.33	13.91	13.50	13.08	12.67	12.25	11.84	11.42	11.01	10.59	10.18	9.76	9.35	9.11	9.62	9.76	9.79	9.95
> 2 years*	0.33	0.33	0.33	0.33	0.33	0.33	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34
Sheep																			
Lowland Sheep	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Upland Sheep	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Rams	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Sheep >1 yrs	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Lambs	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Horses	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Mules	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76
Goats	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Pigs																			
Gilts in Pig	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46
Gilts not yet Served	17.17	17.17	17.17	17.17	17.17	17.17	17.17	17.17	17.17	17.17	17.17	17.17	17.17	17.17	17.17	17.17	17.17	17.17	17.17
Sows in Pig	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46
Other Sows for Breeding	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46
Boars	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46
Pigs > 20 Kg	12.88	12.88	12.88	12.88	12.88	12.88	12.88	12.88	12.88	12.88	12.88	12.88	12.88	12.88	12.88	12.88	12.88	12.88	12.88
Pigs < 20 Kg	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58
Poultry																			
Layers	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28
Broilers	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Turkeys	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08

* Note: This value is low because this category of animal only live part of their third year.

Table E.3 Input Parameters for the calculation of N_2O Emissions from Agricultural Soils

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
$Frac_{GASF}$	0.015	0.015	0.016	0.016	0.016	0.015	0.020	0.021	0.018	0.018	0.021	0.020	0.017	0.015	0.015	0.016	0.016	0.015	0.016
$Frac_{GRAZ}$	0.659	0.658	0.660	0.657	0.658	0.655	0.658	0.658	0.658	0.650	0.650	0.656	0.655	0.657	0.659	0.660	0.657	0.656	0.659
$Frac_{GASM1}$	0.485	0.485	0.485	0.487	0.486	0.487	0.487	0.487	0.487	0.488	0.487	0.486	0.486	0.486	0.485	0.485	0.486	0.485	0.485
$Frac_{GASM2}$	0.043	0.042	0.041	0.041	0.041	0.040	0.041	0.040	0.040	0.040	0.040	0.038	0.038	0.037	0.038	0.036	0.036	0.036	0.036
$Frac_{GASM}$	0.194	0.194	0.192	0.194	0.194	0.194	0.193	0.193	0.193	0.197	0.196	0.192	0.192	0.191	0.190	0.189	0.190	0.191	0.189
F_{BN}	0.010	0.009	0.009	0.017	0.017	0.013	0.014	0.013	0.022	0.012	0.005	0.006	0.005	0.009	0.010	0.013	0.013	0.009	0.007
$Frac_{LEACH}$	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
F_{SN} (tonnes/year)	373,709	364,674	352,521	371,918	398,533	422,508	408,622	372,451	424,071	434,967	398,911	361,348	357,490	382,382	356,974	346,638	336,525	316,641	304,007
F_{AM} (tonnes/year)	76,051	77,519	78,081	78,742	78,618	79,469	80,458	82,408	84,673	85,314	81,730	79,325	78,930	78,319	78,146	77,894	77,559	75,369	74,158
F_S (tonnes/year)	105.527	106.126	106.993	107.583	107.938	97.136	92.189	255.082	364.974	568.682	741.352	932.714	1,103.564	1,228.756	1,687.586	1,839.495	1,869.472	1,899.239	1,928.670
F_{CR} (tonnes/year)	19,692	19,001	19,335	16,199	17,934	19,439	20,849	19,969	19,917	21,127	21,683	19,743	17,757	19,963	23,569	17,959	10,551	10,244	11,522

Table E.4 Allocation of Animal Wastes to Animal Waste Management Systems

Animal Catgeory	Days housed (mean)	% housed	% outwintered	Housing Type		Proportion to each animal waste management sytem		
				% Slurry based	% Straw based	Liquid	Solid	Pasture
Cattle								
Dairy Cows	161	98.18	1.82	93.75	6.25	0.405	0.027	0.567
Suckler Cows	131	83.76	16.24	72.73	27.27	0.220	0.080	0.700
In-calf heifers	137	95.87	4.13	80.02	19.98	0.290	0.070	0.640
Cattle under 1 year old	140	94.34	5.66	67.98	32.02	0.250	0.120	0.640
Cattle 1-2 years old	143	92.10	7.90	79.48	20.52	0.290	0.070	0.640
Cattle over 2 years old	146	86.43	13.57	58.70	41.30	0.200	0.140	0.650
Bulls	143	89.49	10.51	29.94	70.06	0.100	0.250	0.650
Sheep								
Lowland Ewes	61	47.07	52.93	0.00	100	0.000	0.078	0.922
Upland Ewes	85	44.34	55.66	0.00	100	NA	0.103	0.897
Rams	85	22.34	77.66	0.00	100	NA	0.052	0.948
Lambs	58	16.88	83.12	0.00	100	NA	0.027	0.973
Other sheep	61	47.07	52.93	0.00	100	NA	0.078	0.922
Pigs								
Gilts in pig	365	100	0.00	100	0.00	1.000	0.000	0.000
Gilts not yet served	365	100	0.00	100	0.00	1.000	0.000	0.000
Sows in pig	365	100	0.00	100	0.00	1.000	0.000	0.000
Other sows for breeding	365	100	0.00	100	0.00	1.000	0.000	0.000
Boars	365	100	0.00	100	0.00	1.000	0.000	0.000
Pigs < 20 kg	365	100	0.00	100	0.00	1.000	0.000	0.000
Pigs > 20 kg	365	100	0.00	100	0.00	1.000	0.000	0.000
Poultry								
Layers	365	88.00	12.00	84.20	15.80	0.741	0.139	0.120
Broilers	365	100.00	0.00	0.00	100.00	0.000	1.000	0.000
Turkeys	365	100.00	0.00	0.00	100.00	0.000	1.000	0.000
Horses	143	100.00	0.00	0.00	100.00	0.000	0.392	0.608
Mules and Asses	143	100.00	0.00	0.00	100.00	0.000	0.390	0.608
Goats	0.00	0.00	100.00	0.00	0.00	0.000	0.000	1.000

Annex F

Activity Data and Carbon Stock Change Estimates for LULUCF Category 5.A Forest Land

Table F.1 Activity Data and Carbon Stock Change Estimates for LULUCF Category 5.A Forest Land

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
Year	Affor	Refor	Felling	Cleared & Unclass	Forest Cover	Total Forest	Harvest Volume	Harvest Carbon Stock	Affor Carbon Stock	Carbon Stock Young Forests	Carbon Stock Mature Forests	Carbon Stock Total Forests	Total Carbon Stock Change	5.A.1 Carbon Stock Change	5.A.2 Carbon Stock Change	5.A.2a Carbon Stock Change	5.A.2b Carbon Stock Change	5.A.2c Carbon Stock Change	5.A.2d Carbon Stock Change	5.A.2e Carbon Stock Change
	ha	ha	ha	ha	ha	ha	1000 m3	Gg C	Gg C	Gg C	Gg C	Gg C	Gg C	Gg C	Gg C	Gg C	Gg C	Gg C	Gg C	Gg C
1990	15,817	3,882	4,203	111,463	370,160	481,623	1,676	508.83	273.03	1937.10	13948.13	15885.24	215.83	271.16	-55.32	-16.60	-5.53	-31.54	0.00	-1.66
1991	19,147	4,203	4,063	126,982	373,728	500,710	1,769	537.07	330.52	1853.07	14259.25	16112.32	227.09	311.12	-84.03	-25.21	-8.40	-47.90	0.00	-2.52
1992	16,699	4,063	4,621	141,110	376,237	517,347	2,083	632.42	288.26	1801.60	14496.41	16298.01	185.68	237.16	-51.48	-15.44	-5.15	-29.34	0.00	-1.54
1993	15,998	4,621	4,816	152,340	380,940	533,280	2,100	637.60	276.16	1776.21	14730.77	16506.97	208.97	234.36	-25.39	-7.62	-2.54	-14.47	0.00	-0.76
1994	19,459	4,816	5,447	166,060	386,598	552,659	2,287	694.30	335.90	1818.10	14888.70	16706.80	199.83	157.93	41.89	12.57	4.19	23.88	0.00	1.26
1995	23,710	5,447	6,203	181,454	394,834	576,288	2,382	723.28	409.28	1920.39	14999.52	16919.91	213.11	110.82	102.29	30.69	10.23	58.31	0.00	3.07
1996	20,981	6,711	7,090	190,647	406,522	597,169	2,465	748.35	362.17	2044.97	15093.96	17138.94	219.02	94.44	124.58	37.37	12.46	71.01	0.00	3.74
1997	11,434	7,655	7,185	189,286	419,209	608,494	2,322	705.11	197.37	2231.18	15160.72	17391.90	252.96	66.75	186.20	55.86	18.62	106.14	0.00	5.59
1998	12,928	7,494	7,924	186,431	434,877	621,308	2,638	800.90	223.16	2376.68	15300.15	17676.83	284.93	139.43	145.50	43.65	14.55	82.94	0.00	4.37
1999	12,668	8,137	7,747	185,956	447,899	633,855	2,777	156.00	218.67	2517.16	15455.01	17972.17	295.34	154.86	140.48	42.14	14.05	80.07	0.00	4.21
2000	15,695	9,421	8,677	189,829	459,593	649,422	3,008	913.36	270.93	2746.21	15487.80	18234.01	261.85	32.80	229.05	68.71	22.90	130.56	0.00	6.87
2001	15,465	9,139	9,132	189,988	474,733	664,721	2,836	861.01	266.96	3045.46	15494.90	18540.36	306.35	7.09	299.25	89.78	29.93	170.57	0.00	8.98
2002	15,054	9,771	10,286	184,984	494,645	679,629	2,911	883.69	259.86	3295.19	15594.12	18889.31	348.95	99.22	249.73	74.92	24.97	142.35	0.00	7.49
2003	9,097	10,516	9,289	175,723	512,827	688,550	3,000	910.80	157.03	3388.56	15922.14	19310.70	421.39	328.02	93.37	28.01	9.34	53.22	0.00	2.80
2004	9,739	10,699	9,828	175,366	522,738	698,104	2,846	864.19	168.11	3513.93	16130.64	19644.57	333.87	208.50	125.37	37.61	12.54	71.46	0.00	3.76
2005	10,096	8,634	9,781	173,579	534,404	707,983	2,942	893.19	174.28	3642.12	16373.43	20015.55	370.98	242.79	128.19	38.46	12.82	73.07	0.00	3.85
2006	8,037	7,144	9,811	170,036	545,499	715,536	2,968	901.02	138.73	3792.77	16602.88	20395.64	380.09	229.45	150.65	45.19	15.06	85.87	0.00	4.52
2007	7,175	7,194	8,832	159,874	562,486	722,361	2,981	904.98	123.85	3915.60	16999.49	20915.09	519.45	396.61	122.84	36.85	12.28	70.02	0.00	3.69
2008	6,249	7,490	6,279	147,471	581,086	728,557	2,226	675.81	107.87	3973.38	17631.00	21604.38	689.29	631.52	57.78	17.33	5.78	32.93	0.00	1.73

K The value 3,973.38 Gg is the afforestation carbon stock for the years 1989 to 2002 inclusive, similarly 3,915.60 is the afforestation carbon stock for the years 1988 to 2001 inclusive, etc

N Carbon stock change after harvest (corresponding in 2008 to difference between carbon stocks of 21,604.38 Gg in 2008 and 20,915.09 Gg in 2007)

P Carbon stock change for young forests (corresponding in 2008 to difference between carbon stocks of 3,973.38 Gg in 2008and 3,915.60 Gg in 2007)

Q, R, S, T, U The total carbon stock change for 5.A.2 (column P) is split as Cropland (Q) – 0.30; Grassland (R) – 0.10; Wetland (S) – 0.57; Settlements (T) – 0.00; Other Land (U) – 0.03

CARBWARE MODEL

DETERMINATION OF TIME-SERIES FOREST AREAS USING 1995 BASE YEAR DATA

The assumptions use to assign areas to the three different categories were:

1. Afforested and reforested areas 7 years and over, defined as cleared/unclassified in FIPS move each year into the young crops category. Areas were derived from Coillte felling and Forest Service planting records.
2. Five percent of the young crop category moves each year into the mature category. This means that there is a full turn-over of these crops every 20 years.
3. Mature crops are clearfelled and these areas come back to the cleared/unclassified category.
4. For the purposes of the model clearfell is defined as Coillte felling plus an arbitrary 200 ha of private felling.
5. The reforestation is derived from the clearfell area of the previous year.
6. The process works forward or back from FIPS base year 1995.

YOUNG CROPS

General rule for years before 1995:
Current year = (Current year+1) ha. - (afforestation [current year + 1 - minimum age for young trees] + reforestation [current year + 1 - minimum age for young trees])*(Category % related to planting) + (Current year+ 1)*Accretion Rate

Example: 1993 ha. = 1994 ha. - (afforestation 1987 + reforestation 1987)*species % + 1994 ha.*0.05
Example: 1994 ha. = 1995 ha. - (afforestation 1988 + reforestation 1988)*species % + 1995 ha.*0.05

1995 ha. = FIPS ha. For 1995 for a given category

General rule for years after 1995:
Current year = (Current year -1) ha. + (afforestation [current year - minimum age for young trees] + reforestation [current year - minimum age for young trees])*(Category % related to planting) - (Current year - 1)*Accretion Rate

Example: 1996 ha. = 1995 ha. + (afforestation 1989 + reforestation 1989)*species % - 1995 ha.*0.05
Example: 1997 ha. = 1996 ha. + (afforestation 1990 + reforestation 1990)*species % - 1996 ha.*0.05

MATURE CROPS

General Rule for years before 1995:
Current Year = (Current Year + 1)ha - ([Current Year + 1] Young Trees)ha*(Accretion Rate)+ ([Current Year + 1 Felling]ha * [Category % in Felling])

Example: 1993 ha. = 1994 ha. - 1994 'young' ha * 0.5 + 1994 Felling ha * Category % in Felling
Example: 1994 ha. = 1995 ha. - 1995 'young' ha. * 0.5 + 1995 Felling ha * Category % in Felling

1995 ha. = FIPS ha. For 1995 for a given category

General Rule for years after 1995:
Current Year = (Current Year - 1)ha + ([Current Year - 1] Young Trees)ha*(Accretion Rate) - ([Current Year Felling]ha * [Category % in Felling])
Example: 1996 ha. = 1995 ha. + 1995 'young' ha. * 0.5 - 1996 Felling ha * Category % in Felling
Example: 1997 ha. = 1996 ha. + 1996 'young' ha. * 0.5 - 1997 Felling ha * Category % in Felling

CLEARED/UNCLASSIFIED AREAS

The category cleared/unclassified represents total identified forest area by Forest Service less covered forest as located by remote sensing and classified in FIPS. This would include felled areas in which forest cover had not been established, recent plantings not yet classified and other productive unforested sites. This category is assumed not to store carbon.

General Rule for years before 1995:
Current Year= (Current Year + 1 ha) - Afforestation[Current Year +1] - Felling[Current Year + 1] + ([Current Year + 1 - minimum age for young trees]Afforestation) + ([Current Year + 1 - minimum age for young trees]Reforestation)

Example:
1994 ha. = 1995 ha. - 1995 Afforestation -1995 Felling + 1988 Afforestation + 1988 Reforestation

General Rule for years after 1995:
Current Year= (Current Year - 1 ha) + Afforestation[Current Year)+ Felling[Current Year) - ([Current Year - minimum age for young trees]Afforestation) - ([Current Year - minimum age for young trees]Reforestation)

Example:
1996 ha. = 1995 ha. + 1996 Afforestation +1996 Felling - 1989 Afforestation - 1989 Reforestation

The minimum age for young trees is7 in all examples:

Accretion rate represents the movement of young categories into mature categories on the basis that a given percentage per annum reaches a given age. For example here (minimum age of 7 years assumed for young plantations and 25 years for mature plantations) the percentage is calculated as [1/(25-7)] or 0.056%.

Annex G

Summary of Parameter Input Values to Estimate Methane Generation using 2006 IPCC Guidelines Waste Model

Table G.1 Summary of Parameter Input Values to Estimate Methane Generation using 2006 IPCC Guidelines Model

Model Run	Reference	Number of Sites	Active Period	Status in 2008	MSW Total (t)	MSW 2008 (t)	[a]DOC Fraction	DOC_f	[b]Decay Rate k	[c]MCF
1	From 1969	13	1956-2008	Open	6,678,152	290,678	0.15, 0.40, 0.43, 0.24	0.60	0.20, 0.07, 0.04, 0.07, 0.10	0.40-0.67, 1.0
2	From 1979	10	1972-2008	Open	6,262,785	307,128	0.15, 0.40, 0.43, 0.24	0.60	0.20, 0.07, 0.04, 0.07, 0.10	0.40-0.67, 1.0
3	1985-2002	5	1983-2002	Closed	2,190,371	-	0.15, 0.40, 0.43, 0.24	0.60	0.20, 0.07, 0.04, 0.07, 0.10	0.40-0.67, 1.0
4	Small Closed	9	1957-2003	Closed	2,602,723	-	0.15, 0.40, 0.43, 0.24	0.60	0.20, 0.07, 0.04, 0.07, 0.10	0.40-0.67, 1.0
5	Recent Closed	16	1975-2007	Closed	7,487,139	-	0.15, 0.40, 0.43, 0.24	0.60	0.20, 0.07, 0.04, 0.07, 0.10	0.40-0.67, 1.0
6	Arthurstown	1	1997-2008	Open	4,384,831	301,829	0.15, 0.40, 0.43, 0.24	0.75	0.20, 0.07, 0.04, 0.07, 0.10	1.0
7	Dunsink	1	1976-2001	Closed	4,812,569	-	0.15, 0.40, 0.43, 0.24	0.60	0.20, 0.07, 0.04, 0.07, 0.10	0.8,1.0
8	Balleally	1	1971-2008	Open	3,424,942	79,977	0.15, 0.40, 0.43, 0.24	0.60	0.20, 0.07, 0.04, 0.07, 0.10	0.8,1.0
9	Kinsale Road	1	1965-2008	Open	2,602,051	55,324	0.15, 0.40, 0.43, 0.24	0.60	0.20, 0.07, 0.04, 0.07, 0.10	0.8,1.0
10	KTK	1	1999-2008	Open	1,925,320	208,751	0.15, 0.40, 0.43, 0.24	0.75	0.20, 0.07, 0.04, 0.07, 0.10	1.0
11	New Sites	10	1995-2008	Open	3,028,440	691,232	0.15, 0.40, 0.43, 0.24	0.60	0.20, 0.07, 0.04, 0.07, 0.10	1.0
12	Town Dumps	~250	1956-1998	Closed	15,372,064	-	0.15, 0.40, 0.43, 0.24	0.60	0.20, 0.07, 0.04, 0.07, 0.10	0.4
13	Sewage Sludge	1	1995-2008	Open			0.05	0.60	0.20	0.8,1.0
14	Street Cleanings	1	1990-2008	Open	1,230,567	69,546	0.20	0.60	0.10	0.8,1.0

a The four values are for food, paper, wood and straw, textiles and disposable nappies

b The five values are for food, paper, wood and straw, textiles, disposable nappies

c Where two values are given, the first is for years up to 1998 and the second is for subsequent years

Annex H

Ireland's Response to the Recommendations in the UNFCCC Review of Ireland's 2009 Inventory Submission

Sector	Issue	ARR Para	Recommendation	Ireland's Response	2010 NIR Reference
General	C. Completeness	11	The ERT recommends that Ireland improve the completeness of its inventory by its next annual submission, especially for those categories in which emissions are known to occur within the country and for which methodologies to estimate emissions are available in the Intergovernmental Panel on Climate Change (IPCC) Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (hereinafter referred to as the IPCC good practice guidance) and the Revised1996 IPCC Guidelines for National Greenhouse Gas Inventories (hereinafter referred to as the Revised1996 IPCC Guidelines). The ERT also recommends that the Party, when reporting data on emissions for a given category for the first time, ensure that these data are provided for the entire time series and that the rationale for the choice of methods, emission factors (EFs) and other parameters is clearly explained in the NIR.	A full time series of emissions from *2.A.7 Glass production* has been provided in the 2010 submission. All carbonate use in 4 facilities has been accounted for. Chapter 4 section 4.2.5	Section 4.2.5
General	E. Inventory planning	21	The NIR outlines inventory improvements, including planned improvements, for all sectors except the energy sector. In response to a question raised by the ERT, Ireland provided details of planned improvements for the energy sector. The ERT recommends that Ireland ensure that its reporting of improvements is in accordance with the UNFCCC reporting guidelines.	All inventory improvements and planned improvements are documented in the NIR.	
General	E. Inventory preparation: Uncertainties	25	The ERT recommends that Ireland include this information and details of any other changes concerning the uncertainty analysis, in its next annual submission. The ERT also recommends that Ireland explore the possibility of estimating the uncertainty of AD and EFs used for LULUCF categories, for its next annual submission.	Still under consideration for NIR 2010.	
General	E. Inventory preparation: Uncertainties	26	The ERT found that limited descriptions of the uncertainty analysis have been provided in the sector chapters of the NIR, with the exception of the agriculture sector, and recommends that Ireland report on its uncertainty analysis for all sectors in line with the UNFCCC reporting guidelines, in the NIR of its next annual submission.	Improved explanation of tier 1 uncertainty input estimates for AD and EF has been provided in NIR	Section 1.7
General	E. Inventory preparation: Verification and QA\QC	28	However, the ERT found that Ireland has not provided in its NIR a description of its QA/QC procedures for the industrial processes and LULUCF sectors, and that only limited general statements have been provided for the waste sector. Therefore, the ERT recommends that Ireland prepare information on QA/QC in accordance with the IPCC good practice guidance and report thereon in line with the UNFCCC reporting guidelines.		
General	E. Inventory preparation: Verification and QA\QC	29	Ireland reported that EU ETS information used for the inventory submission is subject to independent verification (emissions monitoring reports) that forms part of the EU ETS system. However, the ERT found that the NIR did not include information on which tier approach from the EU ETS guidelines was used, nor did it identify where "Fall Back Approaches" have been used and estimates that are likely to be of higher uncertainty. The ERT recommends that the Party include this information in its next annual submission.	This information is provided in NIR 2010 in relation to combustion emissions in category 1.A.1 and process emissions from category2.A.	Section 3.2.1 and 4.2

General	E. Inventory preparation: Transparency	30-31	(a) Provision of information in the NIR on the use of EU ETS data, as outlined by the ERT in the section on main findings (see para. 12 above); (b) Improved documentation of its uncertainty analysis, especially for LULUCF; (c) Improved documentation on its QA/QC activities; (d) The provision of the rationale for the choice of methods and EFs used in the energy and industrial processes sectors, the inclusion of information on AD for the LULUCF sector (e.g. for grassland and cropland), and the provision of a better explanation for the method used to estimate emissions from nitric acid (EF and type of catalyst). With regard to the above list, the ERT recommends that Ireland addresses these transparency issues and to report hereon in its next annual submission. In addition, the ERT recommends that the Party adhere to the outline for the NIR set out in the UNFCCC reporting guidelines in order to improve the transparency of its annual submission.	(a) Provided in section 3.2.1 and 4.2 of NIR; (b) Improved description of uncertainty assessment is provided in section 1.7 of the NIR; (c) Improved descriptions of QA/QC activities are given in various sectoral chapters; (d) Ireland's rationale for choice of methods and EFs is always the requirement to use the highest possible tier methods and EFs that represent national circumstances as closely as possible.	
Energy	A. Sector overview	37	However, the ERT identified areas for improvement and recommended that the Party improve transparency in the energy sector by providing more information on methods and on other information that would enhance understanding of the inventory and its estimates (see paras. 39 and 45 below).	Improved descriptions of methods and data are provided in the 2010 NIR	Chapter 3
Energy	A. Sector overview	39	The ERT reiterates a recommendation made in the previous review report that the Party provide improved documentation for the transport subsector on underlying trends, including vehicle numbers, population change, gross domestic product, and heating or cooling days. This information would improve the transparency of the inventory submission, enable the validation of the fuel consumption data provided, and also aid understanding of the underlying category-specific emission trends in road transportation and how they contribute to the overall sectoral emission trend.	Additional information on the key drivers in the trend for road transport emissions is included in Chapter 2 of the NIR 2010.	Chapter 2
Energy	B. Reference and sectoral approaches Sector overview	44	The ERT noted many discrepancies when the energy data in Ireland's CRF tables were compared with corresponding data from the International Energy Agency (IEA). Therefore, the ERT reiterates the recommendation made in the previous review report that the Party explore the basis of such discrepancies and investigate how the energy data submitted in the CRF tables of its annual submission can be reconciled with corresponding data provided to IEA by Sustainable Energy Ireland (the compiler of Ireland's energy statistics).	Information provided in Submission 2010 CRF tables relating to the Reference Approach comes directly from the IEA/Eurostat questionnaire returns provided by Sustainable Energy Ireland.	Chapter 3
Energy	Stationary combustion: liquid and solid fuels-N_2O	47	Ireland indicated to the ERT that it will develop technology-specific tier 3 N2O EFs based on the IPCC good practice guidance and the 2006 IPCC Guidelines for its next inventory submission, since, according to the Party, this is the best available information. The ERT recommends that Ireland in the 2010 annual submission report its justification for use of the 2006 IPCC Guidelines where applicable, elaborate on the new methodology, report on recalculations, and explain the impact of the revision of these EFs on emission levels and trends.	Discussion of the new EFs can be found in Chapter 3.2.1 of the NIR 2010 and justification of same in Annex C of the NIR.	Chapter 3.2.1 and Annex C

Energy	Public electricity and heat production: liquid fuels-CH_4	48	Ireland reports CH4 emissions as not occurring. In response to a question raised by the ERT, Ireland indicated that it would undertake a major review of the CH4 and N2O EFs used for this category. The ERT found that the Party has reported CH4 emissions as "NO" even though these emissions do occur. The ERT recommends that the Party undertake the above-mentioned review and report thereon in its next annual submission.	Discussion of the new EFs can be found in Chapter 3.2.1 of the NIR 2010 and justification of same in Annex C of the NIR.	Chapter 3.2.1 and Annex C
IP and Solvents	A. Sector overview	50	However, the ERT identified a number of categories that have been reported as "NE" by the Party. In response to a question raised by the ERT on this issue, the Party indicated that it would address in its next annual submission the completeness of its inventory in terms of the industrial processes and solvent and other product use sectors by reporting on the categories road paving with asphalt, glass production, food and drink, and use of N2O for anaesthesia, which have currently been reported as "NE". The Party also indicated that it would revise its attribution of the notation key from "NE" to "NA" for asphalt roofing and to "NO" for the CO2 recovery for cement production and lime production, in its next annual submission. The ERT recommends that the Party ensure the inclusion in its next annual submission of emissions for categories which have currently been reported as "NE" and for which methods to estimate emissions are available in the Revised 1996 IPCC Guidelines and/or in the IPCC good practice guidance; where emissions cannot be estimated for any category, the Party is to provide sufficient explanation for this in the NIR.	These issues are addressed in the 2010 submission	
IP and Solvents	A. Sector overview	51	The ERT found that the sections of Ireland's NIR on the industrial processes and solvent other product use sectors did not adhere to the outline set out in the UNFCCC reporting guidelines. The NIR would be more transparent if the recommended detailed structure was used. Therefore, the ERT reiterates the recommendation that Ireland, for its next annual submission, structure its NIR following the outline set out in the UNFCCC reporting guidelines.	Ireland has improved the structure of Chapter 4 for Industrial Processes in NIR 2010.	Chapter 4
IP and Solvents	B. Consumption of halocarbons and SF_6: substitutes for ODS-HFCs	55	The ERT recommends that Ireland carefully evaluate its estimates of emissions from stationary refrigeration and air-conditioning, taking into consideration their relationship to the bank, and that Ireland include more detail on the bank and its relationship to emissions in future inventories. The ERT also recommends that Ireland correct the EFs used for motor vehicle airconditioning in CRF table 2(II)F, which are too low by a factor of 100.	in response to ert	
IP and Solvents	B. Consumption of halocarbons and SF_6: substitutes for ODS-HFCs	56	The NIR states that "potential emissions account for the total available product", implying that the potential emissions may be equated to the full bank of gas in the equipment. This would not be consistent with the IPCC good practice guidance, and, based on Ireland's responses to questions raised by the ERT, this is not in fact Ireland's method of estimating potential emissions. Therefore, the ERT recommends that Ireland clarify the method used to estimate potential emissions of HFCs from fire extinguishers.	Issues relating to potential emissions are not important	

IP and Solvents	C. Lime production-CO_2	57	For the period 1990–2003 the ERT found the trend in the CO2 IEF to be unstable, ranging from 0.75 to 0.88 t CO2/t lime and the values for 1997 and 2003 are higher than the IPCC default range (0.59–0.86 t CO2/t lime). The ERT found no explanation of this fluctuation or the inconsistency in the time series in the NIR. Therefore, the ERT reiterates the recommendation that Ireland explain and justify the time-series inconsistency and fluctuations in the IEF for this category.	This has been explained in the NIR. The difference between Ireland's EFs and default EFs is insignificant	Chapter 4.2.2
Agriculture	B. Eneteric fermentation-CH_4	63	The ERT reiterated the finding indicated in previous review reports that a constant average weight has been used for dairy cattle. In response to question raised by the ERT on this matter, the Party repeated the explanation given in previous years that there is no clear relationship between average milk yield and the weight of the dairy cows. Nevertheless, since the tier 2 methodology developed take into account liveweight for maintenance requirements as each kg liveweight lost contributed 24.9 MJ to net energy for lactation (NEi) to energy requirements, while each kg of liveweight gained required 32 MJ NEi). The ERT reiterates the recommendation made in the previous review reports that the Party revise this figure and/or provide a clear explanation of the basis for this assumption.	The explanation has been provided in the review and in the NIR	Chapter 6.2.2
Agriculture	B. Eneteric fermentation-CH_4	64	Ireland used an IPCC tier 1 approach to estimate emissions for other livestock categories (e.g. swine and sheep), using default IPCC EFs for each category, adjusted on the basis of the animals' weight. As result, the IEFs for sheep and swine were lower than the default IPCC values. The ERT recommends that Ireland provide information to support the use of these adjusted default EFs.	The difference is due to the adjustment for weight among different animal categories - only the weighted average is lower than the IPCC default	Chapter 6
Agriculture	B. Direct soils-N_2O	66	The inter-annual changes in N2O emissions from nitrogen-fixing crops varied between +100 per cent and –50 per cent, but no explanation for this trend over the time series has been provided in the NIR. Therefore, the ERT recommends that Ireland in its next annual submission explain the emission trend observed for this category.	This has been explained in the 2010 NIR. The variation is due only to fluctuating production of the different crops	
LULUCF	A. Sector overview	69	The ERT noted that, with the exception of that used to estimate emissions from forest land, most methods were based on the IPCC tier 1 approach; therefore, the ERT recommends that Ireland explore the possibility of using higher-tier methods, particularly for estimating CO2 emissions from land converted to grassland (recently identified as a key category) and land converted to cropland.		
LULUCF	A. Sector overview	70	For those land categories or conversions identified as key (forest land remaining forest land, land converted to forest land, land converted to grassland, and grassland remaining grassland), the ERT reiterates the recommendation made in previous review reports that Ireland develop higher-tier methods to estimate emissions, in accordance with the IPCC good practice guidance for LULUCF.		

LULUCF	A. Sector overview	72	Ireland did not estimate the uncertainty of either AD or EFs for any of the subcategories in this sector. While the ERT acknowledges the validity of the Party's arguments for not having done so (see section 7.9 of the 2009 NIR), it strongly recommends that the Party make every effort to estimate the uncertainty of this sector in accordance with the IPCC good practice guidance for LULUCF and to report thereon in its next annual submission.		
LULUCF	A. Sector overview	74	The ERT also noted that the Party intends to improve its reporting tools and refine the estimation of carbon stock changes in forest for its reporting under both the Convention and the Kyoto Protocol. The Party is also working on the development of a single dataset regarding the coverage and attributes of its forest, which in its final version will include location, planting year, species area and open space area, for all forest greater than 0.5 ha in area (with the post-1990 data on afforestation for areas down to 0.1 ha in area). The ERT recommends that Ireland make efforts to complete the above-mentioned improvements in time for its next annual submission, which is to include activities under Article 3, paragraph 3, of the Kyoto Protocol.	This information is provided in the 2010 NIR	
LULUCF	A. Sector overview	75	The ERT also recommends that Ireland provide documentation in the NIR as to how and to what extent QA/QC activities are applied in the LULUCF sector, in its next annual submission.	Addressed in the 2010 NIR	
LULUCF	B. Forest land remaining forest land-CO_2	76	For this category, removals of CO2 (1,491.13 Gg CO2) were estimated on the basis of changes in the carbon stocks in living biomass (above and below-ground) using the CARBWARE model. This model does not estimate deforestation – it does not provide information on forest land converted to other land uses. Therefore, the ERT reiterates a recommendation made in the previous review report that the Party remedy this deficiency in the model or implement another compatible methodology to obtain separate data on the gains and losses in living biomass associated with deforestation.	The gains and losses for deforestation lands are described in the 2010 NIR	Chapter 7 and 11
LULUCF	B. Forest land remaining forest land-CO_2	78	The Party has made a major advance by moving to a tier 2 approach using the CARBWARE model. However, some emission and expansion factors used were still IPCC default values. Therefore, the ERT recommends that Ireland develop country-specific parameters in order to improve the accuracy of its current methodological approach.	Much more use is made of country-specific information in the 2010 submission and this is described in the 2010 NIR	Chapter 7 and 11
LULUCF	B. Grassland remaining grassland-CO_2	79	Using the data available from Ireland's Central Statistics Office, it was difficult to estimate changes in area within grassland remaining grassland. As a consequence, soil emissions resulting from any intensive grazing of cattle and sheep on these grasslands have not been reported. The ERT recommends that Ireland examine the transparency, accuracy (i.e. possible underestimations) and comparability (i.e. the possibility of using of a higher-tier method) of the reporting for this category.		
LULUCF	B. Grassland remaining grassland-CO_2	80	The ERT reiterates the recommendation made in the previous review report that the Party disaggregate this category into subcategories related to the management regimes adopted in Ireland, thereby facilitating the reporting of CO2 emissions in accordance with the IPCC good practice guidance for LULUCF.	The relevant emissions are mainly those due to liming and there are no appropriate management regimes to apply disaggregation	

Waste	A. Sector overview	83	The ERT recommends that the Party ensure the inclusion in its next annual submission of emissions for categories which have currently been reported as "NE" and for which methods to estimate emissions are available in the Revised 1996 IPCC Guidelines and/or in the IPCC good practice guidance; where emissions cannot be estimated for any category, the Party is to provide sufficient explanation for this in the NIR.	The recommendation is implemented for 2010	
Waste	A. Sector overview	84	In Ireland, the incineration of municipal waste has not been used as a means to manage waste. However, Ireland has reported GHG emissions from waste incineration as "NE" in CRF table 6, as waste incineration does currently take place in a small number of chemical and pharmaceutical facilities. The ERT recommends that Ireland report GHG emissions from waste incineration that is currently occuring in the country, using methods outlined in the Revised 1996 IPCC Guidelines and/or the IPCC good practice guidance.	The NIR explains that there is no waste incineration relevant to GHG estimation in Ireland	Chapter 8.1
Waste	B. Solid waste disposal on land-CH_4	85	In order to estimate CH4 emissions more accurately, Ireland is considering using the method from the 2006 IPCC Guidelines for its next annual submission. The ERT recommends that the Party include in its next annual submission documentation supporting its use of this method, and also that Ireland ensure that resultant recalculations are time-series consistent and reported in accordance with the IPCC good practice guidance.	Ireland has changed the methodology for this category in Submission 2010. Detailed information is provided in Chapter 8.	Section 8.2.2
Waste	B. Solid waste disposal on land-CH_4	87	In response to a question raised by the ERT, Ireland explained that the data on CH4 flaring are based on the European Pollution Emission Register (EPER), and that the Party has initiated a major study to quantify the amount of CH4 flared in all years since this practice commenced with the results of this study to be incorporated in the next annual submission. The ERT recommends that the Party include in its next annual submission documentation on EPER and the above-mentioned study, and also that Ireland ensure that resultant recalculations are time-series consistent and reported in accordance with the IPCC good practice guidance.	Detailed information on methane recovery at landfills is described in Chapter 8, section 8.2.3 of the NIR.	Section 8.2.3
Waste	C. Waste water handling-CH_4	88	Ireland has reported CH4 emissions from septic tanks as "NO", since the temperature in septic tanks is not conducive to the occurrence of methanogenesis. CH4 emissions from wastewater treatment plants have also been reported as "NO", since wastewater sent to wastewater treatment plants is treated aerobically. The ERT recommends that Ireland provide reasonable justification for reporting CH4 emissions from these sources as "NO", and encourages the Party to consider the possibility that CH4 is emitted from both septic tanks and wastewater treatment plants, taking into consideration the seasonal ground temperature and the wastewater treatment conditions in Ireland.	Reasonable justification was provided during the review and is given in the 2010 NIR	Section 8.3.1
Waste	C. Waste water handling-CH_4	89	Ireland estimated CH4 emissions from both wastewater and sludge treatment in line with the Revised 1996 IPCC guidelines. However, country-specific parameters were used for the fraction of biochemical oxygen demand that readily settles and for the organic content of industrial sludge, without any explanation or justification. Furthermore, the estimation of the key parameter of population equivalent has not been documented and annual data are unknown. The ERT recommends that Ireland improve the transparency of its reporting with regard to the use of these parameters, in its next annual submission.	The recommendation is implemented for 2010	

Art 7.1 KP	SEF and registry	90	The SIAR was forwarded to the ERT prior to the review, pursuant to decision 16/CP.10. The ERT reiterated the recommendations contained in the SIAR.		
Art 7.1 KP	SEF and registry	92	The ERT further noted from the SIAR that Ireland had identified as confidential the public information pursuant to paragraphs 44 to 48 of the annex to decision 13/CMP.1. The ERT reiterated the recommendation made in the SIAR that Ireland should improve the website of its registry by clearly stating the confidential nature of this public information, and should report, in its next annual submission, on any changes to its public information.	The recommendation is implemented for 2010	Chapter 14
Art 7.1 KP	SEF and registry	94	Therefore, the ERT reiterated the recommendation of the SIAR that Ireland, in accordance with paragraphs 25(e) and 26 of the annex to decision 24/CP.8, should improve its registry in order to reduce the number of reconciliation events terminated and report in its next annual submission on any changes related to the handling of the reconciliation process in its registry, including the relevant test plans and test reports.	The recommendation is implemented for 2010	Chapter 14
Art 7.1 KP	Changes to the national registry	98	The ERT noted from Ireland's 2009 annual submission that the production environment of Ireland's national registry migrated to a new data centre on 17 March 2009, and that the training and test environments are expected to follow in April 2009. The migration will not require further interoperability testing. The connectivity testing for the production environment was successfully completed with the ITL administrator. The complete readiness documentation associated with this migration is still being compiled with the assistance of Ireland's new hosting provider and will be submitted to the ITL administrator as soon as possible. The ERT recommends that Ireland report these changes in its next annual submission.	The recommendation is implemented for 2010	Chapter 14
Conclusions and recommenda tions		107	In the course of the review, the ERT formulated a number of recommendations relating to the completeness and transparency of the information presented in Ireland's annual submission. The key recommendations are that Ireland: (a) Provide improved information on its uncertainty analysis and QA/QC activities; (b) Provide information on whether EU ETS data has been prepared and incorporated into the inventory submission in line with the principles of the IPCC good practice guidance; whether these data has been subject any QA and/or verification and if so, which tier approach from the EU ETS guidelines has been used and how this relates to corresponding QA and/or verification procedures set out in the IPCC good practice guidance; and information on how the Party has ensured time series consistency when using these data and the impact of using EU ETS data on the emission trends; (c) Ensure, to the extent possible, the inclusion in its next annual submission of emissions for categories currently reported as "NE" and for which methods for estimating emissions are available in the Revised 1996 IPCC Guidelines and/or in the IPCC good practice guidance, and where emissions cannot be estimated for any category then the Party is to provide sufficient explanation for this in its NIR.	All recommendations have been addressed or implemented for 2010, as indicated above	Various

Annex I

Allometric Equations for Biomass

Growth Models and Pre-processing Functions for CARBWARE v5

Table I.1: Allometric equations used to calculate biomass component for individual trees (kg d.wt tree^{-1}).

Similar species are grouped into 6 different cohorts based on available research information (Spruces, Pines, Larches, Other conifers, fast growing broadleaves and slow growing broadleaves). Abbreviations: AB-above ground, TB-total biomass, BB-below ground, FB-foliage, SB-stem (i.e. timber >7cm diameter), L_{HR}= lop and top from harvest residues, DBH diameter at breast height (1.3 m) in cm, H –height in m.

Eq	Function	Range	Equation	Coefficients				r^2	RMSE	Slope	Source
				a	b	c	d				
Spruce											
1	AB	H>4.5m	$a \times DBH^b + c \times H^d$	0.23	2.12	5 x 10^{-7}	4.99	0.91	0.29	1.01	i, ii
2	AB	H<4.5m	$a \times H^b \times c$	1.32	1.7	1.38		0.86	0.2	1.1	i, ii
3	TB		$\exp[Ln(a) + b \times Ln(AG)]$	1.02	1.033			0.91	0.08	1.03	ii, iii
4	BB		TB-AB								
5	FB		$AB \times a + b \times \exp[-c \times AB]$	0.025	0.089	0.003		0.68	3.4	0.98	i, ii
6	SB		$\exp[Ln(a) + b \times Ln(AG)]$	0.405	1.09			0.99	2.99	1.03	ii, iii
7	L_{HR}		AB-SB								
Pines											
8	AB	H>3.8m	$a \times DBH^b + c \times H^d$	0.07	2.42	0.039	2.51	0.93	0.13	0.94	ii, iii
9	AB	H<3.8m	$a \times H^b$	0.12	3.91			0.95	0.74	0.95	i, ii
10	TB		$\exp[Ln(a) + b \times Ln(AG)]$	1.15	1.01			0.96	0.4	1.01	ii, iii
4	BB		TB-AB								
5	FB		$AB \times a + b \times \exp[-c \times AB]$	0.025	0.089	0.003		0.68	3.4	0.98	i, ii
11	SB		$\exp[Ln(a) + b \times Ln(AG)]$	0.71	1.005			0.97	0.27	0.96	ii, iii
7	L_{HR}		AB-SB								
Larch											
12	AB	H>2m	$a \times DBH^b + c \times H^d$	0.11	2.31	0.001	3.29	0.94	0.27	0.94	ii, iii
13	AB	H<2m	$a \times H^b$	0.03	1.91			0.67	0.44	1.2	i, ii
14	TB		$\exp[Ln(a) + b \times Ln(AG)]$	1.43	0.98			0.99	0.25	0.99	ii, iii
4	BB		TB-AB								

Eq	Function	Range	Equation	Coefficients				r^2	RMSE	Slope	Source
				a	b	c	d				
5	FB		$AB \times a + b \times \exp[-c \times AB]$	0.025	0.089	0.003		0.68	3.4	0.98	i, ii
15	SB		$\exp[Ln(a) + b \times Ln(AG)]$	0.903	0.972			0.98	0.28	0.96	ii, iii
7	L_{HR}		AB-SB								
Other conifers											
16	AB	H>3.8m	$a \times DBH^b + c \times H^d$	0.022	2.73	0.19	2.06	0.96	0.46	1.008	ii, iii
17	AB	H<3.8m	$a \times H^b \times c$	0.005	1.58	1.12		0.86	0.28	1.02	i, ii
18	TB		$\exp[Ln(a) + b \times Ln(AG)]$	1.59	0.96			0.99	0.28	1.005	ii, iii
4	BB		TB-AB								
5	FB		$AB \times a + b \times \exp[-c \times AB]$	0.025	0.089	0.003		0.68	3.4	0.98	i, ii
19	SB		$\exp[Ln(a) + b \times Ln(AG)]$	0.89	0.96			0.98	0.57	1.055	ii, iii
7	L_{HR}		AB-SB								
Slow growing broadleaves											
20	AB	H>3.0m	$a + \left[\frac{b \times DBH^c}{DBH^c + 246872}\right]$	0.08	25000	2.5	246872				iv
21	AB	H<3.0m	$a \times H^b$	0.031	1.72			0.84	0.88	0.91	i, ii
22	BB		$\exp(-a + Ln(DBH) + b)$	1.509	0.284						iv
23	FB	DBH>10cm	$a \times (DBH \times 10)^b$	0.009	1.47			0.96			v
24	FB	DBH<10cm	$AB \times 0.3$					0.78	1.2	0.79	i, ii
25	SB	DBH>19cm	$a \times (DBH \times 10)^b$	0.0002	2.5			0.97			v
26	SB	DBH<9cm	$\frac{AB + BB}{1.4}$								BEF
7	L_{HR}		AB-SB								
Slow growing broadleaves											
20	AB	H>3.0m	$a + \left[\frac{b \times DBH^c}{DBH^c + 246872}\right]$	0.06	25000	2.5	246872				iv

Eq	Function	Range	Equation	Coefficients				r^2	RMSE	Slope	Source
				a	b	c	d				
21	AB	H<3.0m	$a \times H^{b}$	0.031	1.72			0.84	0.88	0.91	i, ii
22	BB		$\exp(-a + Ln(DBH) + b)$	1.509	0.284						iv
27	FB	DBH>3cm	$a + b \times DBH^{c}$	0.375	0.0024	2.517		0.90			vi
28	FB	DBH<3cm	$AB \times 0.3$					0.78	1.2	0.79	i, ii
29	SB	DBH>35cm	$a \times DBH^{b}$	0.0001	2.535			0.97			v
30	SB	DBH<9cm	$\frac{AB + BB}{1.4}$								BEF, vii
7	L_{HR}		AB-SB								

i National research harvested tree database (COFORD funded project CARBiFOR)
ii Black et al., Biomass equations for modelling C dynamics in Irish forests (in prep)
iii Forest Research pulled tree database (Brice Nicholl, NRS, Forest Research, UK)
iv Brown S (2002) . Measuring carbon in forests: current status and future challenges. Environmental Pollution 116: 363-372.
v Johansson, T. Dry matter amounts and increment in 21-to 91-year-old common alder and grey alder some practical implicatons. Canadian Journal of Forest Research 29 1679-1690.
vi Bartelink, H.H., Allometric relationship for biomass and leaf area of beech (Fagus sylvatica L). Annals of Forest Science, 1997. 54: p. 39-50.
vii Black K., Tobin B., Saiz G., Byrne K. & Osborne B. (2004). Improved estimates of biomass expansion factors for Sitka spruce. Irish Forestry 61:50-65.

Appendix I.1: CARBWARE pre-processing functions and growth models

The NFI permanent plot sampling procedure does not sample all trees in a plot (see Figure 11.4). Therefore, it is not possible to derive productivity index information, such as Height index or Yield class, which can be used to drive conventional stand based productivity models. The alternative and most statistically valid procedure adopted was the use of single tree models, to simulate tree growth between NFI cycles. These models can be cross-validated and re-parameterised once a repeat NFI cycle is completed. This section discussed the development of the CARBWARE growth model from draft versions for submission to International, peer reviewed Scientific Journals.

I.1-A: Pre-processing functions

Height-Diameter And Crown Ratio Modelling For Six Species Cohorts.

It is common among forestry datasets that tree height (H) or crown ratio (CR) is not measured on every tree. This creates interest in estimating the height of such trees.

A common forest inventory approach used to derive missing H and CR values involves the use of single parameter (DBH) models based on species and plot specific predictions (NFI, 2007; Wykoff et al., 1982). However, is has been suggested that these Chapman-Richards functions, or derivations there of, are problematic because the function approaches the asymptote too rapidly, particularly when there is a weak relationship between DBH and H in larger trees. In addition, individual plot DBH-H data is sometimes too sparse to parameterise plot specific functions. Generalised DBH-H functions avoid the need to parameterise relationship for every stand. Since the relationship between DBH and H is influenced by the relative competitive position of trees within a stand and management interventions, site-level stand-density information is often incorporated (Temesgen and Gadow, 2004). Taking their results as a starting point, we address here several issues that arise in the context of our modelling dataset. These include the application of nonlinear mixed effects models which successfully borrow strength across all permanent plots, thereby facilitating imputation in plots where data is sparse or unevenly distributed. The permanent sample plot data, taken from a range of spacing and thinning experiments, used in this study is well suited, albeit not arising by design, to evaluate these stand-density parameters to describe variations in H and CR across different silvicultural conditions.

Materials and methods

Data
Data used were obtained from Coillte Teoranta's (the Irish Forestry Board state commercial forestry company) permanent sample plot record system. The dataset contains records from many silvicultural and thinning trials established during the period 1963 to 2001. The trials were initially established as replicated experimental designs with repeated measurements typically undertaken every five years. The dataset is described in Broad and Lynch (2007).

Incorporating competition covariates

The modelling here follows Temesgen and Gadow (2004) who based their work on Yang et al. (1978) and incorporated competition covariates into the Yang/Weibull function (Table 1, Model 2).We evaluate that model and also use test for differences between management regimes conditional on the DBH-H model by incorporating dummy indicator variables in the linear regression models of the model parameters.Our aim in this section was to test if the inclusion of certain covariates, typically relating to the competition in a forest stand/plot, improved the baseline DBH-H model (Table G.2.1, Model 1). We also investigated whether the model was improved by including random effects on the level of the plot (Table G.2.1, Model 3).

The competition covariates are plot basal area (BA, m^2 ha^{-1}), basal area in larger trees (BAL, m^2 ha^{-1}) which is the integral of the empirical frequency distribution of the BA variable from the subject tree to the largest diameter tree in the plot and plot density (DENS, trees ha^{-1}). Models were fitted in NLMixed procedure in SAS using the Trust-Region algorithm. Grids were specified as starting values for parameters where sensible.

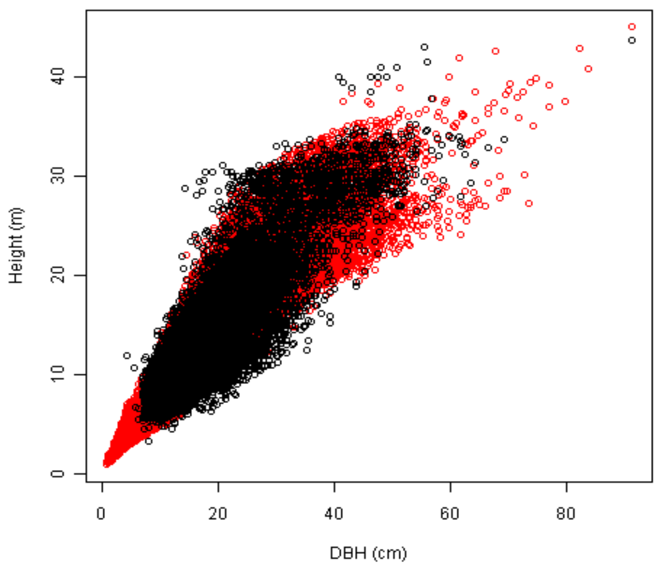

Figure I.1-A.1. Model 2 Height estimates (red) and actual heights (black).

The estimates presented here depict a "cloud" because they are conditioned on covariates that vary between trees (BAL) and plots (Density, Basal Area) and over time (BAL, Density, BA).

Table I.1-A.1

	Model	-2l	BIC
1	$H = a(1 - \exp(b.DBH^{c}))$	65185	65223
2	$H = (a_1 + a_2 BAL + a_3 BA)(1 - \exp(b.DBH^{(c_1 - c_2 BAL)}))$	58341	58417
3	$H = (Ui + a_1 + a_2 BAL + a_3 DENS + a_4 BA)(1 - \exp(b.DBH^{(c_1 - c_2 BAL)}))$	44980	45034

Table I.1-A.2 Likelihood statistics for different forms of the DBH-H model.

Model 2 is the model used in CARBWARE for the 6 different cohorts. If dependent variables had no significant influence on the H model prediction, these variables were excluded from the model.

Cohort	Model (2 variation)	a1	a2	a3	b	c1	c2
Spruce	$H = (a_1 + a_2 BAL + a_3 BA)(1 - \exp(b.DBH^{(c_1 - c_2 BAL)}))$	33.69	-0.274	0.1603	0.024	0.8846	0.0064
Pine	$H = (a_1 + a_2 BAL + a_3 BA)(1 - \exp(-b.BAL))$	16.905	0.083	0.0803	0.042		
Larch	$H = (a_1 + a_2 BAL + a_3 BA)(1 - \exp(-b.BAL))$	32.59	0.1052	0.1229	0.023		
Conifers	$H = (a_1 + a_2 BAL + a_3 BA)(1 - \exp(-b.DBH^{c_1}))$	23.226	0.1381	0.0703	0.027	1.1021	
FGB	$H = (a_1 + a_2 BAL + a_3 BA)(1 - \exp(-b.DBH))$	14.661	0.1167	0.0187	0.076		
SGB	$H = (a_1 + a_2 BAL)(1 - \exp(-b.DBH^{c}))$	29.677	0.1034		0.044	0.7813	

BAL is the sum of the basal area of all individual trees larger than the subject tree (m^2 per ha)
BA is the basal area of all trees in the plot (normalised to a ha)
DBH is the diameter at breast height (cm)

Table I.1-A.3. CR models used in CARBWARE for the 6 different cohorts.

If dependent variables had no significant influence on the H model prediction, these variables were excluded from the model.
The CR model takes the form of:

$$CR = \frac{\exp(lCR)}{1+\exp(lCR)}$$

where *lCR* is derived from the non linear equations, which may vary for different cohorts.

Cohort	Model (*lCR* variations)	a1	a2	a3	a4	a5	b	c
Spruce	$lCR = (a_1 + a_2 BAL + a_3 Ln(CCF) + a_4 H + a_5 \left[\frac{H}{BAL}\right] + bDBH^c$	4.8705	-0.017	-0.397	-0.119	-0.296	0.0003	2
Pine	$lCR = (a_1 + a_2 BAL + a_3 Ln(CCF) + a_4 H + bDBH^c$	3.8478	-0.024	-0.213	-0.137		0.0002	2
Larch	$lCR = (a_1 + a_2 BAL + a_3 Ln(CCF) + a_4 H$	5.8306	-0.018	-0.794	-0.039			
Conifers	$lCR = (a_1 + a_2 BAL + a_3 Ln(CCF) + a_4 H + bDBH^c$	4.1759	-0.019	-0.394	-0.965		0.0004	2
FGB	$lCR = (a_1 + a_2 BAL + a_3 Ln(CCF) + a_4 H + a_5 \left[\frac{H}{DBH}\right] + bDBH^c$	2.4539	-0.009	-0.145	-0.045	-0.591	0.0001	2
SGB	$lCR = (a_1 + a_2 BAL + a_3 H + a_5 \left[\frac{H}{BAL}\right]$	1.477	-0.005	-0.017	-0.578			

BAL is the sum of the basal area of all individual trees larger than the subject tree (m^2 per ha)

CCF is the crown competition factor, which is a measure of the crown areas of the subject tree relative to a open grown tree that would not be subjected to crown competition (taken from Hassenhaur, see section B of this appendix)

DBH is the diameter at breast height (cm)

H is height (m) form actual or predicted H estimates (Table I.1-A.2)

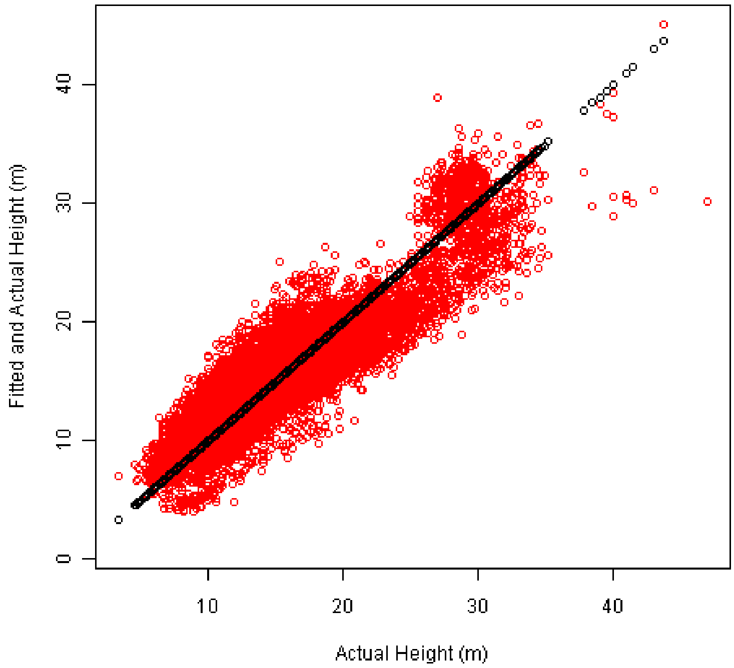

Figure I.1-A.2. Fitted and actual height plotted (all cohorts model 2) against actual height.

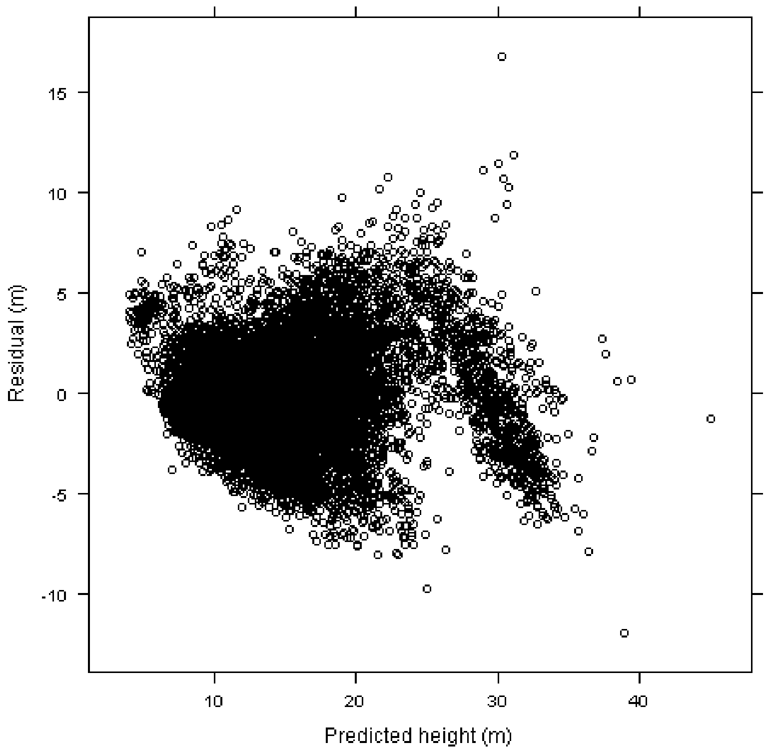

Figure I.1-A.3. Raw residuals from the fitted model plotted against the fitted height value.

External validation
Based on the data presented above, model 2 was selected for validation against external data sets. In this section we compare model predictions against data from PSP non-research plots.

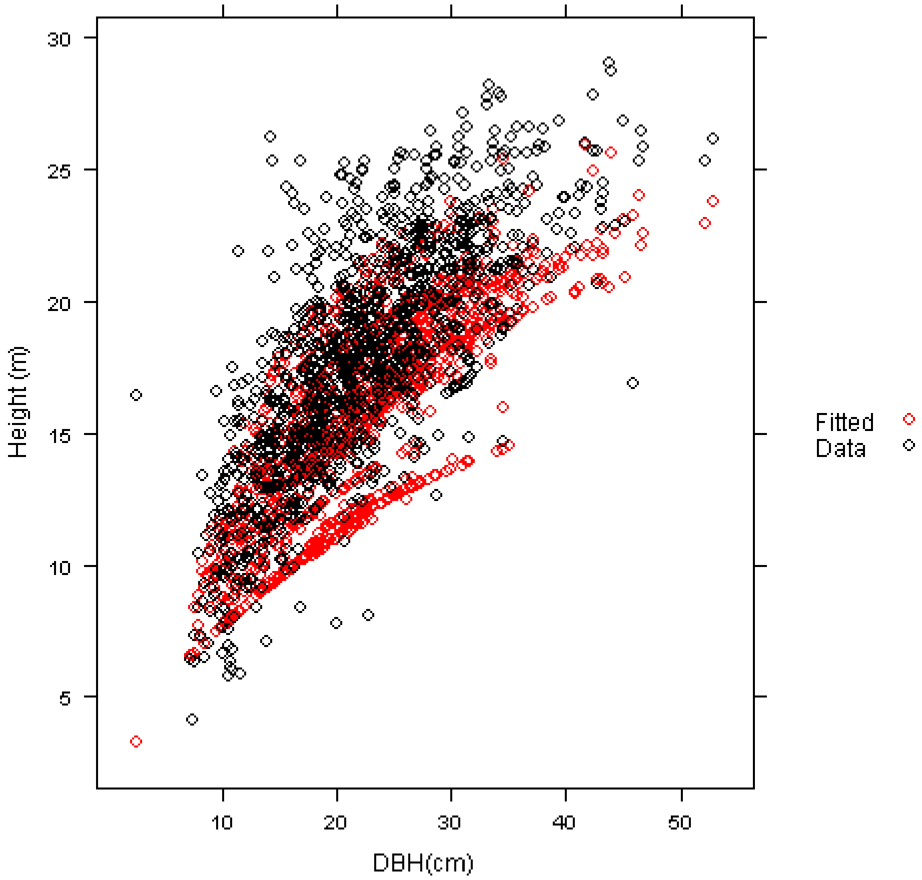

Figure I.1-A.4. Estimated and observed validation heights versus DBH.

Generalised and plot-specific models
In this section we discuss the implications of using a generalised DBH-H model (i.e. one whose parameters are fitted to the entire dataset) with a plot-specific model (i.e. one whose parameters are estimated for each plot separately). We compare a mixed effects model and a plot-specific model. The former is plot-specific by the inclusion of a random residual plot effect. In what follows, by *mixed model* we mean the random asymptote model (Table I.1-A.1, Model 3). To get an idea of the difference between plot-specific and mixed-model results, we extract a plot from the dataset that exhibits a wide range of DBH and H values and then compare the models for that plot. This makes sense because the context of the comparison is how well a given model will perform for a given plot, primarily. In particular we will compare the standard error of prediction for a new tree height for both models. In the case of the mixed model , this standard error of prediction is derived as conditional on the estimated random plot effect.

A plot-specific Yang/Weibull model gives a smaller standard error of prediction than the same model estimated from the entire dataset, because residual variability for any given model will always increase from a subset of the data (plot specific) to the entire dataset (generalised). In other words, the generalised model predictions are less precise than the plot-specific predictions for any given plot, and the model mean estimate tends *towards* the overall mean and *away* from the plot-specific mean.

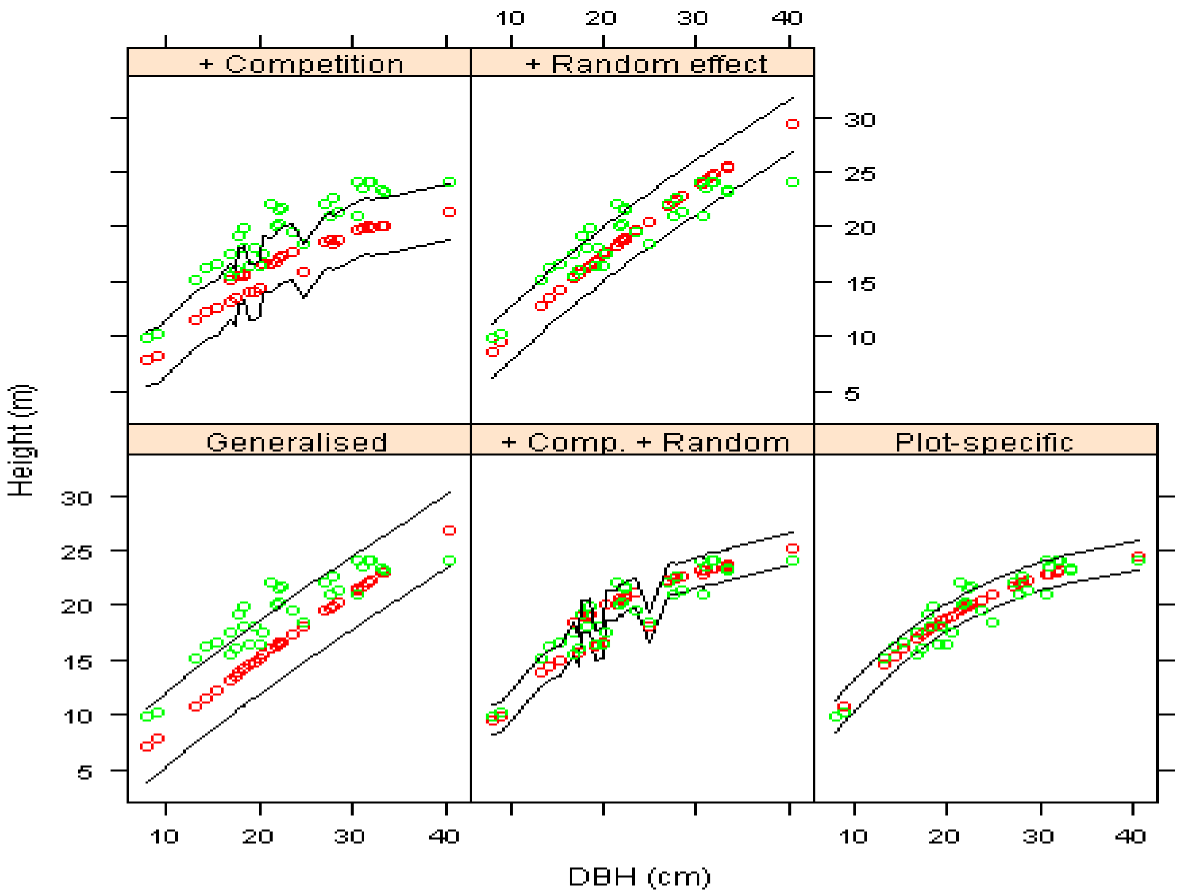

Figure I.1-A.5. Model predictions for a single plot with various models, all based on the Yang/Weibull funtion (cf. Table I.1-A.1).

Green, red and black are data, estimates, and single standard error of prediction, respectively. *Competition* denotes a generalised model with competition covariates (cf. Model 2, Table I.1-A.1), *Random* denotes a plot-specific random asymptote (cf. Model 3, Table I.1-A.1), *Generalised* denotes parameters are estimated from the entire dataset. The smallest standard error of prediction is associated with the *Plot-specific* model, followed by the + *Comp.* + *Random* model. Average s.e.p. for these models are 1.39 and 1.25 respectively.

Thinning effects

All observations in the dataset were categorised by us as "thinned" or "non-thinned" depending on the general management regime for the plot. We estimated the following model to test for a residual thinning effect, having conditioned on other effects. :

$$H = (U_i + a + a_1 BAL + a_2 DENS + a_3 BA + a_4 I(Thinned))(1 - \exp(b.DBH^{(c_1 - c_2 BAL)}))$$

where I(*Thinned*) is an indicator function valued 1 if the plot was thinned and 0 otherwise. The BIC of this model was 45037, and the Wald test for the a_4 parameter (p = 0.08) indicated that the thinning effect was not statistically significant at the 5% level. The a_4 estimate was greater than zero, perhaps reflecting the longer tail in the height distribution for trees in thinned plots (Figure I.1-A.6).

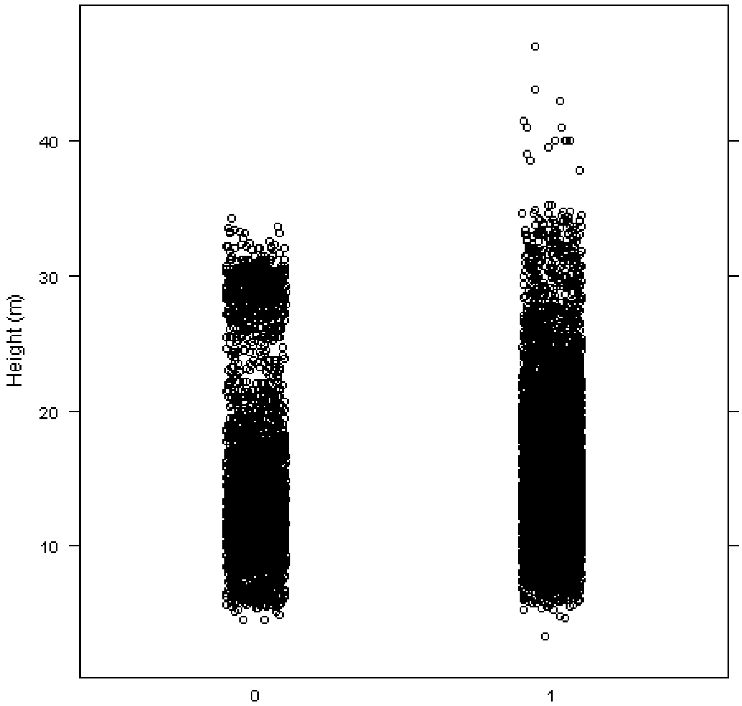

Figure I.1-A.6. Strip-plot of Heights in the calibration dataset.
1 = Thinned, 0 = Unthinned.

Discussion

We have shown that it is possible to derive a generalised model that performs well and which by its nature deals with the data sparseness issue by estimating the "typical" parameter value and modifying this value as a function of the plot- and tree-level characteristics. The BIC results and the graphical results suggest that the inclusion of covariates in the model improves the DBH-H model (i.e Model 2), as was shown by Temesgen and von Gadow.

The inclusion of covariates in the model is a move away from the baseline model, which is a generalised approach that presumes that competition (as measured on the scale of the plot by DENS, and BA, and on the scale of the tree by BAL) does not affect the allometric relationship between DBH and H over the tree's lifetime, when subjected to different competition pressure introduced by spacing or thinning. In the next section we address the issue of generalised vs plot specific modelling. However, our results at this point suggest that the Temesgen and von Gadow model that models plot differences through competition variables is a unified single-step approach. By contrast, the plot-specific approach can be seen as a multi-step approach, whereby the DBH-H relationship for each subject is modelled individually, and competition effects are at best implicitly described by the plot-specific fitted parameters. We might suspect that datasets that are heterogeneous across plots might be more accurately modelled using plot-specific approaches. Similarly, a generalised model might perform well on plots that are nearer the centre of the sample space than plots where management conditions are more atypical for a given dataset.
In conclusion, we adopt the use of generalised competition based models in the CARBWARE software because this performs better across all data (See Table I.2.2).

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I.1-B: Growth Modelling

(a) Modelling diameter increments in Irish Forests

Introduction

The modelling approach adapted in this version of CARBWARE v5 is the use of diameter increment models for all trees with a DBH greater that 5cm. This model in a distance independent individual tree growth model parameterised on Coillte permanent plot data recorded every 4 to 6 year since 1954 to 2003. Theses include pure and mixed species stands at establishment planting densities of 5000 to 1000 trees per ha and with different thinning treatments. The advantage of using a single tree growth model and the nature of the parameterisation data set is that different silvicultural regimes and species mixtures can be handled by one generalised modelling framework. In addition, the application data set, i.e. the data from which models will be run, does not contain explicit complete longitudinal data representing stand variable, which are used in conventional growth models.

Data operations

Two datasets are referred to, Coillte permanent sample plot (PSP) and NFI. Some of the data operations referred to below differ between these because the former has complete enumeration on a plot and is longitudinal, the latter samples from the plot and is cross-sectional.

In general, the modelling framework that we base our work on, PrognAus (see various references below), informed the types of data operations required. The framework involves, using their terminology, site, competition and size variables. Our focus was on the latter variables, and site or plot effects were accounted for using mixed model methods, whereby plot or site effects are random, blocking, effects, rather than effects whose levels have physical dimension. In any case, site or plot effects are not a feature of the growth simulator. Furthermore, incomplete enumeration of certain independent variables meant that random effects were difficult to estimate because of the sparse data. We can illustrate that elsewhere but such detail is not relevant to the CARBWARE software manual.

The variables described here are those that feature in the diameter increment model that we aim towards calibrating :

$$Dinc(cm) = \exp(a_0 + a_1 \ln DBH + a_2 DBH^2 + a_3 . \ln CR + a_4 . \ln CCF + a_5 . BAL)$$

See Table G.4 and the text for explanation of symbols.

Data operations were concerned with assembling datasets of the variables used in the growth model, insofar as was feasible. Below, we describe any substantive data operations that were performed on the variables of interest. We exclude from this description any operations related to “data cleaning”. The main data cleaning result was to omit negative diameter increments from the dataset. Such omissions were made after such derived variables as BAL, BA and plot density were calculated. That decision was based on the fact that the omission did not have a significant impact on the results, which suggested that no further modelling was necessary to compensate for the omission. Also, if the trees involved were omitted prior to the calculation of derived variables, those variables would have been subject to an even greater bias.

Table I.1-B.1. Explanation of some symbols used in the text.

Variable	**Formula**	**Scale of measurement**
CR	Crown length/height	Range (0,1)
DBH	Diameter at 1.3 m	Cm
Crown competition factor (CCF)	The "open-grown" (e.g. if every tree had zero competitors) crown area of all trees in a plot expressed as a percentage of plot area.	Percent
BAL	A function for each plot that takes as its argument any tree's rank in the diameter distribution ordered from smallest to largest and returns the combined basal area of all trees with higher rank.	M^2 ha^{-1}
BA	Plot basal area.	M^2 ha^{-1}
Annualised diameter increment (Dinc)	(DBH(t+1)-DBH(t))/([t+1] – [t]). DBH(t) stands for "DBH on the occasion of the t^{th} measurement". Since measurment intervals vary, this implies that [t +1] – [t] = 1 is not necessarily true, hence the use of the term "annualised".	cm

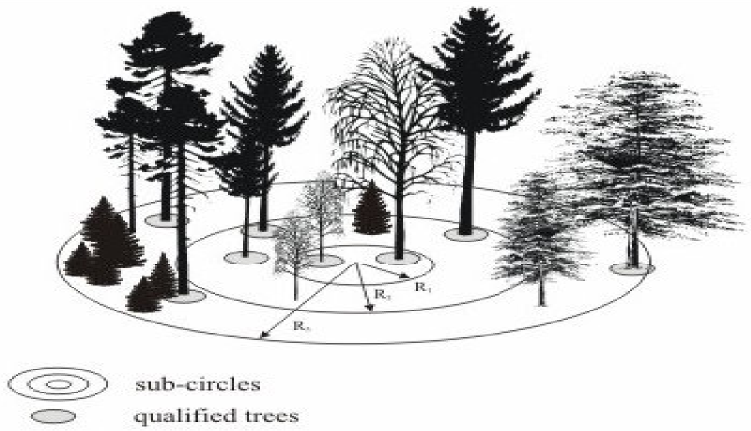
.

Open-grown crown width (cw), is an intermediary variable in the calculation CCF. We estimated *cw* using equations derived by Hasenauer (1997). These equations return open-grown crown width in *metres*. Hasenauer (1997) derived species-specific equations that we apply in approximation to cohorts,

Spruce : cw = exp(-**0.3232**)*((DBH)$^{0.6441}$)
Other conifers : cw = exp(**0.092**) *((DBH)$^{0.538}$)
Pine : cw = exp(-**0.1797**)*((DBH)$^{0.6267}$)
Larch : cw = exp(-**0.3396**)*((DBH)$^{0.6823}$)
Slow-growing broadleaves : cw = exp(-**0.3973**)*((DBH)$^{0.7328}$)
Fast-growing broadleaves : cw = exp(**0.1366**)*((DBH)$^{0.6183}$)
(where a circumflex denotes exponentiation.)

Open grown crown area (m^2) = (**0.25**)*(**3.141593***cw^2)
NFI and PSP datasets differed primarily in the fact that PSP plots were fully enumerated, whereas NFI plots were sampled. The sampling method, in conjunction with an assumption of homogeneous spatial diameter distribution, informs the calculation of a sampling weight or *expansion factor* which is used to allow for the possibility that some trees on a given plot were not sampled. The expansion factor is inversely proportional to the prior probability of a given tree's inclusion in the sample, based on the trees diameter class. Each tree in the sample is thus duplicated by a number of times equal to its expansion factor. This duplication is allowed for when calculating plot-level derived variables, e.g.

Density, by incorporating the expansion factor into the equations. For example, the estimated number of trees on a plot with a single sampled tree of 8cm is $(12.62/3)^2$. See Figure I.1-B.1 for an explanation.



	R_1	R_2	R_3
Sub-circle radius (m)	3	7	12,62
Sub-circle area (m^2)	28,3	153,9	500
Treshold diameter (mm)	70	120	200

Figure I.1-B.1. The NFI sampling scheme at the plot-level.
The *expansion factor* for a tree in the *i*th diameter class is $(R_3/R_i)^2$

Diameter increment

The diameter increment model for each cohort was calibrated by fitting to data from the PSP dataset.

$$Dinc = \exp(a_0 + a_1 lnDBH + a_2 DBH\hat{}^2 + a_3 .lnCR + a_4 .lnCCF + a_5 .BAL) + e$$

Where a_i, i = 1…5 are coefficients and *e* is a residual that was autocorrelated between measurements on the same tree and independent otherwise. The fitting was done in the Glimmix procedure in SAS, and the model is a GLM with Gaussian variance function and a log link. This is slightly different from Monserud and Sterba (1997), who log-transformed the response, where we log-transform the expected value of *Dinc*, and didn't model autocorrelation.

Where fitting was unsatisfactory, i.e. because of parameter instability or data sparseness, a submodel was selected. A criteria of model selection was that the parameters should be qualitatively similar to those estimated by Monserud and Sterba (1997). In this respect, the fitting of the increment models is better described as model calibration than model selection.

The parameters for the fitted models were:

FGB
E(Dinc) = EXP(-2.8528 + LN(DBH)*1.1729 - 0.00012*DBH^2 + LN(CR)*0.8241 - 0.000015*CCF)
Larch
E(Dinc) = EXP(-2.2969 + LN(DBH)*0.6338 - 0.00096*CCF)
OC
E(Dinc) = EXP(-1.4191 + LN(DBH)*0.554 - 0.00025*DBH^2 + LN(CR)*0.5549 - 0.00052*CCF - 0.00646*BAL)
Pine
E(Dinc) = EXP(-1.3466 + LN(DBH)*0.741 - 0.001*DBH^2 + LN(CR)*0.998 - 0.00066*CCF -

0.00417*BAL)

SGB

E(Dinc) = EXP(-2.5897 + LN(DBH)*0.7534 - 0.00068*DBH^^{2} - 0.0006*CCF - 0.00979*BAL)

Spruce

E(Dinc) = EXP(-1.8628 + LN(DBH)*0.9456 - 0.0005*DBH^2 + LN(CR)*1.1639 - 0.000638*CCF-0.00273*BAL)

Uncertainty:

In this section we look at various measures of the performance for the different models discussed above. The performance measures quoted give rough ideas about how the models perform. It should be noted that performance can be improved somewhat by including plot and site effects but since these are problematic for extrapolation from PSP to NFI, they were omitted from the Dinc model. They were also omitted from within NFI imputation models, by which we mean imputation models calibrated on NFI data, for similar considerations. They were not omitted from PSP-specific models.

We looked at the performance of the various models – DBH-H, CR, Dinc – for the two datasets. Some measures we could have used, that are used by Thurig et al (2005), for example, are *accuracy, precision,* and *excess error,* calculated as follows.

Accuracy : ((Σ(**pred**icted-**obs**erved)/n)*100)/m. Where *m* is E(obs), and *n* is the number of observations.

Precision : SD(pred-obs)

Empirical Excess error (%): ((1-Sec)/Sei)*100. Where *Sec* is the *precision* of the calibration data, and *Sei* the *precision* of the independent data.

Theoretical Excess error : (1/n)[Σ$(pred_{(-1)}\text{-obs})^2$- Σ$(\text{pred-obs})^2$]. Where pred(-1) is the leave one out prediction error

Note that *empirical excess error* is only viable when doing external validation.

Temesgen and von Gadow (2004), for example, use *root mean squared error* (RMSE) and Bias to evaluate their models.

Bias : (Σ(pred-obs)/n)

RMSE : √(Σ$(\text{pred-obs})^2$/n-p). Where *p* is the number of parameters in the model.

Another measure is *mean absolute error* (MAE).

MAE : Σ |pred-obs|/n

A certain amount of model selection was done, as noted above, when fitting the models to the data in the first place. This ensures that the fitted models are the most parsimonious to minimise residual error. However, model performance is best evaluated by external validation or, failing that, some cross-validation. We conduct leave-k-out cross validation on the Dinc calibration data. *MAE* and *RMSE* are calculated for each cross-validation dataset replicate. External validation data was only available for the PSP DBH-H model, and that is discussed in another document.

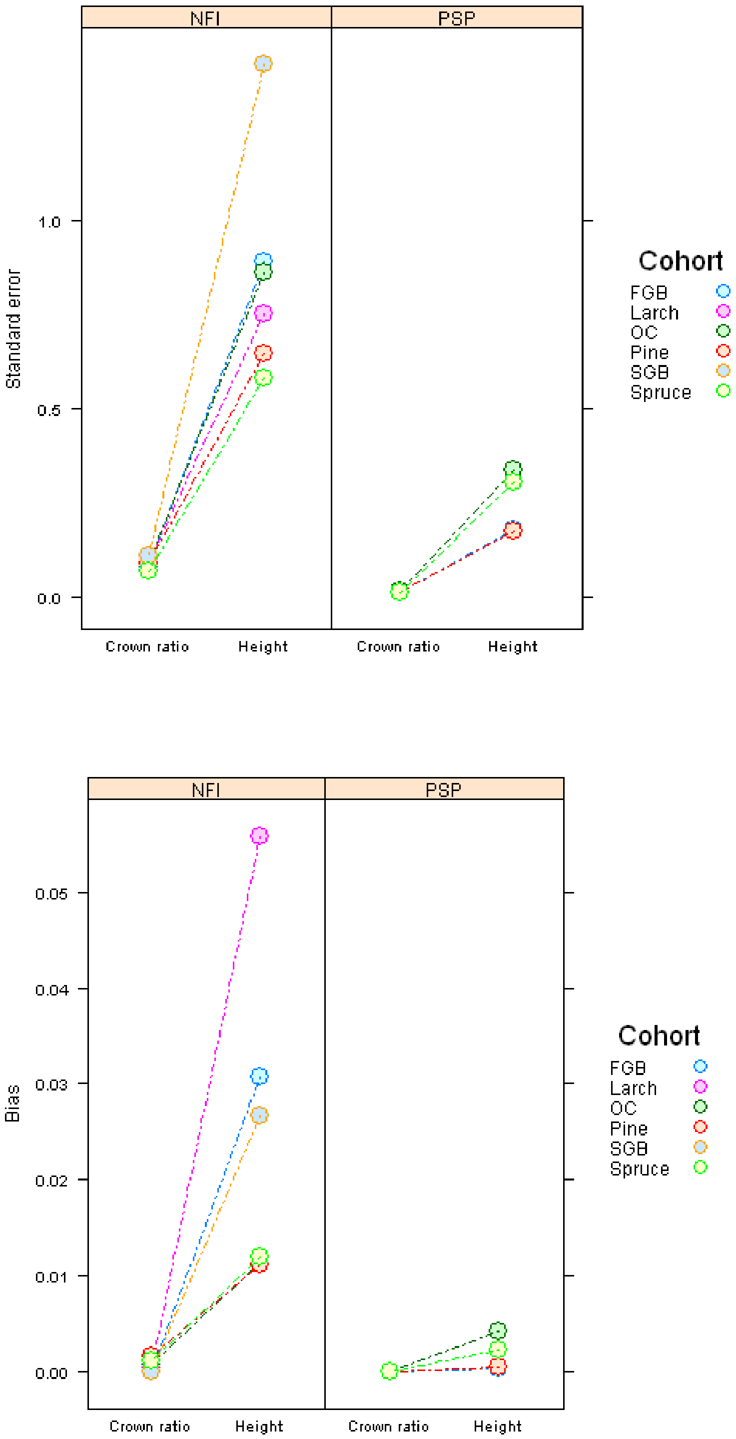


Figure I.1-B.2. Within-sample Precision (upper panel) and Bias (lower panel) for imputation. Values are plotted for each dataset, for cohorts, and for models of Height and Crown ratio.

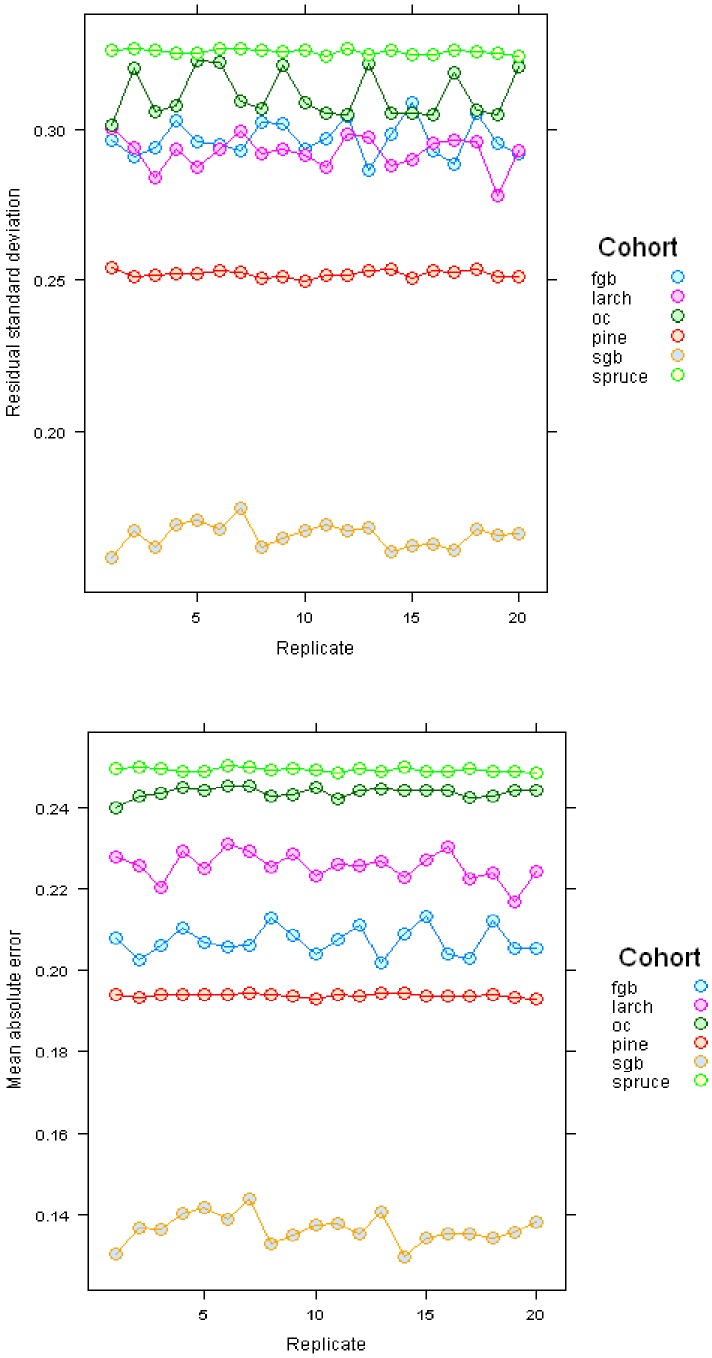


Figure I.1-B.3. Leave k-out crossvalidation results, precision (top) and mean absolute error (bottom) for the Dinc model.
The probability of inclusion in the validation dataset is 0.33. 20 cross-validation replicates are displayed.

Discussion and conclusions

The lines joining the points in Figure I.1-B.2 are only included to facilitate a comparison between panels. The interpolating lines in Figure I.1-B.3 are indicative of variability between the different cross-validation runs. This variability is partly a function of data resources, i.e. the number of cases, and the size of the validation sample as a proportion of the number of cases. The low variability of Pine and Spruce, the cohorts with by far the most number of cases, reflects this.

In Figure I.1-B.2, the better performance of PSP versus NFI is partly a result of including such blocking effects as site and plot. This idea is also illustrated with more detail in the document on DBH-H modelling.

From Figure I.1-B.2, bias levels are low for both NFI and PSP. Pine and Spruce, the most important cohorts, are among the top performers. This partly reflects the better data resources for those cohorts.

Taken together, these results can inform uncertainty/sensitivity analyses) to be completed in 2011).

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(b) Modelling height increments for small trees

Introduction

Height growth for small trees is a driving developmental force as trees compete for light and vertical growing space. Because of this, the small-tree portion of CARBWARE is a height-growth driven model; height growth is estimated first, and then diameter growth is predicted from height growth (see section B of this appendix E3). Equations used to predict small-tree height increment vary by species, variant, silvicultural practice and site type. Most single tree based models for young growth, generally use the same the same predictors as described for DBH increment models. However, the NFI data set provides little or no information on predictors for young tree height. The development of a H growth model for trees less than 1.3 m to a maximum H of 2.3 to 5.1 m (i.e. the diameter at breast H, DBH) is described here. The model uses a empirical Chapman-Richards approach for different species with sub models for different height index ratios (i.e. mean H over age as proxy's for young stand productivity and site factors).

Methodology

Modelling framework

The model uses a empirical Chapman-Richards approach for different species with sub models for different height index ratios (i.e. mean H over age as proxy's for young stand productivity and site factors).

$$xHinc_{i,j}^{n+1} = \frac{a_1}{1+\exp(-1\times\left[\dfrac{age^n - a_2}{a_3}\right])} \quad \text{.........(1)}$$

where, *xH* is mean height of all trees in the NFI plot for the $_i$th species and $_j$th H index ratio at the determined age (n+1). The age of the forest (n) is obtained from the NFI stand attribute data. The partial coefficients (*a*) for each species and productivity class and goodness of f
Once the new mean tree H ($xH_n + xHinc_{n+1}$) is computed, the individual tree H is recalculated based on a scaling function:

$$H_{n+1} = \frac{H_n}{xH_n} \times H_n \quad \text{.......}(2)$$

where, H_{n+1} is the individual H of the tree in the plot in the year following the NFI , H_n is the individual H in the year the last NFI was completed (2005), and xH_n is the mean H of trees in the plot in the year the last NFI was completed.

The Productivity class (H over age) categories were defined to match conventional yield class productivity indices (YC*eq*) as described by (Christy and Edwards, 1981). This was derived by comparison of Chapman Richard outputs from each H index ratio (HI) with static age-H tables at ca. 10 to 20 year old crops.

$$YCeq = HI = \min, \{YCH_{ij} - xH_{ij}\}^2$$

where, YC *eq* is the *HI* equivalent to YC at the lowest least-squares different between the yield table H values (*YCH*) and the predicted mean height (*x*H see equation 1) for the *i*th cohort and *j*th HI.

Selection of tree for H increment model

All trees with no measurable DBH are selected for growth increment using the H model. The CARBWARE model also selects eligible trees to be grown using the H growth model based on cohort-specific threshold DBH values (Table I.1-B.2). These are derived from analysis of the minimum DBH ranges suitable for the DBH increment model. The transition from the H to DBH increment model is based on the threshold H value which corresponds to the minimum allowable DBH value to be used in the DBH increment model (Table I.1-B.2). If a tree has a larger corresponding DBH than the threshold value, it is grown using the DBH increment model.

Table I.1-B.2. Threshold minimum DBH values suitable for use din DBH increment model and corresponding cut-off H values used for H growth in small trees

Cohort	DBH threshold (cm)	Corresponding H (m)
Spruce	4	2.7
Pine	4	5.1
Larch	2	3.6
Other conifers	4	3.1
Slow growing Broadleaves (SGB)	2	4.2
Fast growing Broadleaves (FGB)	2	3.2

Datasets and measure of goodness of fit

We used both the Coillte PSP and NFI individual tree data base to develop H-age curves (range 0.1 to 12 m). Data operations were concerned with assembling datasets of the variables used in the H model, insofar as was feasible.

We looked at the performance of the various models –H-Age for different cohort for the combined datasets. Some measures we could have used, that are used by Thurig et al (2005), for example, are *accuracy, precision,* and *excess error,* calculated as follows.

Accuracy : ((Σ(**pred**icted-**obs**erved)/n)*100)/m. Where *m* is E(obs), and *n* is the number of observations.

Precision : SD(pred-obs)

Empirical Excess error measures could not be performed because there was no external validation data set (Thirig et al., 2005).

Bias : (Σ(pred-obs)/n)

RMSE : $\sqrt{(\Sigma(\text{pred-obs})^2/\text{n-p})}$. Where *p* is the number of parameters in the model.

Results

Fitted model parameters

Table I.1-B.3 shows the partial coefficients for each species and productivity class for the Chapman-Richards H-Age functions.

Table I.1-B3. Spruce cohort

HI range	YCeq				Precision	RMSE	Bias
		a_1	a_2	a_3			
>1.2	>24	1.02	5.59	2.04	1.8	4.69	0.32
1-1.2	24	1.05	7.05	2.32	1.42	4.23	-0.23
0.8-1	22	0.76	5.98	1.63	1.33	3.21	0.11
0.6-0.8	20	0.66	5.51	1.33	0.66	2.55	0.56
0.5-0.6	18	0.57	5.26	1.12	0.89	1.69	0.45
0.4-0.5	16	0.53	5.35	1.47	1.11	3.66	0.32
0.3-0.4	14	0.48	5.32	0.54	0.74	3.54	0.62
0.2-0.3	12	0.44	6.59	2.20	1.53	4.53	0.24
0.1-0.2	10	0.35	6.93	2.27	0.69	1.77	-0.43
<0.1	<10	0.28	8.02	0.35	1.9	4.23	-0.7

Appendix I.2: CARBWARE stand modification functions

The NFI permanent plots structure is modified at each growth cycle iteration to simulate the losses associated with natural mortality and harvest. This section discusses the development of the CARBWARE modification functions from draft versions for submission to International, peer reviewed Scientific Journals.

I.2-A: Mortality models

Introduction

In the general context of forest growth models, and at the most basic level, the tree mortality module's role at each iteration is to classify a particular tree in the dataset as being either dead or alive. This paper approaches this problem in the context of an individual-tree model of mortality, that is both age- and distance-independent. The specific modelling framework within which the mortality module will be applied, is a framework similar to the PrognAus framework, with the goal of estimating annual forest dynamics for Ireland.

Literature review

There are two areas of interest for the literature context of this paper: *tree-mortality* modelling, and *threshold-based* classification. (Note that this paper is not focussed on a survival analysis, as one might perhaps expect, because such models are time-dependent.)

1. *Mortality modelling* in Forest Succession.

Wunder et al. [2006a] compared the use of classical stress-thresholds in mortality modules of forest succession (\gap") models. They conclude that logistica1 regression-based models are superior to stress-threshold models with regard to predicting time of tree death.

Baesens et al. [2003] review threshold-based classifiers in the context of credit-scoring. They examine logistic regression, discriminant analysis, k-nearest neighbour, neural networks and decision trees, advanced kernel-based classification algorithms such as support vector machines and least-squares support vector machines (LS-SVM). They assess performance using the classification accuracy and the area under the receiver operating characteristic curve. They found that both the LS-SVM and neural network classifiers yield a very good performance, but also simple classifiers such as logistic regression and linear discriminant analysis perform very well for credit scoring.

Bigler and Bugmann [2004] introduced a new approach to modelling tree mortality based on different growth patterns of entire tree-ring series. They were interested in predicting time of tree death. In their study, dendrochronological data from *Picea abies* (Norway spruce) in the Swiss Alps were used to calibrate mortality models using logistic regression. They introduced a mortality threshold and classified a tree as dead if its modelled mortality probability curve plotted over time went above that threshold. They ignored autocorrelation at the modelling stage, and applied a jackknife method to correct for the resulting biased variance estimates. They found that the most reliable models were those that included relative growth rate and a short-term growth trend as explanatory variables.
Focussing on the role played by life-history strategies in determining tree mortality Wunder et al. [2008] investigated whether the relationship between growth and mortality divers among tree species and site conditions. This carries on from Monserud [1976] who showed that reduced growth generally accompanies a higher mortality risk. For each of nine species, they modelled mortality probablity as a function of relative basal area increment, tree size and site. They selected the species-specific model with the highest goodness-of-fit and calculated the area under the receiver operating characteristic curve and calibration measures. The discriminatory power as measured by AUC ranged from 0.62 to 0.87. They found that most growth-mortality relationships differed among species and sites, i.e. there is no universal growth-mortality relationship.
It has been noted that a lack of long-term growth/mortality data has made it difficult to evaluate the performance of mortality models. Wunder et al. [2006b] adopt a “virtual ecology" approach to this problem, simulating forests with either of two a priori specified growth-mortality relationships. They simulate different sampling regimes in these virtual forests, thereby generating virtual tree-ring data, forest inventory data, or a combination of both. They compare eight existing or newly developed models of different structural flexibility by their ability to model the growth-mortality relationship in the simulated data, and quantify the deviation from the *a priori* specified growth-mortality relationships with the Kullback-Leibler distance. Of the models they evaluated, the highest accuracies were obtained with tree-ring based models, which required only small (approx. 60) numbers of dead trees. For larger sample sizes (approx 500 dead trees) forest inventory based models were also seen to be accurate. They also showed that exible statistical approaches were superior to less flexible models only for large sample sizes (totally 2000 trees) and that the additional use of Bayesian statistics, model accuracies only when model flexibility was constrained. They also provided guidelines for sufficient sampling schemes in real forests.

In the PrognAus framework, Monserud and Sterba [1999] modelled mortality in Austrian forests for six major species based on 5-year re-measurements of the permanent plot network of the Austrian National Forest Inventory. Their general results, varying slightly between species, was that inverse of tree diameter, crown ratio and BAL were respectively the three most closely correlated factors in their model with 5-year mortality rates. They compared mortality rates across tree diameter class, thereby identifying a classic U-shape in mortality rates as diameter class increased. They modelled mortality rates rather than individual tree mortality probability, and validated the model with the chi-square statistic calculated between observed and estimated. Because the explanatory variables in their model were measured on the scale of the individual tree, they were able to calculate the classification success rate using the complement of the overall proportion
of mortality (i.e., approx 93%, although it is not clear from the text) as the threshold. On this basis, their model correctly classifieded between 81 and 92%, of live trees, and between 25 and 44%, of dead trees. However, their treatment of the threshold is very brief, and may not be a typical interpretation, e.g. in their interpretation, a tree is classified as dead if the threshold exceeds the modelled probability. Also, they derive a total correct classification accuracy of 86%.

Materials and Methods

We fitted logistic regression models to the growth dataset. We investigated model performance in the case of separate models for each cohort. (Principal issue here was the lack of data for some cohorts). The response variable was a binary indicator of mortality (arbitrarily, 1 = tree dead at time of DBH measurement, 0 = tree alive). We only included trees whose cause of death was natural mortality, e.g. such causes as windblown, diseased, were excluded. Explanatory variables were as such that were selected by Monserud and Sterba [1999] {DBH and transformations thereof, CR, BAL, CCF}, but we also investigated relative growth indicators that Bigler and Bugmann [2004] noted as being useful correlates. Site and plot effects were modelled as random, and consecutive observations on the same tree were modelled as being correlated. Conditional on this correlation structure the fixed effects parameters were selected by backward selection starting with the candidate set of covariates just listed.

Models were fitted by maximum likelihood and individual fixed effects were identified as non-significant on the basis of asymptotic Wald-tests. This was done for each cohort separately. Performance of candidate models was then evaluated by cross-validation and external validation (comparing fitted to observed mortality in NFI dataset) and with threshold-based classification tools like the ROC and ROL curves and related measures and hypothesis tests. Cross-validation was done on a leave-k out basis, where the data \left-out" was selected at random. Up to twenty independent cross-validation runs were performed, and up to 33% of the data was left-out as cross-validation data for each run.

Other performance measures were consulted, and the ROC convex hull played a role in our chosen classifier. We used threshold-averaging to investigate the performance of the classifier in cross-validation and bootstrap scenarios. We derived confidence bands for the ROC curve of the chosen classifier following the approach of Macskassy et al. [2005]. (Note, the authors have also developed techniques for point interval estimation also, the reference appearing in that paper.)

Performance measures in ROC space and their role in uncertainty analysis

The AUC of the ROC curve is the estimated probability that the classifier will give a higher score to positive cases than negative cases. (In our application, that the estimated probability of mortality is higher for dead trees than live trees.) We envisage that an uncertainty analysis of the forest growth model of which the mortality classifier is a component part could utilise this probability and its standard error in monte-carlo simulation assessments of overall uncertainty and sensitivity.

The AUC is equivalent to the Mann-Whitney U-statistic, and methods for comparing AUCs have been developed as a result, e.g. Heagerty et al. [2000]. The principal complicating factor here is the underlying correlation structure of the comparison, which can be influenced by details pertaining to the derivation of the classification forecasts, the setup of the calibration datasets, or whether the forecasts are clustered in someway, e.g. DeLong et al. [1988], Obuchowski [1997], Heagerty et al. [2000], Mason and Graham [2002].

The convex hull of a classifier, or group of classifiers, in ROC space, can be seen as the optimal attainable classification performance. Fawcett [2006] notes that candidate classifiers that do not attain the convex hull can be discarded, on the grounds that a better classifier in ROC space exists. He suggests a method for interpolating between candidate classifiers to better approach the limit of performance estimated by the convex hull based on mis-classification costs and the prior class distribution.

When comparing ROC curves, per se, a complicating factor when it is of interest to compare different classifiers crops up if the classifiers in question are of a different \class", e.g. a probabilistic classifier versus a discrete classifier, or, more generally, comparisons across model classes, whose scoring systems are incommensurate Fawcett [2006].

Datasets

Permanent Sample Plot

The mortality model is calibrated on data extracted from the permanent sample plot record system of Coillte Teoranta (the Irish Forestry Board state commercial forestry company). Broad and Lynch [2006b] provide details of the dataset in the context of modelling plot volume. The database consists of records of many silvicultural and thinning trials. These longitudinal trials were established from the 1950s onwards, and were initially established as replicated and blocked experimental designs Broad and Lynch [2006a].

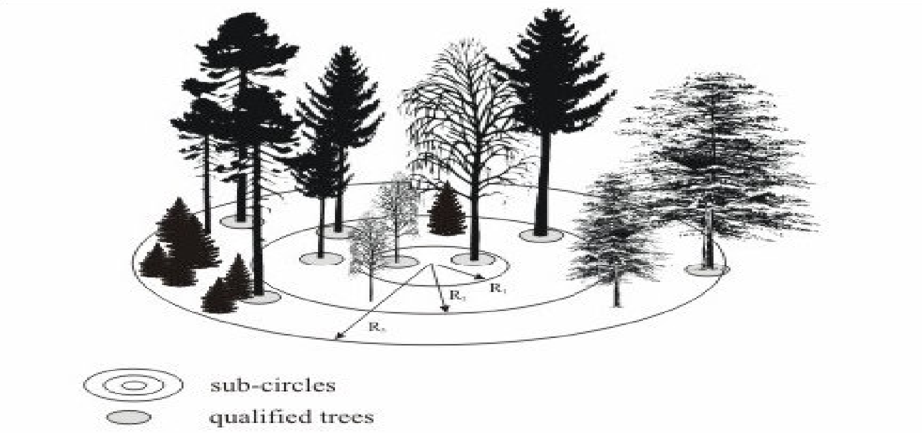
Although there are several categories of disease or mortality causes in the PSP database {including, Windblown, Uprooted, Diseased, Broken and Dead}, we modelled only the binary response Dead/Alive for the initial model. In this way, after derived variables { basal area, plot density, etc. {were calculated, only data points that could be classified as Dead/Alive, were kept in the calibration dataset

National Forest Inventory Plot data
We validated the ROC curve for the chosen model on the NFI data. In the NFI sample, the probability that a tree's status as dead or alive will be recorded { more generally, the probability that any feature of the tree is measured { is a function of its diameter class at the time of survey, and its distance from the centre of the plot. The expansion factor concept is a weight that varies between each tree in the dataset that estimates the prior probability of the tree's inclusion in the dataset. Figure I.2-A.1 shows that trees of three diameter classes are only recorded if they are observed within a certain distance from the plot centre. The expansion factor we use, and that used by the NFI, assumes a random distribution for tree diameter in the plot. Because of that assumption, the weight assigned to a tree in the ith diameter class is:

$$\frac{R_3^2}{R_i^2} \qquad \ldots\ldots(1)$$

where Ri denotes the radius of the concentric circle associated with the ith diameter class.

In practice, the expansion factor, or weight, is used to estimate plot-level features, e.g. basal area. In such calculations, we estimate the number of trees of the ith diameter class that were not included in the sample by $\frac{R_3^2}{R_i^2}$ * ni, where ni is the number of trees of the ith class



	R_1	R_2	R_3
Sub-circle radius (m)	3	7	12,62
Sub-circle area (m²)	28,3	153,9	500
Treshold diameter (mm)	70	120	200

Figure I.2-A.1. The NFI concentric-plot sampling schema.

that are included in the sample. The expansion factor therefore defines the relationship between each included tree and the estimated number of trees of the same class that were not included (Equation 2).

$$n_{ij} \times EF_{ij} = \hat{N}_{ij} \qquad \ldots\ldots (2)$$

where n_{ij} _ EF_{ij} is the product of the expansion factor for the *j* th tree in the *I* th class, and $\check{N}_{ij}$ is the corresponding estimate. In the terminology of the NFI, the RHS of Equation 2 is the representative tree number. With minor and obvious changes to the equation, we can calculate other tree-level estimates, including representative basal area, and individual-tree estimates can be aggregated for the entire plot to give plot-level estimates, including representative density.

The question to address in the current paper is whether we can arrive at a sensible definition of representative mortality. At issue is how to derive a binary individual-tree-level mortality rule based on information in the NFI dataset, given the fact that there is missing information due to the sampling scheme. With this in mind, Figure I.2-A.2 classifies all dead trees in the PSP database by cohort, and describes the empirical distribution of diameter classes conditional on mortality status. (We have included the diameter class (0,7] for completeness, even though there is no equivalent in the NFI dataset.) Note that the left-hand column is very similar to the unconditional distribution of diameter classes, so it does not need to be displayed. On those grounds, a comparison of the columns of Figure I.2-A.2 shows the dramatic extent to which the chance of mortality declines if a tree does not die while in the lowest diameter class. For example, the global fraction of trees in the Spruce cohort in the lowest diameter class is very small, but this class represents 50% of dead trees in the cohort. Similarly for Pine, OC and FGB.

The right-hand column of Figure I.2-A.2, at least for the cohorts with enough observations, suggests a way to make the operation of a binary mortality rule more accurate in the context of the NFI sampling scheme. The basic idea would be to use the column heights as weights in a finite mixture function whose components would be the outcome of the mortality rule. Rather than reducing the expansion factor by one unit when death is predicted (which, we can show, can lead to an unrealistically height global mortality rate), the actual reduction would be a function of the weight for the given diameter class. This method could be stochastic or deterministic. Other information might be used to inform the values of the weights, including a forester's rule of thumb about global mortality (i.e., _ 6%), or information from the NFI or a meta-analysis.

A similar approach would be to mix the outcome of the mortality rule with the diameter class mortality weights. It might be possible to iteratively tune the weights and/or the rule's cut-off parameter.

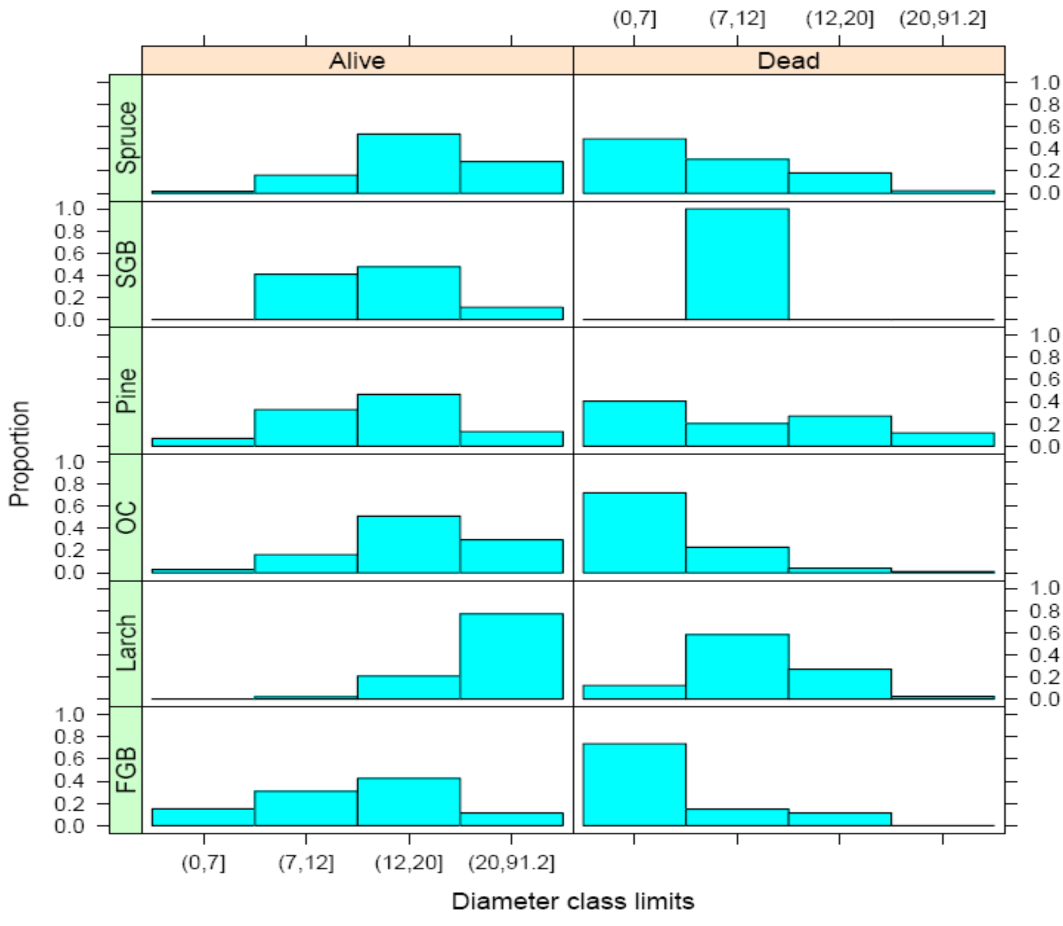


Figure I.2-A.2 The empirical distribution in the PSP dataset of diameter classes of dead/alive trees classified by cohorts.

Results

*Candidate model Number 1*Candidate model 1 was a fixed effects model. A logistic GLM was fitted in Glimmix. The _fixed effects were DBH, BAL, and

RelDiamInc $\left(\frac{growth(t-t-1)}{DBH(t)}\right)$

Part of the reason for looking at this model was that it was not subject to additional uncertainty due to imputation of missing X data, as would have been the case with the model put forward by Monserud and Sterba [1999], which also conditioned mortality on CR, a variable that was not measured on every tree in our dataset.

There are several points of interest to the results of this model fitting:

1. The characteristics of the parameters.
2. The cross-validation exercise.
3. The out-of-sample/deployment performance. E.g. how well the model described NFI mortality.

Estimated parameters Candidate Model 1 (Used in CARBWARE models)

The fitted parameters and their standard errors are presented in Table I.2-A.1. We supply parameter estimates for cohort-wise fits and the fit to the entire dataset, with no cohort-effect parameter.

Table I.2-A.1. Candidate model 1 parameters

Fast-growing broadleaves cohort

Parameter	Estimate	s.e.	df	Wald statistic	Wald p-value
Intercept	-2.9295	0.1510	11784	-19.41	0.0001
DBH	-0.4307	0.02508	11784	-17.17	0.0001
BAL	0.06816	0.004384	11784	15.55	0.0001
RelDiamInc	-1.6783	1.2147	11784	-1.38	0.1671

Larch cohort

Parameter	Estimate	s.e.	df	Wald statistic	Wald p-value
Intercept	3.0526	0.1691	6544	18.06	0.0001
DBH	-0.4373	0.01276	6544	-34.27	0.0001
BAL	0.05688	0.003066	6544	18.56	0.0001
RelDiamInc	-14.7793	2.5794	6544	-5.73	0.0001

Other conifers

Parameter	Estimate	s.e.	df	Wald statistic	Wald p-value
Intercept	4.3636	0.1090	21239	40.02	0.0001
DBH	-0.8384	0.01447	21239	-57.95	0.0001
BAL	0.05970	0.002078	21239	28.72	0.0001
RelDiamInc	-29.2957	1.0322	21239	-28.38	0.0001

Pine cohort

Parameter	Estimate	s.e.	df	Wald statistic	Wald p-value
Intercept	2.3952	0.04531	187E3	52.86	0.0001
DBH	-0.8127	0.007225	187E3	-112.49	0.0001
BAL	0.08083	0.000999	187E3	80.91	0.0001
RelDiamInc	-23.0015	0.3995	187E3	-57.57	0.0001

Slow growing broadleaves

Parameter	Estimate	s.e.	df	Wald statistic	Wald p-value
Intercept	29.6029	7.1305	1027	4.15	0.0001
DBH	-2.1970	0.4873	1027	-4.51	0.0001
BAL	-0.1225	0.01754	1027	-6.98	0.0001
RelDiamInc	-2199.90	521.36	1027	-4.22	0.0001

Spruce cohort

Parameter	Estimate	s.e.	df	Wald statistic	Wald p-value
Intercept	1.2286	0.02747	298E3	44.72	0.0001
DBH	-0.6640	0.003840	298E3	-172.93	0.0001
BAL	0.05051	0.000529	298E3	95.57	0.0001
RelDiamInc	-13.0524	0.2544	298E3	-51.30	0.0001

Candidate Model 2

The fixed effects in Candidate model 2 were those in Monserud and Sterba [1999], and diameter increment as a proportion of diameter (RelDiamInc).

Cross-validation and deployment performance

We performed plot-wise and case-wise leave k-out cross-validation of the chosen models. The case-wise deletion algorithm was very slow for the Pine and Spruce cohorts, in which case we opted to use only plot-wise deletion. The algorithm selected plots for deletion from the fitting dataset using a Bernoulli mechanism with parameter p, which we sometimes changed depending on the number of plots in the cohort dataset. Details are provided with each graphical representation of the results in Figures below. Twenty \leave-outs"were performed and the variability in these twenty runs is represented by the
dotted curves.

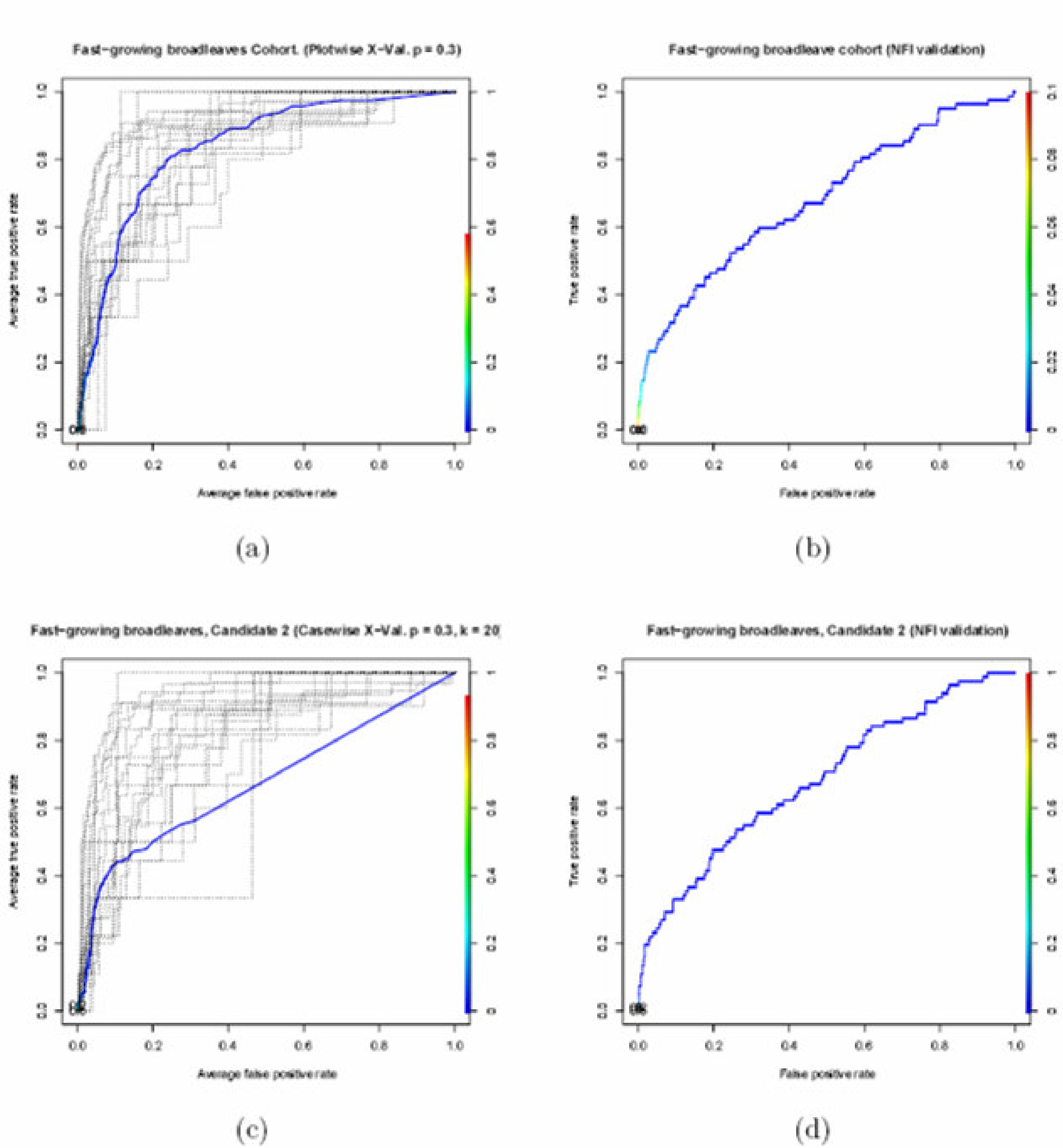


Figure I.2-A.3. The Receiver operating characteristic curve for Candidate model 1 (panels (a),(b)) and model 2 (panel (c),(d)) in the Fast-growing broadleaves cohort.

20-fold cross-validation plotwise with average leave-out probability p = 0.3. Curves for each cross-validation run and a threshold-averaged curve are shown.

We estimated the ROC curve for each cohort model's out-of-sample performance by comparing model predictions with the actual NFI mortality data (Figures I.2-A.3). The cross-validation and deployment performance plots are presented pair-wise in the Figures below.

In all cased model candidate outperformed candidate based on false positives and fit. For example we show the results for Fast growing cohorts in Figure I.2-A.3

Note that Slow-growing broadleaves cohort did not have enough data for the cross-validation to be feasible, so the ROC curve for that cohort depicts in-sample performance.

Models fitted to NFI data

When fitting models to the NFI data we used backward elimination, starting with the parameters in the Monserud and Sterba [1999] model. Relative diameter was not used, because the dataset is cross-sectional. In Figure I.2-A.4 we present an example of the out-of-sample performance (i.e. their performance in predicting NFI data) of the two PSP-calibrated models, and the in-sample performance of the NFI-calibrated model.

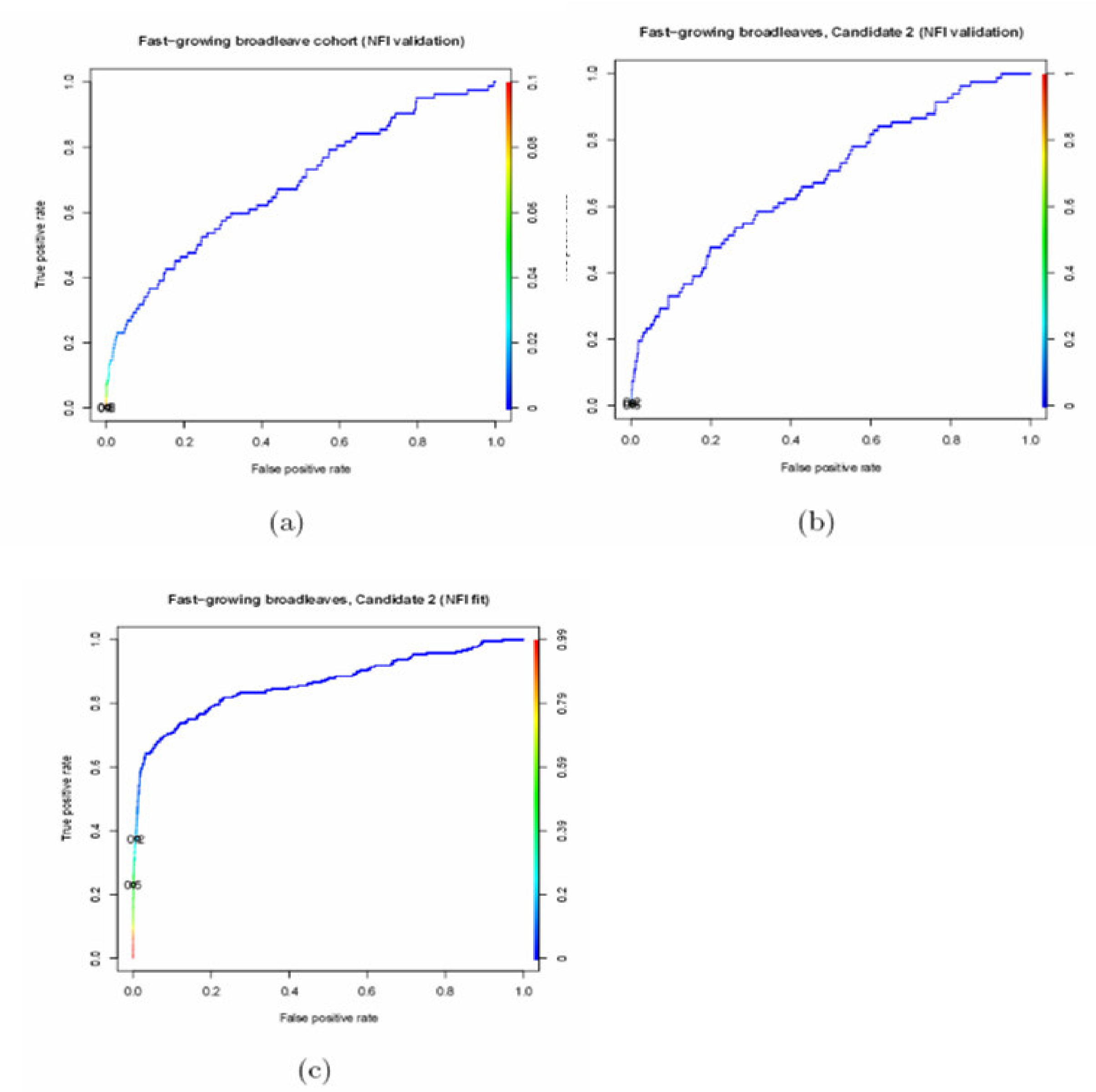


Figure I.2-A.4. The Receiver operating characteristic curve for Fast-growing broadleaves cohort Candidate models 1 and 2 fitted on PSP, and for the NFI-fitted model.

The selected CARBWARE models based on NFI data fits

Fast-growing broadleaves cohort

$$Pmort = IL(12.93 + 0.068 \times BAL - 2.868 \times CR - 0.962 \times DBH - 72.28 \times \frac{1}{DBH} + 0.009 \times DBH^2$$

Larch cohort

$$Pmort = IL(-4.9266 + 0.04273 \times DBH)$$

Other conifers

$$Pmort = IL(-4.5226 + 0.067 \times BAL - 6.05 \times CR + 0.066 \times DBH)$$

Pine cohort

$$Pmort = IL(2.395 + 0.0408 \times BAL - 3.0036 \times CR - 0.2263 \times DBH - 24.21 \times \frac{1}{DBH})$$

Slow growing broadleaves

$$Pmort = IL(15.78 + 0.0109 \times BAL - 2.2807 \times CR - 0.771 \times DBH - 94.002 \times \frac{1}{DBH} + 0.00449 \times DBH^2$$

Spruce cohort

$$Pmort = IL(6.8976 + 0.0912 \times BAL - 21.3795 \times CR - 0.8287 \times DBH - 49.15 \times \frac{1}{DBH} + 0.008 \times DBH^2$$

Where (0 < Pmort < 1) is the probability the tree is dead. We map then this estimated probabiilty onto the binary (Dead, Alive) outcome using a cutoff, which may differ between cohorts. More details on this is give elsewhere. IL(.) is the inverse logit, e.g. IL(x) = exp(x)/(1+exp(x)).

Choosing the operational cut-off

To identify a cut-off level to use for the mortality probability estimate, we plotted the True positive rate (TPR) and (FPR) on the same axis versus the cut-off (e.g. Figure I.2-A.5). In forest mortality, the number of positive cases (dead trees) is usually greatly outnumbered by the number of negative cases. This suggests that, all mis-classification costs being equal, the cut-off should be chosen with a view to keeping as small as feasible the rate of false positives predicted by the resulting rule, even though the rate of true positives is reduced as an unavoidable consequence. When combining individual cohort results to make an aggregate prediction the issue of false positive rate is of particular importance for large cohorts, because they have a greater weight in the aggregate estimate. In Figure I.2-A.5 we represent an FPR of not greater than 0.001 with a blue vertical line, and an FPR of not greater than 0.01 with a green vertical line, to illustrate the trade-off involved in each particular case.

Table I.2-A.2 Formulae for some standard performance measures used in the text.

Note TP, TN, FP, and FN are the numbers of true positives, true negatives, false positives and false negatives, which are tallied by comparing the predictions with the data.

Performance Measure	Formula
Accuracy	$\frac{TP+TN}{TP+FP+TN+FN}$
Rate of positive predictions	$\frac{TP+FP}{TP+FP+TN+FN}$
Correlation Coefficient	$\frac{(TP.TN)-(FP.FN)}{\sqrt{(TP+FN).(TN+FP).(TP+FP).(TN+FN)}}$

Figures I.2-A.6 illustrate some other considerations for choosing cut-off points. accuracy, rate of positive predictions and a correlation coefficient are plotted for a range of cut-offs (cf. Table G.9 for definitions of terms).

The graphs illustrate why the accuracy measure should not be used in isolation when choosing a cut-off. For example, in Figure I.2-A.6 a high accuracy is obtained despite the correlation coefficient indicating that the correlation between correct predictions and the data is worse than random, i.e. a negative correlation coefficient. Some performance measure formulas are given in Table G.8. These measures and others are described in Sing et al. [2005].

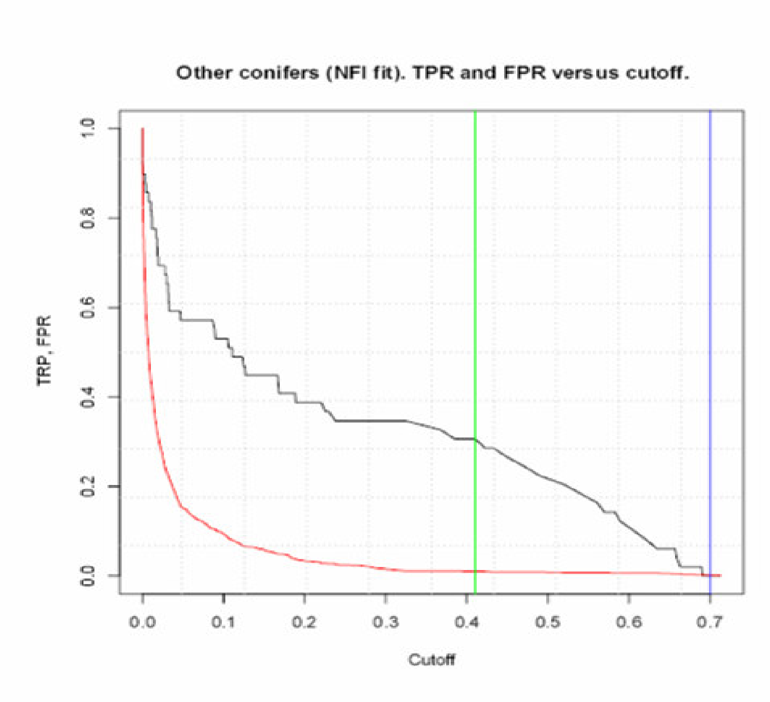


Figure I.2-A.5 TPR (Black) and FPR (Red) versus cut-off for Fast-growing broadleaves.
The vertical green line shows the cut-of where FPR < 0.01, the blue vertical line shows the cut-off where FPR< 0.001.

Discussion

In binary classification, a common approach is to visualise the parameterised curve described by plotting two performance measures as a parametric curve parameterised by the threshold value. Comparing models based on classification and mis-classification rate (precision, recall, etc.) make more sense when there is some hierarchy of misclassification errors. That is, that we can quantify the relative importance of gains from correct classification and losses from incorrect classification. Such a loss function is particularly useful when the number of objects to be classified is not equal, because then the trade-off curves are much more likely to be nonlinear and the concept of trade-off between competing performance measures is not easy to understand. The problem is how to specify losses/gains, in other words, how to quantify Trade-off, how to measure gains and losses in the same units so a net trade-off can be calculated. Otherwise, it is not always clear, even for commonly presented parameterised curves, in what sense the trade-off is occurring, particularly when a “good" classifier, e.g. one that exhibits desirable tendencies in threshold-space, can *a priori* exhibit a number of different “shapes" when presented as a “trade-off" curve.
For example, the class ROC trade-off curve has *a priori* a sense in which a classifier is good or bad. This is when the majority of the ROC curve lies below the line of equality. However, the precision-recall curve is not so easily understood. We know that the best classifier from a group is the one with the largest area between the curve and the line of equality. However, because the value of the precision at zero threshold is a function of the number of objects in each class to be classified, it is possible to have a “good" classifier for which that area is zero. However, such a classifier is probably not statistically better than the naive, 50:50 classifier. We propose that for a classifier to be demonstrably better than the naive classifier, it should at the minimum describe a positive region between the curve and the line of equality. We conclude that the precision-recall curve does not describe a trade-off, and that in fact, a trade-off should have a point of equilibrium and the gains and losses should be incurred when the threshold moves from that point in either direction. In other words, the gains and losses as quantified by the two performance measures should be negatively correlated, for the parameterised graph to truly describe a trade-off. The precision-recall performance measures, for example, are positively correlated (both have TP in the numerator), and so their parameterised curve representation does not describe a true trade-off situation in every region of threshold space. If we overlay the two graphs with precision and recall on the y and y' axes, and threshold on the x axis, we can see more clearly where a true trade-off may occur. It is likely that should a true trade-off occur, that the region between the parameterised curve and the line of

equality will have to be positive. As external corroboration, DeLong et al. [1988] note that the cost or loss function is essential to deciding the optimal cutpoint/threshold for a ROC curve. In summary, there are therefore two issues: comparing classifiers and, given a classifier, choosing a cut-off point.

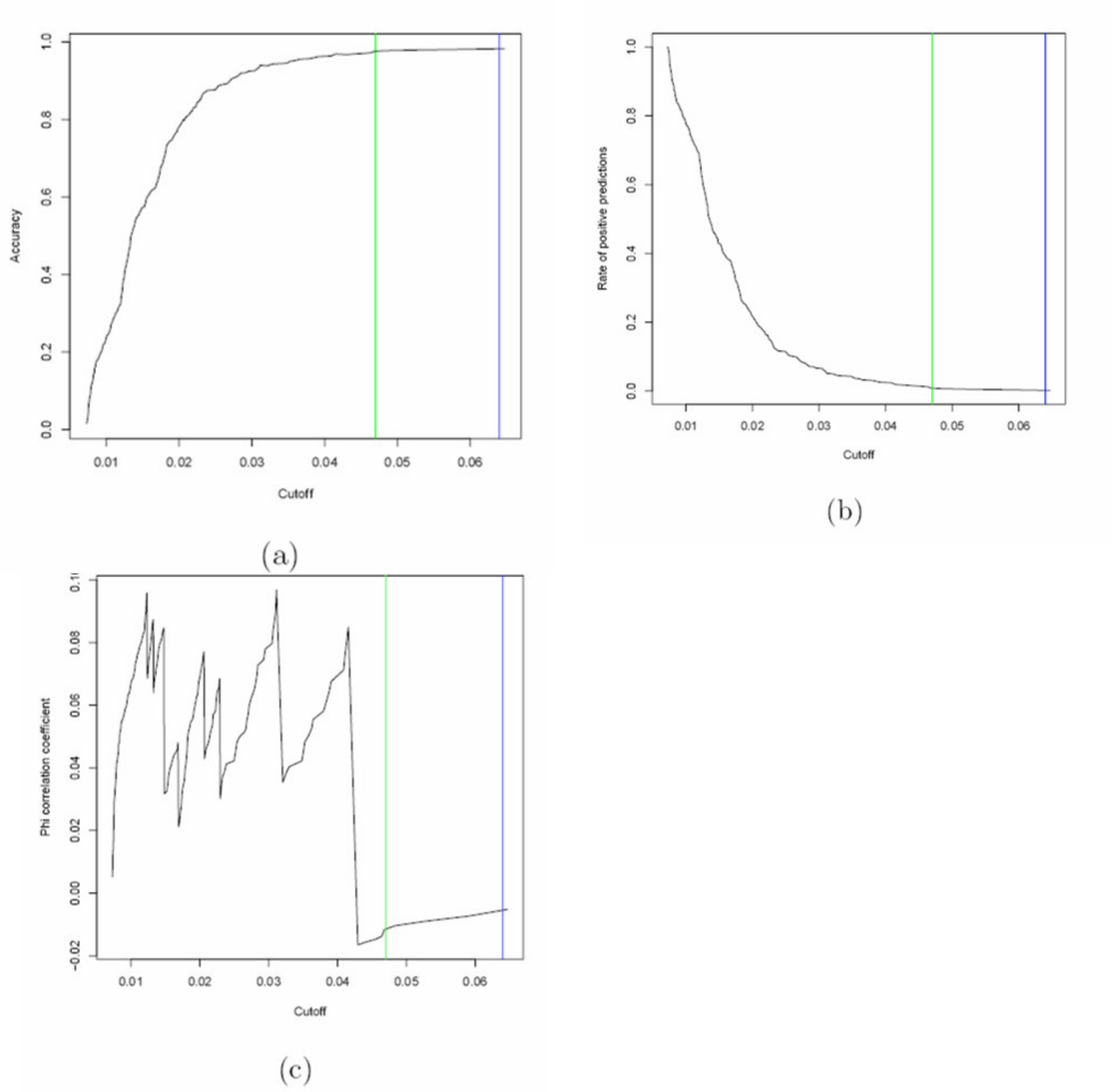


Figure I.2-A.6 Illustrating some other performance measures of the NFI-calibrated model for the Larch cohort across the cut-off range and in particular the 0.01 (green vertical) and 0.001(blue vertical) cut-off points.

This latter can only be done in conjunction with some kind of loss function describing costs of the different types of classification error. The kind of classifier we are using, based on multiple correlation/regression, and therefore wholly empirical, is easier to select than other types of classifier. We can use model selection criteria based on correlation/regression, or minimization of errors, or some other abstract modelling concepts. Then, the classifier selected, we can choose the cut-off. In what we call mechanistic classifiers, such as described in Martin-Davila et al. [2005], where the classifier is predicated first and foremost on an understood pathway, not naive correlation, the threshold has a physical dimension, and the choice of cut-off has a defined purpose in a physical system. Note that a logistic regression with a single explanatory variable can be made to fit such a schema. In fact, it might be possible to define a convex hull of the multiple explanatory variables to take the place of single-variable classifier in that schema. Also, some variables might be better at defining the threshold than others and this can also be examined. A convex hull defined by cut-off points in each explanatory variable might be envisaged to play the role of a kind of “syncretized" cut-off point. In such an instance, it would be relevant to assess the cross-correlations among the explanatory variables.

Conclusions

We set out to determine a logistic regression model of mortality that could be used to describe mortality in the NFI data. This was the ultimate goal of the model. We investigated the possibility of calibrating this model on the permanent sample plot longitudinal data but found that we could improve the result be simply calibrating the parameters on the NFI data alone. In the absence of a mis-classification cost function we chose the cut-off for transforming predictions on the logit scale to the binary (dead, alive) scale based on the false positive rate (the rate at which the model predicted mortality incorrectly). Specifically, we chose the cut-off to keep this as small as reasonably possible.

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I.2-B: Other modifications in the growth simulator

Thinning/Harvest

We assume that all thinning occur randomly. Random thinning can be implemented on an individual plot level. The CARBWARE user sets a basal area (BA) to be removes as stipulated in the harvest activity data (in the '**Eventstable**') so thinning of trees are selected at random from the plot until this target BA is achieved. The thinned or harvested trees in a given plot are removed from the growth database and populated in a modifier table within the CarwKP_08 database. These data are then called up in the allocation module (Appendix E2 and NIR section 11.2.3).

Although it is common practice that clear felled stands are replanted within 2 years, the CARBWARE model does no re-populate clear felled plots due to uncertainty of re-establishment success and species choice. This is a conservative approach and is consistent with the rules applied, which differentiate between deforestation and clear fell with re-establishment (NIR section 11.4.2)

Annex J

Standard Electronic Format (SEF) 2009

UNFCCC SEF application

Version 1.2

Workflow

Settings

Party:	Ireland
ISO:	IE
Submission year:	2010
Reported year:	2009
Commitment period:	1
Completeness check:	YES
Consistency check:	YES
File locked:	YES
Lock timestamp:	01/03/2010 15:05
Submission version number:	1
Submission type:	Official

Functions

Export XML

Export XML (Imported)

Party	Ireland
Submission year	2010
Reported year	2009
Commitment period	1

Table 1. Total quantities of Kyoto Protocol units by account type at beginning of reported year

Account type	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Party holding accounts	294214188	NO	NO	NO	NO	NO
Entity holding accounts	20753605	NO	NO	3670980	NO	NO
Article 3.3/3.4 net source cancellation accounts	NO	NO	NO	NO		
Non-compliance cancellation accounts	NO	NO	NO	NO		
Other cancellation accounts	NO	NO	NO	NO	NO	NO
Retirement account	NO	NO	NO	NO	NO	NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
lCER replacement account for expiry	NO	NO	NO	NO		
lCER replacement account for reversal of storage	NO	NO	NO	NO		NO
lCER replacement account for non-submission of certification repor	NO	NO	NO	NO		NO
Total	314967793	NO	NO	3670980	NO	NO

Party	Ireland
Submission year	2010
Reported year	2009
Commitment period	1

Table 2 (a). Annual internal transactions

Transaction type	Additions						Subtractions					
	Unit type						Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Article 6 issuance and conversion												
Party-verified projects		NO					NO		NO			
Independently verifed projects		NO					NO		NO			
Article 3.3 and 3.4 issuance or cancellation												
3.3 Afforestation and reforestation			NO				NO	NO	NO	NO		
3.3 Deforestation			NO				NO	NO	NO	NO		
3.4 Forest management			NO				NO	NO	NO	NO		
3.4 Cropland management			NO				NO	NO	NO	NO		
3.4 Grazing land management			NO				NO	NO	NO	NO		
3.4 Revegetation			NO				NO	NO	NO	NO		
Article 12 afforestation and reforestation												
Replacement of expired tCERs							NO	NO	NO	NO	NO	
Replacement of expired lCERs							NO	NO	NO	NO		
Replacement for reversal of storage							NO	NO	NO	NO		NO
Replacement for non-submission of certification report							NO	NO	NO	NO		NO
Other cancellation							245	NO	NO	NO	NO	NO
Sub-total		NO	NO				245	NO	NO	NO	NO	NO

Transaction type	Retirement					
	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Retirement	19668515	NO	NO	713192	NO	NO

Party	Ireland
Submission year	2010
Reported year	2009
Commitment period	1

Table 2 (b). Annual external transactions

	Additions						Subtractions					
	Unit type						Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Transfers and acquisitions												
AT	26500	NO	NO	NO	NO	NO	NO	NO	NO	260760	NO	NO
CZ	3500	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
DK	84000	NO	NO	1627172	NO	NO	309000	NO	NO	NO	NO	NO
FR	396842	NO	NO	200000	NO	NO	567435	NO	NO	NO	NO	NO
DE	86000	NO	NO	NO	NO	NO	1500	NO	NO	45000	NO	NO
IT	932	NO	NO	NO	NO	NO	8000	NO	NO	NO	NO	NO
JP	NO	NO	NO	121600	NO	NO	NO	NO	NO	3754655	NO	NO
NL	110600	NO	NO	534306	NO	NO	NO	NO	NO	NO	NO	NO
PT	50000	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
SK	72736	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
ES	227400	NO	NO	NO	NO	NO	360954	NO	NO	500000	NO	NO
SE	76000	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CH	NO	NO	NO	1644381	NO	NO	NO	NO	NO	125300	NO	NO
GB	2103192	NO	NO	5157595	NO	NO	2022744	NO	NO	1076505	NO	NO
Sub-total	3237702	NO	NO	9285054	NO	NO	3269633	NO	NO	5762220	NO	NO

Additional information

Independently verified ERUs								NO				

Table 2 (c). Total annual transactions

Total (Sum of tables 2a and 2b)	3237702	NO	NO	9285054	NO	NO	3269878	NO	NO	5762220	NO	NO

Party	Ireland
Submission year	2010
Reported year	2009
Commitment period	1

Table 3. Expiry, cancellation and replacement

Transaction or event type	Expiry, cancellation and requirement to replace		Replacement					
	Unit type		Unit type					
	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Temporary CERs (tCERS)								
Expired in retirement and replacement accounts	NO							
Replacement of expired tCERs			NO	NO	NO	NO	NO	
Expired in holding accounts	NO							
Cancellation of tCERs expired in holding accounts	NO							
Long-term CERs (lCERs)								
Expired in retirement and replacement accounts		NO						
Replacement of expired lCERs			NO	NO	NO	NO		
Expired in holding accounts		NO						
Cancellation of lCERs expired in holding accounts		NO						
Subject to replacement for reversal of storage		NO						
Replacement for reversal of storage			NO	NO	NO	NO		NO
Subject to replacement for non-submission of certification report		NO						
Replacement for non-submission of certification report			NO	NO	NO	NO		NO
Total			NO	NO	NO	NO	NO	NO

Party	Ireland
Submission year	2010
Reported year	2009
Commitment period	1

Table 4. Total quantities of Kyoto Protocol units by account type at end of reported year

Account type	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Party holding accounts	274071230	NO	NO	NO	NO	NO
Entity holding accounts	21195872	NO	NO	6480622	NO	NO
Article 3.3/3.4 net source cancellation accounts	NO	NO	NO	NO		
Non-compliance cancellation accounts	NO	NO	NO	NO		
Other cancellation accounts	245	NO	NO	NO	NO	NO
Retirement account	19668515	NO	NO	713192	NO	NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
lCER replacement account for expiry	NO	NO	NO	NO		
lCER replacement account for reversal of storage	NO	NO	NO	NO		NO
lCER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
Total	314935862	NO	NO	7193814	NO	NO

Party	Ireland
Submission year	2010
Reported year	2009
Commitment period	1

Table 5 (a). Summary information on additions and subtractions

	Additions						Subtractions					
	Unit type						Unit type					
Starting values	**AAUs**	**ERUs**	**RMUs**	**CERs**	**tCERs**	**lCERs**	**AAUs**	**ERUs**	**RMUs**	**CERs**	**tCERs**	**lCERs**
Issuance pursuant to Article 3.7 and 3.8	314184272											
Non-compliance cancellation							NO	NO	NO	NO		
Carry-over	NO	NO		NO								
Sub-total	314184272	NO		NO			NO	NO	NO	NO		
Annual transactions												
Year 0 (2007)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 1 (2008)	2029090	NO	NO	3778980	NO	NO	1245569	NO	NO	108000	NO	NO
Year 2 (2009)	3237702	NO	NO	9285054	NO	NO	3269878	NO	NO	5762220	NO	NO
Year 3 (2010)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 4 (2011)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 5 (2012)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 6 (2013)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 7 (2014)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 8 (2015)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sub-total	5266792	NO	NO	13064034	NO	NO	4515447	NO	NO	5870220	NO	NO
Total	319451064	NO	NO	13064034	NO	NO	4515447	NO	NO	5870220	NO	NO

Table 5 (b). Summary information on replacement

	Requirement for replacement		Replacement					
	Unit type		Unit type					
	tCERs	**lCERs**	**AAUs**	**ERUs**	**RMUs**	**CERs**	**tCERs**	**lCERs**
Previous CPs			NO	NO	NO	NO	NO	NO
Year 1 (2008)		NO	NO	NO	NO	NO	NO	NO
Year 2 (2009)		NO	NO	NO	NO	NO	NO	NO
Year 3 (2010)		NO	NO	NO	NO	NO	NO	NO
Year 4 (2011)		NO	NO	NO	NO	NO	NO	NO
Year 5 (2012)	NO	NO	NO	NO	NO	NO	NO	NO
Year 6 (2013)	NO	NO	NO	NO	NO	NO	NO	NO
Year 7 (2014)	NO	NO	NO	NO	NO	NO	NO	NO
Year 8 (2015)	NO	NO	NO	NO	NO	NO	NO	NO
Total	NO	NO	NO	NO	NO	NO	NO	NO

Table 5 (c). Summary information on retirement

	Retirement					
	Unit type					
Year	**AAUs**	**ERUs**	**RMUs**	**CERs**	**tCERs**	**lCERs**
Year 1 (2008)	NO	NO	NO	NO	NO	NO
Year 2 (2009)	19668515	NO	NO	713192	NO	NO
Year 3 (2010)	NO	NO	NO	NO	NO	NO
Year 4 (2011)	NO	NO	NO	NO	NO	NO
Year 5 (2012)	NO	NO	NO	NO	NO	NO
Year 6 (2013)	NO	NO	NO	NO	NO	NO
Year 7 (2014)	NO	NO	NO	NO	NO	NO
Year 8 (2015)	NO	NO	NO	NO	NO	NO
Total	19668515	NO	NO	713192	NO	NO

Party	Ireland
Submission year	2010
Reported year	2009
Commitment period	1

Table 6 (a). Memo item: Corrective transactions relating to additions and subtractions

	Additions						Subtractions					
	Unit type						Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs

Table 6 (b). Memo item: Corrective transactions relating to replacement

	Requirement for replacement		Replacement					
	Unit type		Unit type					
	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs

Table 6 (c). Memo item: Corrective transactions relating to retirement

	Retirement					
	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs