

**GREENHOUSE GAS EMISSIONS IN ESTONIA
1990–2007**

NATIONAL INVENTORY REPORT
to the UNFCCC secretariat

Common Reporting Formats (CRF)
1990-2007

Tallinn 2009

PREFACE

Estonian National Inventory Report under the UNFCCC (United Framework Convention on Climate Change) contains the following parts:

Part I. Description of the greenhouse gas emission inventory according to the UNFCCC reporting guidelines (FCCC/SBSTA/2004/8) containing description of the organisation of the national greenhouse gas inventory, IPCC and other methods applied in calculation of the year 2007 emissions and exemptions to the previous inventories. A summarising table of the emissions data for the years 1990-2007 is included as well as description of the current emission trends.

Part II. Kyoto Protocol reporting.

Part III. CRF (Common Reporting Format) data tables of Estonian updated greenhouse gas emission inventories for the years 1990-2007. The CFR tables are compiled with the UNFCCC CRF Reporter software (version 3.2.3).

Department of Thermal Engineering (Inge Roos), Department of Chemistry at Tallinn University of Technology (Olga Gavrilova) and Estonian Environmental Research Centre have made the inventory calculations, the description of the methodologies and other information included in the National Inventory report. Climate and Ozone Bureau of Estonian Environment Information Centre (EEIC) co-ordinates the process of the inventory preparation.

The Ministry of the Environment is responsible for the finalisation of inventory reports and their submission to the UNFCCC Secretariat and the EC Commission.

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TABLE OF CONTENTS

PREFACE.....	2
PART I: CONVENTION GHG INVENTORY	12
EXECUTIVE SUMMARY	12
ES.1. Background information on greenhouse gas inventories.....	12
ES.2. Summary of trends in national emissions and removals	13
ES.3. Overview of source and sink category emission estimates and trends	17
CHAPTER 1. INTRODUCTION.....	19
1.1. Background and institutional arrangement.....	19
1.2. Brief description of the process of inventory preparation.....	20
1.2.1 Estonian Greenhouse Gas National Inventory System (NIS).....	20
1.3. Database information and methodologies.....	24
1.4. Brief description of key source categories.....	26
1.5. Information about the QA/QC plan including verification and treatment of confidentiality issues	34
1.5.1. Quality Assurance and Quality Control (QA/QC).....	34
1.5.2. QA procedures implemented.....	35
1.5.3. QC procedures implemented	35
1.5.4. Future development of QA/QC systems and planned improvements.....	39
1.5.5. Archiving.....	40
1.6. Summary of the uncertainty analysis	41
1.7. General assessment of the completeness	42
1.8. Information of implementation of flexible mechanisms of Kyoto Protocol	42
CHAPTER 2. ENERGY (CRF 1).....	43
2.1. Overview of sector (CRF 1).....	43
2.2. Emissions from fuel combustion (CRF 1.A)	48
2.2.1. Energy Industries and Manufacturing Industries and Construction (CRF1.A.1, CRF1.A.2)	51
2.2.1.1. Source category description	51
2.2.1.2. Methodological issues.....	55
2.2.1.3. Uncertainties and time series consistency	68
2.2.1.4. Source-specific QA/QC and verification	70
2.2.1.5. Source-specific recalculations.....	70
2.2.1.6. Source-specific planned improvements	71
2.2.2. Transport (CRF 1.A.3)	72
2.2.2.1. Source category description	72
2.2.2.2. Methodological issues.....	76
2.2.2.3. Source-specific recalculations.....	83
2.2.2.4. Source-specific planned improvements	84
2.2.3. Other Sectors (CRF 1.A.4)	85
2.2.3.1. Source category description	85
2.2.3.2. Methodological issues.....	85
2.2.3.3. Source-specific recalculations.....	88
2.3. Fugitive Emissions from Fuels (CRF 1.B).....	88
2.3.1. Overview of the sector.....	88
2.3.2. Oil and Natural Gas (CRF 1.B.2)	89
2.3.2.1. Source category description	89
2.3.2.2. Methodological issues.....	89
2.3.2.3. Quantitative overview	90
2.3.2.4. Uncertainty and time series' consistency	91
2.3.2.5. Source-specific recalculations.....	91

3.3.2.6. Source-specific planned improvements	91
2.4. Reference Approach	92
2.5. International Bunkers	92
 CHAPTER 3. INDUSTRIAL PROCESSES (CRF 2).....	 94
3.1. Overview of sector.....	94
3.1.1. Description	94
3.1.2. Quantitative overview	94
3.2. Mineral Products (CRF 2.A).....	97
3.2.1. Source category description	97
3.2.2. Cement Production	97
3.2.2.1. Source category description	97
3.2.2.2. Methodological issues.....	98
3.2.2.3. Uncertainties and time-series consistency.....	98
3.2.2.4. Source-specific QA/QC and verification	99
3.2.2.5. Source-specific recalculations including changes made in response to the review process	99
3.2.2.6. Source-specific planned improvements	99
3.2.3. Lime Production	100
3.2.3.1. Source category description	100
3.2.3.2. Methodological issues.....	100
3.2.3.3. Uncertainties and time-series consistency.....	101
3.2.3.4. Source-specific QA/QC and verification	101
3.2.3.5. Source-specific recalculations including changes made in response to the review process	102
3.2.3.6. Source-specific planned improvements	102
3.3. Chemical Industry (CRF 2.B).....	102
3.3.1. Source category description	102
3.3.2. Methodological issues	103
3.3.4. Uncertainties and time-series consistency	105
3.3.5. Source-specific QA/QC and verification.....	105
3.3.6. Source-specific recalculations including changes made in response to the review process	105
3.3.7. Source-specific planned improvements.....	106
3.4. Other Consumption (CRF 2.D).....	106
3.4.1. Source category description	106
3.4.2. Methodological issues	106
3.4.3. Source-specific recalculations including changes made in response to the review process	106
3.4.4. Source-specific planned improvements.....	106
3.5. Consumption of Halocarbons and SF6 (CRF 2.F)	107
3.5.1. Source category description	107
3.5.2. Refrigeration and Air Conditioning Equipment	110
3.5.2.1. Domestic Refrigeration.....	110
3.5.2.1.1. Source-category description.....	110
3.5.2.1.2. Methodological issues.....	111
3.5.2.1.3. Uncertainties and time-series consistency.....	112
3.5.2.1.4. Source-specific quality assurance/quality control and verification.....	112
3.5.2.1.5. Source-specific recalculations.....	112
3.5.2.1.6. Planned improvements (source-specific)	112
3.5.2.2. Commercial Refrigeration.....	112
3.5.2.2.1. Source-category description.....	113
3.5.2.2.2. Methodological issues.....	114
3.5.2.2.3. Uncertainties and time-series consistency.....	116
3.5.2.2.4. Source-specific quality assurance/quality control and verification.....	116
3.5.2.2.5. Source-specific recalculations.....	117
3.5.2.2.6. Planned improvements (source-specific)	117
3.5.2.3. Transport Refrigeration.....	117
3.5.2.3.1. Refrigerated Vehicles.....	117
3.5.2.3.2. Reefer Containers.....	120
3.5.2.4. Industrial Refrigeration.....	122
3.5.2.4.1. Source-category description	122

3.5.2.4.2. Methodological issues	123
3.5.2.4.3. Uncertainties and time-series consistency	125
3.5.2.4.4. Source-specific quality assurance/quality control and verification	125
3.5.2.4.5. Source-specific recalculations	125
3.5.2.4.6. Planned improvements (source-specific)	125
3.5.2.5. Stationary Air Conditioning	126
3.5.2.5.1. Heat Pumps	126
3.5.2.5.2. Stationary and Room Air-Conditioning	128
3.5.2.6. Mobile Air Conditioning	130
3.5.2.6.1. Passenger Cars	130
3.5.2.6.2. Trucks	133
3.5.2.6.3. Buses	135
3.5.2.6.4. Ships	138
3.5.2.6.5. Railcars	139
3.5.2.6.6. Wheel Tractors and Mobile Machinery	142
3.5.3. Foam Blowing	144
3.5.3.1. PU Insulation Panels	144
3.5.3.1.1. Source category description	144
3.5.3.1.2. Methodological issues	145
3.5.3.1.3. Uncertainties and time-series consistency	145
3.5.3.1.4. Source-specific quality assurance/quality control and verification	146
3.5.3.1.5. Source-specific recalculations	146
3.5.3.1.6. Planned improvements (source-specific)	146
3.5.3.2. Spray and Injection PU Foam	146
3.5.3.2.1. Source category description	146
3.5.3.2.2. Methodological issues	146
3.5.3.2.3. Uncertainties and time-series consistency	148
3.5.3.2.4. Source-specific quality assurance/quality control and verification	148
3.5.3.2.5. Source-specific recalculations	148
3.5.3.2.6. Planned improvements (source-specific)	148
3.5.3.3. PU Integral Skin Foam	148
3.5.3.3.1. Source category description	148
3.5.3.3.2. Methodological issues	149
3.5.3.3.3. Uncertainties and time-series consistency	149
3.5.3.3.4. Source-specific quality assurance/quality control and verification	149
3.5.3.3.5. Source-specific recalculations	150
3.5.3.3.6. Planned improvements (source-specific)	150
3.5.3.4. XPS Insulation Foam	150
3.5.3.4.1. Source category description	150
3.5.3.4.2. Methodological issues	150
3.5.3.4.3. Uncertainties and time-series consistency	151
3.5.3.4.4. Source-specific quality assurance/quality control and verification	151
3.5.3.4.5. Source-specific recalculations	151
3.5.3.4.6. Planned improvements (source-specific)	152
3.5.3.5. One Component PU Foam	152
3.5.3.5.1. Source category description	152
3.5.3.5.2. Methodological issues	152
3.5.3.5.3. Uncertainties and time-series consistency	153
3.5.3.5.4. Source-specific quality assurance/quality control and verification	154
3.5.3.5.5. Source-specific recalculations	154
3.5.3.5.6. Planned improvements (source-specific)	154
3.5.4. Fire Extinguishers	154
3.5.4.1. Source-category description	154
3.5.4.2. Methodological issues	155
3.5.4.3. Uncertainties and time-series consistency	156
3.5.4.4. Source-specific quality assurance/quality control and verification	156
3.5.4.5. Source-specific recalculations	156
3.5.4.6. Planned improvements (source-specific)	156
3.5.5. Aerosols	156
3.5.5.1. Metered Dose Inhalers	157

3.5.5.1.1. Source-category description	157
3.5.5.1.2. Methodological issues	157
3.5.5.1.3. Uncertainties and time-series consistency	158
3.5.5.1.4. Source-specific quality assurance/quality control and verification	158
3.5.5.1.5. Source-specific recalculations	158
3.5.5.1.6. Planned improvements (source-specific)	159
3.5.5.2. General and Novelty Aerosols	159
3.5.5.2.1. Source-category description	159
3.5.5.2.2. Methodological issues	159
3.5.5.2.3. Uncertainties and time-series consistency	160
3.5.5.2.4. Source-specific quality assurance/quality control and verification	160
3.5.5.2.5. Source-specific recalculations	160
3.5.5.2.6. Planned improvements (source-specific)	160
3.5.6. Electrical Equipment	161
3.5.6.1. Source-category description	161
3.5.6.2. Methodological issues	161
3.5.6.3. Uncertainties and time-series consistency	162
3.5.6.4. Source-specific quality assurance/quality control and verification	162
3.5.6.5. Source-specific recalculations	162
3.5.6.6. Planned improvements (source-specific)	162
3.5.7. Other	163
3.5.7.1. Other Electrical Equipment	163
3.5.7.1.1. Source-category description	163
3.5.7.1.2. Methodological issues	163
3.5.7.1.3. Uncertainties and time-series consistency	164
3.5.7.1.4. Source-specific quality assurance/quality control and verification	164
3.5.7.1.5. Source-specific recalculations	164
3.5.7.1.6. Planned improvements (source-specific)	164
3.5.7.2. Sport Shoe Soles	164
3.5.7.2.1. Source-category description	164
3.5.7.2.2. Methodological issues	165
3.5.7.2.3. Uncertainties and time-series consistency	165
3.5.7.2.4. Source-specific quality assurance/quality control and verification	165
3.5.7.2.5. Source-specific recalculations	165
3.5.7.2.6. Planned improvements (source-specific)	166
CHAPTER 4. AGRICULTURE (CRF 4)	167
4.1. Overview of source category description and methodology	167
4.1.1. References – sources of information	169
4.1.2. Quantitative overview	169
4.1.3. Key categories	171
4.1.4. Uncertainty assessment	172
4.2. Enteric fermentation and manure management	172
4.2.1. Source category description	172
4.2.2. Livestock activity data	172
4.2.3. CH ₄ emissions from Enteric Fermentation	176
4.2.3.1. Source category description	176
4.2.3.2. Cattle	177
4.2.3.2.1. Methodology, data availability, data sources and emission factors	177
4.2.3.2.2. Quantitative overview – CH ₄ emission from enteric fermentation of cattle in 2007	184
4.2.3.3. Pigs	186
4.2.3.3.1. Methodology, data availability, data sources and emission factors	186
4.2.3.3.2. Quantitative overview – CH ₄ emission from enteric fermentation of pigs in 2007	187
4.2.3.4. Other livestock	188
4.2.3.4.1. Methodology, data availability, data sources and emission factors	188
4.2.3.4.2. Quantitative overview – CH ₄ emission from enteric fermentation of other livestock in 2007	189
4.2.3.5. Uncertainties and time-series consistency	190
4.2.3.6. Source-specific recalculations	191
4.2.3.7. Source-specific planned improvements	192

4.2.4. CH ₄ emissions from Manure Management.....	192
4.2.4.1. Source category description	192
4.2.4.2. Cattle	193
4.2.4.2.1. Methodology, data availability, data sources and emission factors	193
4.2.4.2.2. Quantitative overview – CH ₄ emission from cattle manure management in 2007	196
4.2.4.3. Pigs.....	197
4.2.4.3.1. Methodology, data availability, data sources and emission factors	197
4.2.4.3.2. Quantitative overview – CH ₄ emission from pig manure management in 2007	198
4.2.4.4. Other livestock	199
4.2.4.4.1. Methodology, data availability, data sources and emission factors	199
4.2.4.4.2. Quantitative overview – CH ₄ emission from other livestock manure management in 2007	200
4.2.4.5. Source-specific recalculations.....	200
4.2.5. N ₂ O emissions from Manure Management	203
4.2.5.1. Source category description	203
4.2.5.2. Cattle	205
4.2.5.2.1. Methodology, data availability, data sources and emission factors	205
4.2.5.2.2. Quantitative overview – N ₂ O emission from cattle manure management in 2007	208
4.2.5.3. Pigs.....	208
4.2.5.3.1. Methodology, data availability, data sources and emission factors	208
4.2.5.3.2. Quantitative overview – N ₂ O emission from swine manure management in 2007	210
4.2.5.4. Other livestock	211
4.2.5.4.1. Methodology, data availability, data sources and emission factors	211
4.2.5.4.2. Quantitative overview – N ₂ O emission from other livestock manure management in 2007	212
4.2.5.5. Quantitative overview - Manure management systems.....	212
4.2.5.6. Uncertainties and time-series consistency.....	213
4.2.5.7. Source-specific recalculations.....	215
4.2.5.8. Source-specific planned improvements	218
4.2.6. N ₂ O emission from Pasture, Range and Paddock (CRF 4.D.2).....	218
4.2.6.1. Methodology, data availability, data sources and emission factors	218
4.2.6.2. Quantitative overview – N ₂ O emission from pasture, range and paddock in 2007	218
4.3. Direct emissions from agricultural soils.....	219
4.3.1. Source category description	219
4.3.2. Activity data employed.....	220
4.3.3. N ₂ O emission from Synthetic Fertilizer nitrogen applied to soils (CRF 4.D.1.1)	220
4.3.3.1. Methodology, data availability, data sources and emission factors	220
4.3.3.2. Quantitative overview – N ₂ O emission from synthetic fertilizers applied to soils in 2007	221
4.3.4. N ₂ O emission from Animal Manure applied to soils and excreted on pasture (CRF 4.D.1.2)	222
4.3.4.1. Methodology, data availability, data sources and emission factors	222
4.3.4.2. Quantitative overview – N ₂ O emission from Animal Manure applied to soils and excreted on pasture in 2007	223
4.3.4.3. Source-specific recalculations.....	224
4.3.5. Nitrogen input in N-fixing crops (CRF 4.D.1.3)	225
4.3.5.1. Methodology, data availability, data sources and emission factors	225
4.3.5.2. Quantitative overview – N ₂ O emission from growing of N-fixing crops in 2007	226
4.3.5.3. Source-specific recalculations.....	227
4.3.6. N ₂ O emission from nitrogen input from crop-residue (CRF 4.D.1.4)	228
4.3.6.1. Methodology, data availability, data sources and emission factors	228
4.3.6.2. Quantitative overview – N ₂ O emission from crop-residues in 2007.....	229
4.3.6.3. Source-specific recalculations.....	230
4.3.7. N ₂ O emission from Organic Soils Cultivation (CRF 4.D.1.5)	231
4.3.7.1. Methodology, data availability, data sources and emission factors	231
4.3.7.2. Quantitative overview – N ₂ O emission from organic soils cultivated in 2007	232
4.3.7.5. Uncertainties and time-series consistency.....	232
4.3.7.5.1. Synthetic Fertilizers used (CRF 4.D.1.1).....	232
4.3.7.5.2. Animal Manure Applied to Soils (CRF 4.D.1.2).....	233
4.3.7.5.3. N-fixing Crops and Crop Residues (CRF 4.D.1.3 and CRF 4.D.1.4).....	233
4.4. Indirect emissions from agricultural soils.....	234

4.4.1. Source category description	235
4.4.2. Atmospheric deposition of NO _x and NH ₄ (CRF 4.D.3.1)	235
4.4.2.1. Methodology, data availability, data sources and emission factors	236
4.4.2.2. Quantitative overview – Atmospheric deposition of NO _x and NH ₄ in 2007	237
4.4.2.3. Source-specific recalculations	237
4.4.3. Leaching/Run-off of applied or deposited nitrogen (CRF 4.D.3.2)	238
4.4.3.1. Methodology, data availability, data sources and emission factors	238
4.4.3.2. Quantitative overview – Leaching/Run-off of applied or deposited nitrogen in 2007	239
4.4.3.3. Source-specific recalculations	239
4.4.3.4. Uncertainties and time-series consistency	240
4.4.3.4.1. Atmospheric Deposition (CRF 4.D.3.1)	240
4.4.3.4.2. Nitrogen Leaching and Run-off (CRF 4.D.3.2)	241
4.4.4. Field Burning of Agricultural Residues (CRF 4.F)	242
4.4.4.1. Methodology, data availability, data sources and emission factors	243
4.4.4.2. Quantitative overview – Emissions from Field Burning of Agricultural Residues in 2007	244
4.4.4.3. Uncertainties and time-series consistency	245
CHAPTER 5. LAND USE, LAND USE CHANGE AND FORESTRY (CRF 5)	246
5.1. Overview of source category	246
5.1.1. References – sources of information	247
5.2. Definitions of land use categories	248
5.3. Quantitative overview	251
5.4. Key category assessment	254
5.5. Forest Land (CRF 5.A)	255
5.5.1. Source category description	255
5.5.2. Methodological issues	256
5.5.3. Quantitative overview – Carbon emissions/removals from forest land	259
5.5.4. Source-specific recalculations	264
5.5.5. Uncertainties and time-series consistency	266
5.5.6. Source-specific planned improvements	267
5.6. Cropland (CRF 5.B)	267
5.6.1. Source category description	267
5.6.2. Methodological issues	268
5.6.3. Uncertainty and time series' consistency	273
5.6.4. Source-specific planned improvements	274
5.7. Grassland (CRF 5.C)	274
5.7.1. Source category description	274
5.7.2. Methodological issues	275
5.7.3. Uncertainty and time series' consistency	277
5.7.4. Source-specific planned improvements	278
5.8. Other Land (CRF 5.D)	278
5.8.1. Uncertainty and time series' consistency	279
5.8.2. Source-specific planned improvements	279
5.9. Wetland (CRF 5.D)	280
5.9.1. Source category description	280
5.9.2. Methodological issues	280
5.9.3. Uncertainty and time series' consistency	282
5.9.4. Source-specific planned improvements	282
5.10. Settlements (CRF 5.E)	283
5.10.1. Source category description	283
5.11. Emissions of Greenhouse Gases from Biomass Burning	283
5.11.1. Biomass burning (CRF 5 (V))	284
5.11.2. Methodology, data availability and sources, emission factors	284
5.11.3. Uncertainties and time-series consistency	285
CHAPTER 6. WASTE (CRF 6)	286
6.1. Overview of source category description and methodology	286
6.1.1. References – sources of information	286

6.1.2. Quantitative overview of the waste sector	287
6.1.3. Key categories	289
6.1.4. Uncertainty assessment	289
6.2. Solid waste disposal on landfills (CRF 6.A)	289
6.2.1. Activity data	289
6.2.2. Methodology, data availability and sources, emission factors	297
6.2.3. Quantitative overview – CH ₄ emission from solid waste disposal (CRF 6.A)	300
6.2.4. Source-specific recalculations	301
6.2.5. Uncertainties and time-series consistency	301
6.3. Waste incineration (CRF 6.C).....	302
6.3.1. Activity data	302
6.3.2. Methodology, data availability and sources, emission factors	304
6.3.3. Quantitative overview – CO ₂ and N ₂ O emissions from solid waste incineration	307
6.3.4. Uncertainties and time-series consistency	307
6.4. Biological Treatment (Composting) of Waste (CRF 6.D).....	308
6.4.1. Activity data	308
6.4.2. Methodology, data availability and sources, emission factors	309
6.4.3. Quantitative overview – CH ₄ and N ₂ O emissions from biological treatment of waste	310
6.4.4. Uncertainties and time-series consistency	311
6.5. Sludge Application on Agricultural Land.....	311
6.5.1. Activity data	311
6.5.2. Methodology, data availability and sources, emission factors	312
6.5.3. Quantitative overview – N ₂ O emission from sludge applied on agricultural land (CRF 4.D.1.6)	313
6.6. N₂O emission from human consumption followed by municipal sewage treatment (CRF 6.B.2.2).....	314
6.6.1. Source category description	314
6.6.2. Methodology, data availability and sources, emission factors	314
6.6.3. Quantitative overview – Human consumption followed by municipal sewage treatment.....	315
6.6.4. Source-specific recalculations	315
6.6.5. Uncertainty and time-series consistency	316
PART II: KYOTO PROTOCOL REPORTING.....	318
1. Information on activities under Articles 3.3 and 3.4	318
2. Information on Kyoto Protocol units and discrepancies	320
3. Changes in National System	320
4. Changes in National Registry.....	321
5. Estonia's commitment period reserve	321
REFERENCES	322
ANNEX 1. DESCRIPTION OF THE INDIVIDUAL SOURCE CATEGORY CHECKLISTS OF THE SECTORS ENERGY, INDUSTRIAL PROCESSES, AGRICULTURE, LULUCF AND WASTE	
ANNEX 2. ASSESSMENT OF COMPLETENESS AND SOURCE AND SINKS OF GREENHOUSE GAS EMISSIONS AND REMOVALS EXCLUDED	
ANNEX 3. ADDITIONAL INFORMATION FOR THE ENERGY SECTOR	
ANNEX 4. ADDITIONAL INFORMATION FOR THE INDUSTRIAL PROCESSES SECTOR	
ANNEX 5. ADDITIONAL INFORMATION FOR THE AGRICULTURE SECTOR	

ANNEX 6. ADDITIONAL INFORMATION FOR THE LULUCF SECTOR

ANNEX 7. UNCERTAINTY ANALYSIS

ANNEX 8. QUALITY ASSURANCE CHECKLISTS OF THE SECTORS ENERGY,
INDUSTRIAL PROCESSES, AGRICULTURE, LULUCF AND WASTE

ANNEX 9. LIST OF ANNUAL INDICATORS

ANNEX 10. STANDARD INDEPENDENT ASSESSMENT REPORT

ANNEX 11. STANDARD ELECTRONIC FORMAT “SEF_EE_2009_3_14-10-15 25-3-
2009”

ANNEX 12. SIAR REPORTS 2009_EE v.1.0

PART I: Convention GHG inventory

EXECUTIVE SUMMARY

ES.1. Background information on greenhouse gas inventories

Estonia signed the Framework Convention on Climate Change at the United Nations Conference on Environment and Development held in Rio de Janeiro in June 1992. In 1994 Estonia ratified the UN FCCC and in 2002, the Kyoto Protocol. Under the Protocol Estonia is obliged to reduce during the period 2008-2012 the emissions of air polluting greenhouse gases from its territory by 8% as compared with the 1990 level. A National Programme for the Reduction of Greenhouse Gas Emissions was compiled taking into consideration the Kyoto Protocol and the European Council Decision 93/389/EC from 24 June 1993 on the monitoring of greenhouse gas emissions in the EU (EÜT L 167, 09/07/1993 p 0031-0033). On 30 April 2004 the Estonian Government approved the National Programme for the Reduction of Greenhouse Gas Emissions for the years 2003-2012.

Estonia has prepared greenhouse gas inventories since the year 1994. Inventory reports are submitted to the UNFCCC Secretariat and the European Commission annually.

Single national entity with overall responsibility for the Estonian greenhouse gas inventory is the Estonian Ministry of the Environment. Financial resources are planned in the State Budget. Practical work is done on the basis of contracts. The Institute of Ecology at Tallinn University was responsible for the inventories under contract to the Ministry of the Environment in Estonia until summer 2006. The 2007 GHG inventory was prepared by 2 departments of Tallinn University of Technology (Department of Thermal Engineering and Department of Chemistry) and Climate and Ozone Bureau of Estonian Environment Information Centre co-ordinated the process. The 2008 and 2009 inventory is produced in collaboration between the Ministry of the Environment, Estonian Environment Information Centre, Tallinn University of Technology and Estonian Environmental Research Centre.

This report presents the national inventory of greenhouse gas (GHG) emissions and removals from 1990 to 2007. The components covered are carbon dioxide (CO₂), methane (CH₄),

nitrous oxide (N₂O) and F-gases - hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF₆). Estimates of the emission data for nitrogen oxides (NO_x), carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs) and sulphur dioxide (SO₂) were also included in inventory data.

The main sources of data were the Statistical Yearbooks and other publications issued by the Statistical Office of Estonia. Unfortunately the availability and reliability of data from different sectors differs, especially for the first years of independence regained in 1991. During the last 10 years Estonia has made great efforts in all directions, including in order increasing the reliability of statistical data.

The report and associated Common Reporting Format (CRF) tables were prepared in accordance with the UNFCCC reporting Guidelines on Annual Inventories. The CRF Tables are produced with the CRF Reporter software (version 3.2.3). The methodology used in calculations of emissions is harmonised with the Guidelines for National Greenhouse Gas Inventories and those of Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories published by the Intergovernmental Panel of Climate Change (IPCC). The methodology is described in detail in the *Estonia's Third National Communication* (2001) and *Estonia's Fourth National Communication* (2006).

The national inventory and reporting system is being constantly developed and improved.

ES.2. Summary of trends in national emissions and removals

By 2005, Estonia reduced its emissions by 53% in comparison to the base year. This drastic decrease was mainly caused by the transition from planned economy to market economy and successful implementation of necessary reforms.

In 2007 the total emission of GHGs, measured as CO₂-equivalents, was 14 115.63 Gg, and without CO₂ from LULUCF 22 018.68 Gg. From 1990 to 2007 the emissions decreased by 47.49 %. Table ES2_1 shows the trends in the total emissions during the period 1990–2007.

In 2007, the most important GHG in Estonia was carbon dioxide (CO₂), contributing 86.71 per cent to total national GHG emissions expressed in CO₂ equivalent, followed by methane (CH₄), 7.83 per cent, and nitrous oxide (N₂O), 4.79 per cent. Fluorocarbons (so-called "F gases") account for about 0.66 per cent of total emissions. The Energy sector accounted for 86.69 per cent of total GHG emissions, followed by Agriculture (6.05 per cent), Industrial Processes (4.09 per cent) and Waste (3.17 per cent).

Table ES.1. Greenhouse-gas emissions in Estonia – changes with regard to the base year

GHG EMISSIONS	Base year	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007
	CO ₂ equivalent (Gg)										
CO ₂ emissions including net CO ₂ from LULUCF	30 909.56	30 909.56	11 049.72	14 092.21	11 657.71	11 581.71	11 587.98	8 676.96	9 285.94	7 395.02	11 187.81
CO ₂ emissions excluding net CO ₂ from LULUCF	37 283.48	37 283.48	18 165.83	15 555.63	15 858.33	15 432.51	17 167.74	17 442.56	16 847.86	16 341.13	19 093.24
CH ₄ emissions including CH ₄ from LULUCF	2 731.11	2 731.11	1 677.41	1 716.89	1 768.51	1 637.40	1 674.59	1 754.60	1 721.76	1 733.10	1 725.59
CH ₄ emissions excluding CH ₄ from LULUCF	2 726.35	2 726.35	1 675.95	1 713.77	1 767.46	1 631.33	1 673.71	1 752.99	1 721.35	1 723.09	1 724.31
N ₂ O emissions including N ₂ O from LULUCF	1 926.67	1 926.67	993.80	1 037.45	885.60	923.82	932.85	1 039.25	949.32	976.73	1 056.47
N ₂ O emissions excluding N ₂ O from LULUCF	1 925.60	1 925.60	992.92	1 036.16	884.52	922.23	931.79	1 038.11	948.31	974.74	1 055.36
HFCs	NA,NO	NA,NO	25.70	70.79	86.21	87.24	93.04	105.71	118.70	139.53	144.73
PFCs	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.07	0.06
SF ₆	NA,NO	NA,NO	3.22	2.73	1.74	1.43	1.31	1.08	1.08	1.15	0.97
Total (including LULUCF)	35 567.34	35 567.34	13 749.85	16 920.08	14 399.77	14 231.60	14 289.78	11 577.60	12 076.80	10 245.60	14 115.63
Total (excluding LULUCF)	41 935.43	41 935.43	20 863.62	18 379.09	18 598.26	18 074.74	19 867.59	20 340.45	19 637.29	19 179.71	22 018.68

GHG SOURCE AND SINK CATEGORIES	Base year	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007
	CO ₂ equivalent (Gg)										
1. Energy	37 285.23	37 285.23	18 154.77	15 569.73	15 895.39	15 585.54	17 331.84	17 428.60	17 016.16	16 482.27	19 087.28
2. Industrial Processes	945.59	945.59	597.46	656.65	693.03	505.80	550.97	674.24	665.21	720.39	901.17
3. Solvent and Other Product Use	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4. Agriculture	3 032.75	3 032.75	1 467.78	1 297.99	1 267.47	1 175.91	1 258.72	1 273.53	1 255.28	1 274.40	1 333.09
5. Land Use, Land-Use Change and Forestry ⁽⁵⁾	-6 368.09	-6 368.09	-7 113.77	-1 459.02	-4 198.49	-3 843.14	-5 577.81	-8 762.86	-7 560.49	-8 934.11	-7 903.05
6. Waste	671.87	671.87	643.60	854.73	742.37	807.49	726.06	812.88	700.65	702.66	697.14

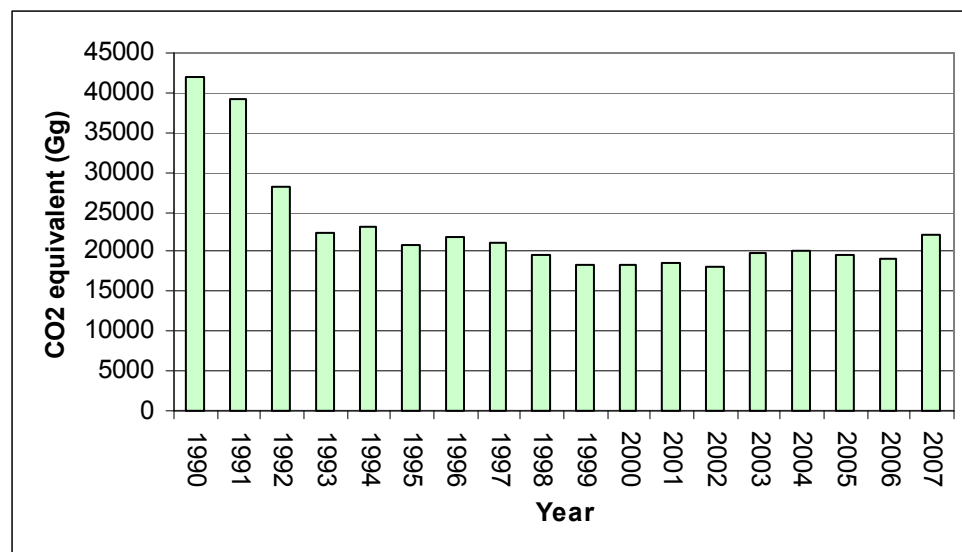


Figure ES.1. Overall development of greenhouse gases in Estonia, in CO₂ equivalents (without CO₂ from LULUCF)

Table ES.2. Greenhouse-gas emissions in Estonia – annual contributions of the various greenhouse gases

GHG EMISSIONS [CO ₂ equivalent (Gg)]	1990		1995		2000		2005		2006		2007	
	[Gg]	[%]	[Gg]	[%]	[Gg]	[%]	[Gg]	[%]	[Gg]	[%]	[Gg]	[%]
CO ₂ emissions excluding net CO ₂ from LULUCF	37 283.48	88.91	18 165.83	87.07	15 555.63	84.64	16 847.86	85.80	16 341.13	85.20	19 093.24	86.71
CH ₄ emissions excluding CH ₄ from LULUCF	2 726.35	6.50	1 675.95	8.03	1 713.77	9.32	1 721.35	8.77	1 723.09	8.98	1 724.31	7.83
N ₂ O emissions excluding N ₂ O from LULUCF	1 925.60	4.59	992.92	4.76	1 036.16	5.64	948.31	4.83	974.74	5.08	1 055.36	4.79
HFCs	NA,NO		25.70	0.123	70.79	0.385	118.70	0.604	139.53	0.727	144.73	0.657
PFCs	NA,NO		NA,NO		NA,NO		NA,NO		0.07	0.000	0.06	0.000
SF ₆	NA,NO		3.22	0.015	2.73	0.015	1.08	0.005	1.15	0.006	0.97	0.004
Total (excluding LULUCF)	41 935.43		20 863.62		18 379.09		19 637.29		19 179.71		22 018.68	

ES.3. Overview of source and sink category emission estimates and trends

The greenhouse gas emissions and removals are divided into the following sectors according to the UNFCCC reporting guidelines on annual inventories (FCCC/SBSTA/2004/8): Energy (CRF 1), Industrial processes (CRF 2), Solvent and other product use (CRF 3), Agriculture (CRF 4), Land use, Land use change and Forestry (LULUCF) (CRF 5) and Waste (CRF 6).

Figure ES.2 shows the contributions of individual source and sink categories to total greenhouse-gas emissions.

Over the period 1990–2007, emissions from the Energy sector decreased by 48.81 per cent, emissions from the Agriculture and Industrial Processes sectors decreased by 56.04 per cent and 4.7 per cent, respectively, and the Waste sector increased 3.76 per cent. Reported net CO₂ removals in the Land-use Change and Forestry (LUCF) sector increased by 24.10 per cent between 1990 and 2007.

In comparison to the previous year, 2006, total emissions increased by 14.80 per cent.

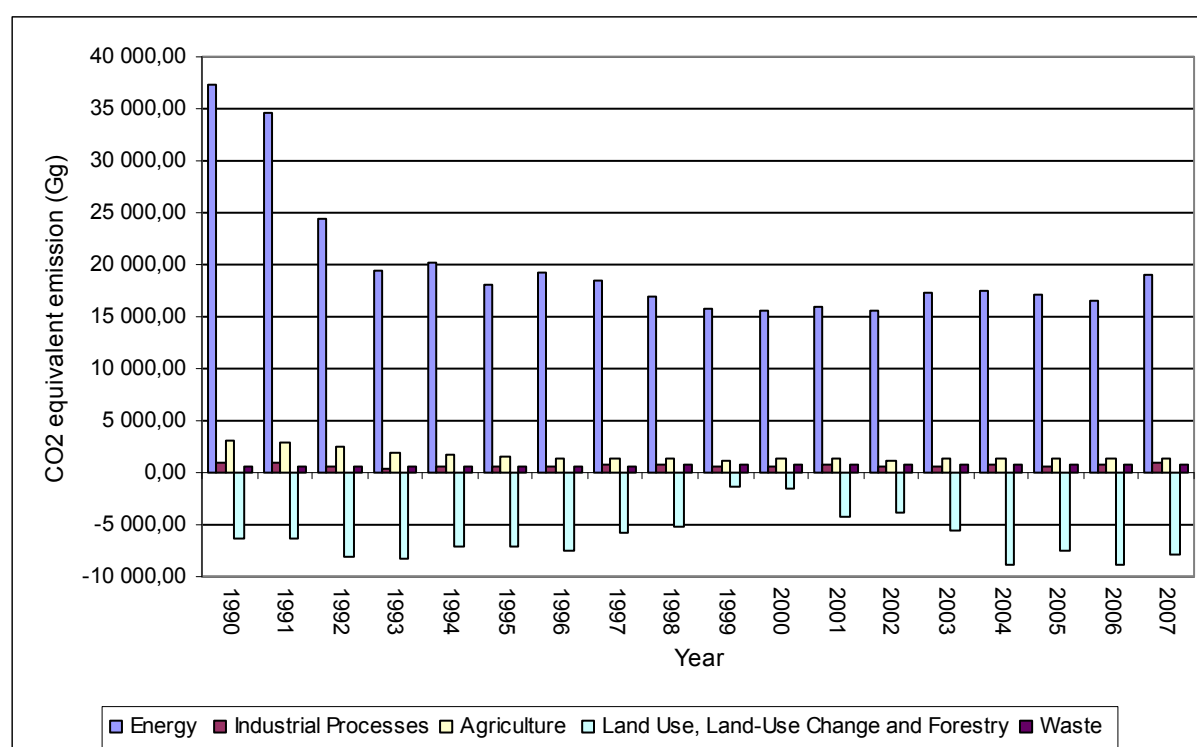


Figure ES.2: Greenhouse-gas emissions trends, by source groups, in CO₂ equivalents

On 30th of April 2004 Estonian Government approved the National Program for reduction of Greenhouse Gas Emissions for years 2003-2012.

CHAPTER 1. INTRODUCTION

1.1. Background and institutional arrangement

Estonia signed the Framework Convention on Climate Change at the United Nations Conference on Environment and Development held in Rio de Janeiro in June 1992. In 1994 Estonia ratified the UN FCCC and in 2002, the Kyoto Protocol. In response to UNFCCC requirements Estonia has prepared the present emission National Inventory Report.

In 1994 an Interministerial Committee of Climate Change was created at the Estonian Government. The Chairman of this Committee is the Minister of the Environment and members are from key ministries, scientists as well as representatives of NGOs. This Committee deals with the problems connected with the implementation of UN FCCC, organises monitoring of emissions of GHG, national communications etc.

The Ministry of the Environment organises the practical providing of GHG inventories and is the designated single national entity. The national inventory compiler is the Climate and Ozone Bureau at the Estonian Environment Information Centre. Financial resources for GHG inventory is planned in the State Budget. Practical work has been done on the basis of contracts. The Tallinn University of Technology and Estonian Environment Research Centre are responsible for the inventories under contract to the Ministry of the Environment in Estonia. The Ministry of the Environment has signed an agreement with the Tallinn University of Technology that sets out the mutual cooperation directions in the field of climate change, including greenhouse gas inventory compilation for 5 years. The Department of Thermal Engineering is responsible for preparing the emission estimates for the energy sector and the Department of Chemistry is responsible for the agriculture, waste and LULUCF sectors. The contract agreement with the Estonian Environmental Research Centre is done on annual bases, wherewith the Estonian Environmental Research Centre obligates to compile the industrial processes sector in Estonia's GHG inventory (including F-gases).

This report presents the national inventory of greenhouse gas (GHG) emissions and removals from 1990 to 2007. The components covered are carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride

(SF₆). Also reported are four indirect greenhouse gases: nitrogen oxides (NO_x), carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs) and sulphur dioxide (SO₂).

The structure of this report corresponds to the UNFCCC reporting guidelines on annual inventories 2004 (FCCC/SBSTA/2004/8). Chapter 1 gives an introduction to the background of greenhouse gas inventories and the arrangement for inventory preparation. Chapters 2-6 give information of GHG emission trends from the base year 1990 to year 2007 for the following sectors: energy; industrial processes; agriculture; land use, land-use change and forestry; waste. Annex 1 contains the QC checklists; Annex 2 includes assessment of completeness. Annexes 3-6 include additional information for the Energy, Industrial Processes, Agriculture sector and LULUCF sector. Annex 7 contains uncertainty analysis, Annex 8 Quality Assurance checklists and Annex 9 includes List of Annual Indicators. Annex 10-12 presents the Standard Independent Assessment Report and relevant annexes.

1.2. Brief description of the process of inventory preparation

Estonian national GHG inventory system is designed and operated according to the guidelines for national system under article 5, paragraph 1, of the Kyoto Protocol (Decision 20/CP7) to ensure the transparency, consistency, comparability, completeness and accuracy of inventories. Inventory activities include planning, preparation and management of the inventories.

1.2.1 Estonian Greenhouse Gas National Inventory System (NIS)

The inventory phases are:

- collecting activity data;
- selecting methods and emission factors appropriately;
- estimating anthropogenic GHG emissions by sources and removals by sinks;
- implementing uncertainty assessment;
- implementing QA/QC activities;
- verification of the inventory data at the national level.

Single national entity with overall responsibility for the Estonian GHG inventory is the Estonian Ministry of the Environment (MoE). The inventory is produced in collaboration between the

MoE, Estonian Environment Information Centre (EEIC), Tallinn University of Technology (TUT) and Estonian Environmental Research Centre (EERC).

The Estonian Environmental Information Centre works under the jurisdiction of the Ministry of the Environment and in accordance with its Statute (RTL 2004, 1, 3), the Climate and Ozone Bureau deals with climate change issues. Responsibilities of the Ministry of the Environment and of the Estonian Environmental Information Centre concerning the greenhouse gas inventory are regulated by the Directive of the Minister of the Environment.

The MoE is responsible for:

- Coordinating the overall inventory preparation process;
- Approving the inventory before official submission to the UNFCCC;
- Concluding the formal agreements with inventory compilers annually by 1st of July (TUT, EERC, etc);
- Coordinating the cooperative work between the inventory compilers and UNFCCC;
- Informing the inventory compilers about the requirements of the national system and ensuring that existing information in national institutions is considered and used in the inventory where appropriate;
- Coordinating the UNFCCC inventory reviews.

Climate and Ozone Bureau in EEIC is responsible for:

- Completing the National Inventory Report according to the parts submitted by the inventory compilers;
- Reporting the greenhouse gas inventory to the UNFCCC, including the National Inventory Report and CRF tables;
- Coordinating the QA/QC plan;
- Preparation of the UNFCCC inventory reviews and coordinating the communication with the expert review team, including responses to the review findings;
- Overall archiving system.

Department of Thermal Engineering and Department of Chemistry at Tallinn University of Technology prepare the estimates for the Energy, Agriculture, Waste and LULUCF sectors. The EERC is responsible for the industrial process sector together with the fluorinated gases estimates. All experts collect activity data, prepare relevant QC, fill in the sectoral data to the

CRF Reporter and prepare sectoral parts of the NIR. They also have archiving system for the sectors that they are working with.

A co-operation agreement between the Ministry of the Environment and Tallinn University of Technology was signed on the 19 October 2007. The agreement sets out the mutual cooperation directions in the field of climate change, including greenhouse gas inventory compilation for 5 years.

The contract agreement with the Estonian Environmental Research Centre is done on annual bases, wherewith the Estonian Environmental Research Centre obligates to compile the Industrial Processes sector in Estonia's GHG inventory. The EERC is responsible for the industrial process sector together with the fluorinated gases estimates, which were prepared during the Twinning project EE05-IB-EN-01 "Enhancing the capacity to reduce the emissions of fluorinated greenhouse gases in Estonia" (twinning partner Germany).

Through the agreements with TUT and EERC, the institutions are committed to implement the QA/QC and archiving procedures, documentation, making information available for review, and delivering data and information in a timely manner to meet the deadline for reporting to the UNFCCC.

The four core institutions: MoE, EEIC, EERC and TUT are in close contact with each other. Several cooperation meetings are held to discuss and agree on the methodological issues, problems that have raised and improvements that need to be implemented. As Estonia is a small country there is close contact between inventory experts (TUT and EERC) and inventory compiler (EEIC) and as a result different problems and misunderstandings are also solved on a daily basis.

During the cooperation meetings the following subjects are addressed:

- Preparation of the annual review;
- Discussion on the comments received from the expert review and agreeing on possible changes that have to be made;
- Discussion on the different problems that came up during the last inventory preparation and find solutions to improve the overall system;
- Discussion on methodologies and possible changes in the future;

- Discussion on QA/QC plan, available resources and possible improvements;
- Discussion on data collection and agreeing on possible institutions that could be also involved;
- Agreement on recalculations;
- Archiving system, updating and possible improvements;
- Exchange of relevant information;
- Reporting the conclusions from the meetings and dividing the responsibilities.

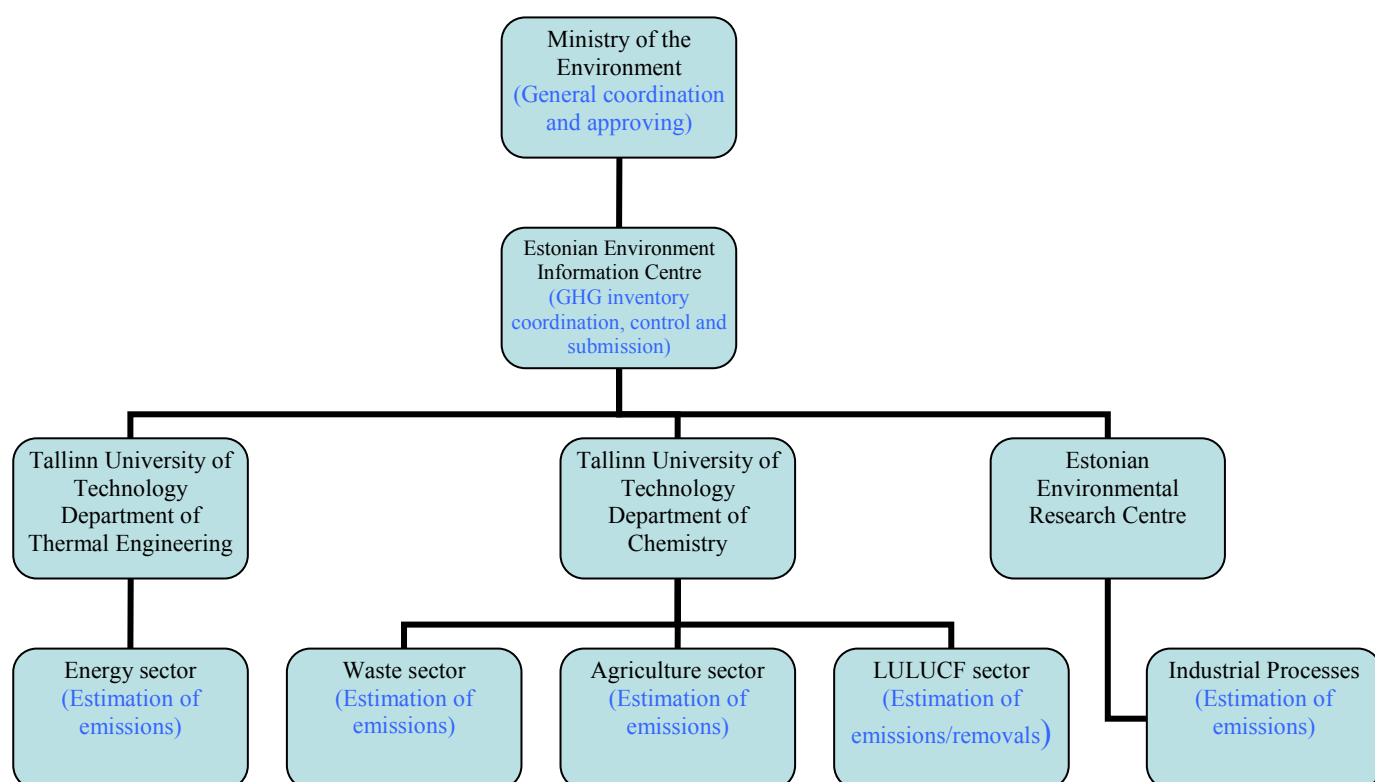


Figure 1.1. Structure of the National Inventory System

Methodological improvements are in accordance with the “Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories”, “Revised 2000 IPCC Guidelines for National Greenhouse Gas Inventories”, “2006 IPCC Guidelines for National Greenhouse Gas Inventories” and the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, and according to the recommendations by the Expert Review Teams, have been implemented in the present inventory as far as possible and will be further implemented in the next submissions.

The estimation of GHG emissions in Estonia is based on Intergovernmental Panel on Climate Change (IPCC 1996, 2000) tier 1, tier 2 and tier 3 methods, default emission factors (EFs) and available Estonian data.

In deriving emissions/removals estimates for LULUCF IPCC *Good Practice Guidance for Land Use, Land-use Change and Forestry* (LULUCF) (hereinafter referred to as the IPCC good practice guidance for LULUCF) and the requirements of decision 14/CP.11 were accounted.

1.3. Database information and methodologies

More detailed description of the methodologies and activity data sources is presented in the “Estonia’s fourth National Communication” which is also available in the UNFCCC website.

Main data sources used in current inventory are given in Table 1.1.

Table 1.1. Methodology, activity data and emission factor sources used

IPCC category	Methodology ⁽¹⁾	Emission factor ⁽¹⁾	Activity data
1. Energy	Revised 1996 IPCC methodology; IPCC good practice guidance	Revised 1996 IPCC methodology	Statistics Estonia (SE) and energy companies (AS Eesti Energia, AS Eesti Põlevkivi)
A. Fuel Combustion	T ₁ , T ₂ , T ₃	D, CS	Energy balances and Annual Yearbooks of Statistics Estonia; data of energy companies
B. Transport	T ₁ , T ₃	D, CS	Energy balances and Annual Yearbooks of Statistics Estonia; Environment Information Centre
C. Fugitive Emissions	T ₁	D	Energy balances of Statistics Estonia
2. Industrial Processes	Revised 1996 IPCC methodology, 2006 IPCC methodology	Revised 1996 IPCC methodology, 2006 IPCC methodology	Statistics Estonia, plant specific data, national and international companies, associations, public institutions
A. Mineral Industry	CS, T ₁	CS, D	Statistics Estonia; Plant specific data
B. Chemical industry	T _{1.a} , T _{1.b}	CS	Plant specific data
C. Consumption of halocarbons and SF ₆	T ₂ , T ₃	CS	National and international companies, associations, public institutions
4. Agriculture	Revised 1996 IPCC methodology, IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories	Revised 1996 IPCC methodology, IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories	Estonian statistics; IPCC default parameters
A. Enteric Fermentation	T ₁ ; T ₂	CS, D	Estonian statistics; IPCC default parameters

B. Manure Management	T ₁	CS, D	Estonian statistics; IPCC default parameters
D. Agricultural Soils	T ₁	D	Estonian statistics; IPCC default parameters
5. LULUCF	Revised 1996 IPCC methodology IPCC good practice guidance for LULUCF	Revised 1996 IPCC methodology, IPCC good practice guidance for LULUCF	
A. Forest land	T ₁	CS, D	Statistical Office of Estonia, 'Estonia forest' reports
B. Croplands	T ₁	D	Statistical Office of Estonia, 'Estonia forest' reports
C. Grassland	T ₁	D	Statistical Office of Estonia, 'Estonia forest' reports
D. Wetlands	T ₁	D	Statistical Office of Estonia, 'Estonia forest' reports
E. Settlements	NA	NA	
6. Waste	Revised 1996 IPCC methodology, IPCC 2006	Revised 1996 IPCC methodology, IPCC 2006	
A. Solid Waste Disposal on Land	T ₁ (the FOD method)	D	Estonian Environment Information Center; Estonian Office of Statistics.
B. Wastewater Handling (Human sewage)	T ₁	D	Estonian Office of Statistics; FAO dataset.
C. Waste Incineration	T ₁	D	Estonian Environment Information Center.
Biological treatment	T ₁	D	Estonian Environment Information Center.

T₁ –IPCC Tier 1; T₂ –IPCC Tier 2; T₃ –IPCC Tier 3; CS –Country specific; NA –not applicable; D –IPCC default value

The main sources of data are from official Estonian statistics (the Statistical Office of Estonia, Estonian Animal Recording Center) and from company's annual emission reports.

MoE has an agreement with the Estonian Statistical Office for receiving the statistical data; this agreement includes the data for the GHG inventory. The Statistical Office of Estonia collects statistical data on the basis of the Official Statistics Act § 3(2), taking into consideration the official statistical surveys approved by the Government of the Republic.

The data collected from other institutions and private companies is done by sectoral experts that have personal contacts in order to receive the data.

Estonia has prepared already four climate reports. The Fourth National Communication covers the GHG inventories of the years 1990 to 2004 including also the years for which inventories have been reported earlier and have been recalculated in 2002. The purpose of all recalculations

was to improve the accuracy and completeness. Now, the inventory of all years up to 2007 is estimated using the same methodology, adjusted statistical data and emission factors.

1.4. Brief description of key source categories

Key categories are the categories of emissions/removals, which have a significant influence on the total inventory in terms of the absolute level of emissions (1990 or 2007), the trend of emissions (change between 1990 and 2007) or both. There are two alternative methods for identifying key categories: Tier 1 and Tier 2. In this report Tier 1 method has been used – the emission categories are sorted according to their contribution to emission level or trend. The key categories are those that represent together 95% of inventory level or trend.

Table 1.2. Key sources in 2007. Level Assessment (without LULUFC)

IPCC code	IPCC source category	Fuel	Greenhouse Gas	2007 CO ₂ eq	Level Assessment	Cumulative Total
1 A 1 a	Public Electricity and Heat Production	Solid Fuels	CO ₂	11328.36	0.514	0.514
1 A 1 a	Public Electricity and Heat Production	Gaseous Fuels	CO ₂	1811.57	0.082	0.597
1 A 3 b	Road Transportation	Diesel oil	CO ₂	1254.02	0.057	0.654
1 A 3 b	Road Transportation	Gasoline	CO ₂	970.79	0.044	0.698
1 A 1 b	Petroleum refining	Solid Fuels	CO ₂	908.83	0.041	0.739
1 A 2 f	Other	Solid Fuels	CO ₂	704.80	0.032	0.771
2 A 1	Mineral Products/Cement Production	Cement Production	CO ₂	596.74	0.027	0.798
6.A.1.	Managed Waste Disposal on Land		CH ₄	516.39	0.023	0.822
1 B 2 b	Natural Gas	Gaseous Fuels	CH ₄	516.18	0.023	0.845
4.A.	Enteric Fermentation: Cattle (CH ₄)		CH ₄	413.55	0.019	0.864
1 A 1 a	Public Electricity and Heat Production	Liquid Fuels	CO ₂	409.59	0.019	0.882
4.D.3.2.	Nitrogen Leaching and Run-off		N ₂ O	170.06	0.008	0.890
4.D.1.5	Cultivation of Histosols		N ₂ O	154.39	0.007	0.897
1 A 2 f	Other	Liquid Fuels	CO ₂	147.77	0.007	0.904
1 A 3 e	Other Transportation	Liquid Fuels	CO ₂	144.41	0.007	0.910
4.D.1.1.	Synthetic Fertilizers		N ₂ O	136.91	0.006	0.917
2 B 1	Chemical Industry/Ammonia Production	Ammonia Production	CO ₂	124.49	0.006	0.922
4.B.	Manure Management (N ₂ O)		N ₂ O	119.71	0.005	0.928
1 A 4 b	Residential	Gaseous Fuels	CO ₂	113.54	0.005	0.933
1 A 3 c	Railways	Liquid Fuels	CO ₂	112.04	0.005	0.938
1 A 2 f	Other	Gaseous Fuels	CO ₂	111.97	0.005	0.943
2 F 1	Refrigeration and Air Conditioning Equipment		HFC	107.66	0.005	0.948
4.D.1.2.	Animal Manure Applied to Soils		N ₂ O	102.24	0.005	0.953
1 A 4 b	Residential	Biomass	CH ₄	99.93	0.005	0.957

Table 1.3. Key sources in 2007. Trend Assessment (without LULUCF)

IPCC code	IPCC source category	Fuel	Greenhouse Gas	1990 Base year CO ₂ eq	2007 CO ₂ eq	Trend Assessment	Contribution to Trend	Cumulative Total
1 A 1 a	Public Electricity and Heat Production	Liquid Fuels	CO ₂	4825.04	409.59	0.184	0.277	0.277
1 A 3 b	Road Transportation	Diesel oil	CO ₂	674.97	1254.02	0.078	0.117	0.394
1 A 1 b	Petroleum refining	Solid Fuels	CO ₂	581.61	908.83	0.052	0.079	0.473
1 A 1 a	Public Electricity and Heat Production	Gaseous Fuels	CO ₂	2547.62	1811.57	0.041	0.062	0.535
2 A 1	Mineral Products/Cement Production	Cement Production	CO ₂	483.08	596.74	0.030	0.045	0.579
1 A 4 b	Residential	Solid Fuels	CO ₂	699.69	44.09	0.028	0.042	0.621
1 A 2 f	Other	Solid Fuels	CO ₂	792.94	704.80	0.025	0.038	0.659
1 A 4 b	Residential	Liquid Fuels	CO ₂	547.06	23.63	0.023	0.034	0.693
1 A 2 e	Food Processing, Beverages and Tobacco	Liquid Fuels	CO ₂	438.64	4.94	0.019	0.029	0.723
1 A 3 b	Road Transportation	Gasoline	CO ₂	1462.15	970.79	0.018	0.026	0.749
6.A.1.	Managed Waste Disposal on Land		CH ₄	599.93	516.39	0.017	0.026	0.775
1 A 2 c	Chemicals	Gaseous Fuels	CO ₂	326.67	0.11	0.015	0.022	0.798
4.A.	Enteric Fermentation: Cattle (CH ₄)		CH ₄	1049.24	413.55	0.012	0.018	0.816
2 F 1	Refrigeration and Air Conditioning Equipment		HFC	0.00	107.66	0.009	0.014	0.830
1 B 2 b	Natural Gas	Gaseous Fuels	CH ₄	787.22	516.18	0.009	0.013	0.843
1 A 3 e	Other Transportation	Liquid Fuels	CO ₂	451.30	144.41	0.008	0.012	0.855
1 A 4 b	Residential	Biomass	CH ₄	33.67	99.93	0.007	0.011	0.866
6.D	Biological treatment		N ₂ O	0.66	72.52	0.006	0.009	0.875
4.D.1.5	Cultivation of Histosols		N ₂ O	166.39	154.39	0.006	0.009	0.884
6.D	Biological treatment		CH ₄	0.60	65.50	0.006	0.008	0.893
1 A 2 f	Other	Gaseous Fuels	CO ₂	101.20	111.97	0.005	0.008	0.900
1 A 4 a	Commercial/Institutional	Gaseous Fuels	CO ₂	18.76	66.20	0.005	0.007	0.908
4.D.3.2.	Nitrogen Leaching and Run-off		N ₂ O	430.86	170.06	0.005	0.007	0.915
1 A 4 b	Residential	Gaseous Fuels	CO ₂	118.06	113.54	0.004	0.007	0.922

4.D.1.1.	Synthetic Fertilizers		N2O	353.65	136.91	0.004	0.006	0.928
1 A 1 a	Public Electricity and Heat Production	Solid Fuels	CO2	21494.04	11328.36	0.004	0.006	0.934
2 A 2	Mineral Products/Lime Production	Lime Production	CO2	145.36	34.18	0.004	0.005	0.939
2 B 1	Chemical Industry/Ammonia Production	Ammonia Production	CO2	317.16	124.49	0.004	0.005	0.945
4.B.	Manure Management (N2O)		N2O	299.46	119.71	0.003	0.005	0.949
1 A 3 c	Railways	Liquid Fuels	CO2	143.06	112.04	0.003	0.005	0.954
1 A 3 b	Road Transportation	Gasoline	N2O	9.80	39.06	0.003	0.004	0.959

Table 1.4. Key sources in 2007. Level Assessment (with LULUFC)

IPCC code	IPCC source category	Fuel	Greenhouse Gas	2007 CO2eq	Level Assessment	Cumulative Total
1 A 1 a	Public Electricity and Heat Production	Solid Fuels	CO2	11328.36	0.364	0.364
5.A	Forest Land		CO2	-6884.68	0.221	0.585
1 A 1 a	Public Electricity and Heat Production	Gaseous Fuels	CO2	1811.57	0.058	0.643
1 A 3 b	Road Transportation	Diesel oil	CO2	1254.02	0.040	0.683
5.C	Grassland		CO2	-1041.26	0.033	0.717
1 A 3 b	Road Transportation	Gasoline	CO2	970.79	0.031	0.748
1 A 1 b	Petroleum refining	Solid Fuels	CO2	908.83	0.029	0.777
1 A 2 f	Other	Solid Fuels	CO2	704.80	0.023	0.800
5.B	Cropland		CO2	606.00	0.019	0.819
2 A 1	Mineral Products/Cement Production	Cement Production	CO2	596.74	0.019	0.838
5.F	Other land		CO2	-570.82	0.018	0.857
6.A.1.	Managed Waste Disposal on Land		CH4	516.39	0.017	0.873
1 B 2 b	Natural Gas	Gaseous Fuels	CH4	516.18	0.017	0.890
4.A.	Enteric Fermentation: Cattle (CH4)		CH4	413.55	0.013	0.903
1 A 1 a	Public Electricity and Heat Production	Liquid Fuels	CO2	409.59	0.013	0.916

4.D.3.2.	Nitrogen Leaching and Run-off		N2O	170.06	0.005	0.922
4.D.1.5	Cultivation of Histosols		N2O	154.39	0.005	0.927
1 A 2 f	Other	Liquid Fuels	CO2	147.77	0.005	0.932
1 A 3 e	Other Transportation	Liquid Fuels	CO2	144.41	0.005	0.936
4.D.1.1.	Synthetic Fertilizers		N2O	136.91	0.004	0.941
2 B 1	Chemical Industry/Ammonia Production	Ammonia Production	CO2	124.49	0.004	0.945
4.B.	Manure Management (N2O)		N2O	119.71	0.004	0.948
1 A 4 b	Residential	Gaseous Fuels	CO2	113.54	0.004	0.952
1 A 3 c	Railways	Liquid Fuels	CO2	112.04	0.004	0.956
1 A 2 f	Other	Gaseous Fuels	CO2	111.97	0.004	0.959

Table 1.5. Key sources 2007. Trend Assessment (with LULUFC)

IPCC code	IPCC source category	Fuel	Greenhouse Gas	1990 Base year CO2eq	2007 CO2eq	Trend Assessment	Contribution to Trend	Cumulative Total
5.A	Forest Land		CO2	-8037.50	-6884.68	0.660	0.236	0.236
1 A 1 a	Public Electricity and Heat Production	Solid Fuels	CO2	21494.04	11328.36	0.499	0.179	0.416
1 A 1 a	Public Electricity and Heat Production	Liquid Fuels	CO2	4825.04	409.59	0.269	0.096	0.512
5.C	Grassland		CO2	66.54	-1041.26	0.191	0.068	0.580
1 A 3 b	Road Transportation	Diesel oil	CO2	674.97	1254.02	0.176	0.063	0.643
1 A 1 a	Public Electricity and Heat Production	Gaseous Fuels	CO2	2547.62	1811.57	0.143	0.051	0.695
1 A 1 b	Petroleum refining	Solid Fuels	CO2	581.61	908.83	0.121	0.043	0.738
5.F	Other land		CO2		-570.82	0.102	0.037	0.775
2 A 1	Mineral Products/Cement Production	Cement Production	CO2	483.08	596.74	0.072	0.026	0.800
1 A 3 b	Road Transportation	Gasoline	CO2	1462.15	970.79	0.070	0.025	0.825
1 A 2 f	Other	Solid Fuels	CO2	792.94	704.80	0.070	0.025	0.850
6.A.1.	Managed Waste Disposal on Land		CH4	599.93	516.39	0.050	0.018	0.868
1 A 4 b	Residential	Solid Fuels	CO2	699.69	44.09	0.042	0.015	0.883

1 B 2 b	Natural Gas	Gaseous Fuels	CH4	787.22	516.18	0.036	0.013	0.896
1 A 4 b	Residential	Liquid Fuels	CO2	547.06	23.63	0.035	0.012	0.909
1 A 2 e	Food Processing, Beverages and Tobacco	Liquid Fuels	CO2	438.64	4.94	0.030	0.011	0.919
1 A 2 c	Chemicals	Gaseous Fuels	CO2	326.67	0.11	0.023	0.008	0.928
2 F 1	Refrigeration and Air Conditioning Equipment		HFC	0.00	107.66	0.019	0.007	0.935
4.D.1.5	Cultivation of Histosols		N2O	166.39	154.39	0.016	0.006	0.940
1 A 4 b	Residential	Biomass	CH4	33.67	99.93	0.015	0.006	0.946
6.D	Biological treatment		N2O	0.66	72.52	0.013	0.005	0.950
1 A 2 f	Other	Gaseous Fuels	CO2	101.20	111.97	0.013	0.005	0.955
1 A 4 b	Residential	Gaseous Fuels	CO2	118.06	113.54	0.012	0.004	0.959

Table 1.6. Key sources 1990. Level Assessment (without LULUCF)

IPCC code	IPCC source category	Fuel	Greenhouse Gas	1990 Base year CO2eq	Level Assessment	Cumulative Total
1 A 1 a	Public Electricity and Heat Production	Solid Fuels	CO2	21494.04	0.513	0.513
1 A 1 a	Public Electricity and Heat Production	Liquid Fuels	CO2	4825.04	0.115	0.628
1 A 1 a	Public Electricity and Heat Production	Gaseous Fuels	CO2	2547.62	0.061	0.688
1 A 3 b	Road Transportation	Gasoline	CO2	1462.15	0.035	0.723
4.A.	Enteric Fermentation: Cattle (CH4)		CH4	1049.24	0.025	0.748
1 A 2 f	Other	Solid Fuels	CO2	792.94	0.019	0.767
1 B 2 b	Natural Gas	Gaseous Fuels	CH4	787.22	0.019	0.786
1 A 4 b	Residential	Solid Fuels	CO2	699.69	0.017	0.803
1 A 3 b	Road Transportation	Diesel oil	CO2	674.97	0.016	0.819
6.A.1.	Managed Waste Disposal on Land		CH4	599.93	0.014	0.833
1 A 1 b	Petroleum refining	Solid Fuels	CO2	581.61	0.014	0.847

1 A 4 b	Residential	Liquid Fuels	CO2	547.06	0.013	0.860
2 A 1	Mineral Products/Cement Production	Cement Production	CO2	483.08	0.012	0.871
1 A 3 d	Navigation	Residual Oil	CO2	472.73	0.011	0.883
1 A 3 e	Other Transportation	Liquid Fuels	CO2	451.30	0.011	0.893
1 A 2 e	Food Processing, Beverages and Tobacco	Liquid Fuels	CO2	438.64	0.010	0.904
4.D.3.2.	Nitrogen Leaching and Run-off		N2O	430.86	0.010	0.914
4.D.1.1.	Synthetic Fertilizers		N2O	353.65	0.008	0.923
1 A 2 c	Chemicals	Gaseous Fuels	CO2	326.67	0.008	0.930
1 A 2 f	Other	Liquid Fuels	CO2	324.01	0.008	0.938
2 B 1	Chemical Industry/Ammonia Production	Ammonia Production	CO2	317.16	0.008	0.946
4.B.	Manure Management (N2O)		N2O	299.46	0.007	0.953
4.D.1.2.	Animal Manure Applied to Soils		N2O	252.55	0.006	0.959

Table 1.7. Key sources 1990. Level Assessment (with LULUCF)

IPCC code	IPCC source category	Fuel	Greenhouse Gas	1990 Base year CO2eq	Level Assessment	Cumulative Total
1 A 1 a	Public Electricity and Heat Production	Solid Fuels	CO2	21494.04	0.416	0.416
5.A	Forest Land		CO2	-8037.50	0.156	0.572
1 A 1 a	Public Electricity and Heat Production	Liquid Fuels	CO2	4825.04	0.093	0.665
1 A 1 a	Public Electricity and Heat Production	Gaseous Fuels	CO2	2547.62	0.049	0.714
5.B	Cropland		CO2	1605.84	0.031	0.745
1 A 3 b	Road Transportation	Gasoline	CO2	1462.15	0.028	0.774
4.A.	Enteric Fermentation: Cattle (CH4)		CH4	1049.24	0.020	0.794
1 A 2 f	Other	Solid Fuels	CO2	792.94	0.015	0.809
1 B 2 b	Natural Gas	Gaseous Fuels	CH4	787.22	0.015	0.825
1 A 4 b	Residential	Solid Fuels	CO2	699.69	0.014	0.838
1 A 3 b	Road Transportation	Diesel oil	CO2	674.97	0.013	0.851

6.A.1.	Managed Waste Disposal on Land		CH4	599.93	0.012	0.863
1 A 1 b	Petroleum refining	Solid Fuels	CO2	581.61	0.011	0.874
1 A 4 b	Residential	Liquid Fuels	CO2	547.06	0.011	0.885
2 A 1	Mineral Products/Cement Production	Cement Production	CO2	483.08	0.009	0.894
1 A 3 d	Navigation	Residual Oil	CO2	472.73	0.009	0.903
1 A 3 e	Other Transportation	Liquid Fuels	CO2	451.30	0.009	0.912
1 A 2 e	Food Processing, Beverages and Tobacco	Liquid Fuels	CO2	438.64	0.008	0.920
4.D.3.2.	Nitrogen Leaching and Run-off		N2O	430.86	0.008	0.929
4.D.1.1.	Synthetic Fertilizers		N2O	353.65	0.007	0.936
1 A 2 c	Chemicals	Gaseous Fuels	CO2	326.67	0.006	0.942
1 A 2 f	Other	Liquid Fuels	CO2	324.01	0.006	0.948
2 B 1	Chemical Industry/Ammonia Production	Ammonia Production	CO2	317.16	0.006	0.954

1.5. Information about the QA/QC plan including verification and treatment of confidentiality issues

1.5.1. Quality Assurance and Quality Control (QA/QC)

This section presents the general QA/QC programme including the quality objectives and the QA/QC plan for the Estonian greenhouse gas inventory at the national inventory level. Source-specific QA/QC details are discussed in the relevant sections of this NIR.

Quality assurance/quality control plan is under development. General (Tier 1) Quality Control (QC) procedures are applied to all categories as following:

- activity data are compiled and cross-checked;
- mostly default factors are used;
- all units are checked.

All institutions involved in the inventory process (MoE, EEIC; TUT and EERC) are responsible for implementing QC procedures to meet the data quality objectives.

MoE as the national entity is responsible for overall QC and is in charge of checking on an annual basis that the appropriate QC procedures are implemented internally in TUT; EERC and EEIC. The EEIC has an overall responsibility for QC of the data of the emission inventory. EEIC checks the QC reports of TUT and EERC. When EEIC disagrees with the report then the errors are discussed and changes are made if necessary.

Each institution is responsible for reporting on their completion of the QC procedures on an annual basis. This reporting is based on a checklist of general and source-specific QC checks and a textual description of possible recalculations, issues to be followed up before the next submissions, and other relevant information.

MoE as the national entity is responsible for the overall QA of the national system, including the UNFCCC reviews and any national reviews undertaken.

1.5.2. QA procedures implemented

From the 2008 submission all data collected by institutions involved in the inventory process is being checked by an independent expert from Tallinn University of Technology. Quality assurance of the Energy, Industrial Processes, Agriculture, Waste and LULUCF sectors were carried out by Tiina Randla, assistant of Tallinn University of Technology, Institute of Chemistry, MSc. Quality assurance checklists are presented in Annex 8.

Also public review was carried out. The draft NIR was uploaded to the EEIC website www.keskkonnainfo.ee where all interested parties had an opportunity to comment on it. The public reviews of the draft document offer a broader range of researchers and practitioners in non-governmental organizations, industry and academia, as well as the general public, the opportunity to contribute to the final document. The comments received during these processes were reviewed and, as appropriate, incorporated into the NIR.

One part of QA is UNFCCC reviews. The reviews are performed by a team of experts (sectoral experts and generalist) from other countries. They are examining the data and methods that Estonia is using, checking the documentation, archiving system and national system. In conclusion they report whether Estonia's overall performance is in accordance with current guidelines. The review report indicates the specific areas where the inventory is in need of improvements.

1.5.3. QC procedures implemented

The Estonian Greenhouse Gas Inventory is compiled by the EEIC. The data compilation and reporting for source sectors are performed by TUT and EERC.

The quality of the inventory is ensured in the course of the compilation and reporting, that consists of four main stages: planning, preparation, evaluation and improvement. The quality management of inventory is a continuous process.

It starts from the consideration of the inventory principles. The setting of concrete annual quality objectives is based on this consideration. The next step is elaboration of the QA/QC plan and implementing the appropriate quality control measures (e.g. routine checks, documentation) focused on meeting the quality objectives set and fulfilling the requirements. In addition, the QA

procedures are planned and implemented. In the improvement phase of the inventory, conclusions are made on the basis of the realized QA/QC process and its results.

The sectoral experts from TUT and EERC are collecting data for the national inventory. The current system complies with the Tier 1 procedures outlined in the Good Practice Guidance (IPCC, 2000). The Tier 1 QC checks for key sources are carried out and individual source category checklists are produced. Also assessment of completeness is evaluated. The system is being developed so that the system complies with Tier 2.

The sectoral experts send their xml files to the compiler (EEIC) who puts all the sectors together and completes the CRF tables. During that time the numbers are cross-checked in the CRF reporter to make sure that no mistakes were made during the importing process. Also the CRF completeness check is carried out to make sure that all the necessary data is filled. When EEIC has completed the CRF tables, then all data is checked by an independent expert from Tallinn University of Technology. The results of the independent expert will be looked through in collaboration with the experts and EEIC and necessary adjustments will be carried out as a result.

When the CRF tables are finalized, the experts will start preparing the sectoral chapters of the NIR. The chapters of the NIR will be sent to the independent expert who will make sure that the structure of the chapters follows the set out requirements. All figures on emissions and removals in tables and text are checked to make sure that they are consistent with those reported in the CRF. It is also checked that all methodological changes, recalculations, trends and removals are well explained.

Then the sectoral chapters are sent to the compiler who adds the introduction part and puts the draft NIR together. The compiler arranges the different chapters into one uniform document and makes sure that the structure of the report follows the IPCC guidelines. The compiler also double checks the data in the NIR, so that it is consistent with those reported in the CRF.

When the draft NIR is completed it is sent to the MoE. The Ambient Air and Radiation Protection Bureau in Environmental Management and Technology Department looks over the inventory report and makes sure that the submitted data is officially valid. Also the structure of the report is assessed based on the established requirements. When there are no contradictions

the report is introduced for coordination to the Forestry, Waste and Water Department, Deputy Secretary General on Environmental Management and Deputy Secretary General on International Co-operation and afterwards to the Secretary General. When the report is approved by the Secretary General the report can be sent to the EC and UNFCCC.

MoE and EEIC, in collaboration with the expert organizations responsible for the inventory calculation sectors, set yearly quality objectives for the whole inventory at the inventory planning stage and designs the QC procedures needed for achieving these objectives. In addition, the expert organizations set their own, sector and/or category specified quality objectives and prepare their QC plans.

The setting of quality objectives is based on the inventory principles presented in the UNFCCC Guidelines and in the EUs decision on a mechanism for monitoring community greenhouse gas emissions, that is, transparency, consistency, comparability, completeness, accuracy and timeliness. In addition, the principle of continuous improvement is included.

Tier 1 QC checks for key sources of Energy, Industrial Processes, Waste, Agriculture and LULUC sectors were carried out. The checks incorporated in the CRF reporter were undertaken for the period 1990 – 2007 (checklists of QC are presented in Annex 1).

Table 1.8. Inventory production plan

	Responsible	Deadline
Looking over the changes needed for the next year's reporting, including the comments and suggestions made by the review team.	All	May 15
Agreement on the changes and adjustments to be made for the next year's reporting	All	July 1
Collection of information (activity data) from the Statistical Office of Estonia:		
Energy sector	TUT (Department of Thermal Engineering)	October 01-31
Industrial Processes sector (<i>pulp & paper, food & drink</i>)	EERC	September
Agriculture sector	TUT (Department of Chemistry)	August 15
LULUCF sector	TUT (Department of Chemistry)	Sept. 1
<i>Collection of information (activity data) from AS Estonian Energy:</i>		
Energy sector	TUT (Department	October

	of Thermal Engineering	01-31
<i>Collection of information (activity data) from different factories):</i>		
Industrial Processes sector (cement, ammonia, lime, etc factories)	EERC	September
<i>F-gases: Collection of information (activity data) from different companies (for industrial refrigeration, commercial refrigeration, fire extinguishers etc.), associations (for Stationary Air-Conditioning etc.) and Statistics (for commercial refrigeration etc.)</i>	EERC	Aug. 01- Oct. 31
<i>Collection of information (activity data) from Animal Recording Centre:</i>		
Agriculture sector	TUT (Department of Chemistry)	March 1
<i>Collection of information (activity data) from Forest yearbook:</i>		
LULUCF sector	TUT (Department of Chemistry)	Nov. 1
<i>Collection of information (activity data) from Waste yearbook:</i>		
Waste sector	TUT (Department of Chemistry)	Sept. 1
<i>Collection of information (activity data) from Wastewater yearbook:</i>		
Waste sector	TUT (Department of Chemistry)	July 1
Compilation of the xml files by the experts and completion of QC and sent to EEIC	TUT, EERC	Dec. 1
Compilation of the CRF tables and completion of QC	EEIC	Dec. 10
QA of the CRF tables by independent expert	TUT	Jan. 1
Draft inventory to MoE for comments and QC	EEIC	Jan. 1
Comments by the MoE	MoE	Jan. 10
Final inventory (CRF tables)	EEIC	Jan. 15
NIR 1 st draft by sectoral experts	TUT	Feb. 1
QA of the NIR 1 st draft	TUT	Feb. 10
NIR 1 st draft	EEIC	Feb. 15
NIR 1 st draft to MoE for comments and QC	EEIC	Feb. 15
Comments by the MoE	MoE	March 1
Public review		March 10
NIR finalized	EEIC	April 1
Formal approval of inventory for the purpose of reporting	MoE	April 10
Reporting	EEIC	April 15

1.5.4. Future development of QA/QC systems and planned improvements

Estonia's inventory needs to be further developed before it can fulfil the data quality objectives. All institutions involved in the making of the inventory are all part of developing plans for improving the data. The plan will be based on the UNFCCC review, QA/QC activities, information that came up during the previous reporting cycle and other information.

Estonia is planning a twinning light project in 2009. Project title is "Improving the quality of Estonia's National Greenhouse Gas Inventory"; Twinning number: EE06-IB-TWP-ENV-06. The project is addressed at improving the implementation of article 3.1 of Decision No 280/2004/EC of the European Parliament and of the Council of 11 February 2004 concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol.

Potential problems concerning Estonia's Greenhouse Gas Inventory were highlighted during the in-country review of Estonia's Initial Report under the Kyoto Protocol and 2006 Inventory Submission: the status of the legal arrangements, the lack of a quality assurance/quality control plan and the lack of an uncertainty analysis were identified by the UN Review Team as potential problems.

In 2007/2008 a Twinning project EE05-IB-EN-01 "Enhancing the capacity to reduce the emissions of fluorinated greenhouse gases in Estonia" (twinning partner Germany) was conducted and for the first time an inventory of F-gas emissions was prepared. The idea for the proposed project also evolved from the mentioned Twinning project, when it was realized that the quality of other parts of the inventory (the above mentioned project covers only the part of F-gases) should be improved.

The proposed project will focus on the following sectors of the inventory: Energy, Industrial processes (except F-gases, as this sector was considered in the previous Twinning project EE05-IB-EN-01), Agriculture, Land Use, Land-Use Change and Forestry (LULUCF), Waste.

Mandatory results of the project:

- 1 Estonia's GHG inventory for 5 sectors (Energy, Industrial processes (except F-gases), Agriculture, Waste and Land Use, Land-Use Change and Forestry (LULUCF) analyzed.

- 2 Terms of reference elaborated to develop a single national IT system to facilitate GHG emission data handling, calculation and reporting (IT system itself will be developed and maintenance will be covered from national resources after the end of the project).
- 3 Concept and suggestions developed to improve the quality assurance/control procedures of GHG inventory with examples from existing systems of other Member States.
- 4 Concept and suggestions developed to improve the uncertainty management of GHG inventory with examples from existing systems of other Member States.
- 5 Estonian specialists have knowledge that enables to prepare a reliable and transparent GHG inventory.

Activities:

- Sector by sector revision of the current inventory and providing recommendations to improve its quality, pointing out the strengths and weaknesses and making suggestions for improvements with examples of existing systems in other Member States.
- Carrying out the existing IT systems analyses and elaboration of Terms of Reference to develop a single national IT system, involving all relevant inventory data used by sectoral experts and if necessary integrating them with the current emission databases/IT systems used for emission reporting.
- Development of a concept to improve the quality assurance/control procedures and uncertainty management of GHG inventory.
- Seminar on the set up of inventory system of the twinning partner with the examples of best practice in European Union for Tallinn University of Technology (3-4 participants), Estonian Environmental Research Centre (2-3 participants), Environmental Information Centre (3 participants), Ministry of the Environment (2-3 participants).
- Seminar to discuss the results of the project and to define the future steps that should be undertaken by Estonia in this field for Estonian experts.
- Preparation of a bilateral cooperation agreement concerning GHG inventory.

1.5.5. Archiving

As part of general QC procedures, it is good practice to document and archive all information required to produce the national emissions inventory estimates.

It is good practice for inventory compilers to maintain this documentation for every inventory produced and to provide it for review. It is good practice to maintain and archive this documentation in such a way that every inventory estimate can be fully documented and reproduced if necessary.

All institutions are responsible for archiving the data they collect and the estimates they calculate. But it is necessary to have a central archiving system located at a single location.

Estonian Environment Information Centre (EEIC) bears the responsibility of archiving and Estonia's central inventory archive is located there. When the reporting cycle ends and all inventory calculations are finalized all experts send their documentation to the compiler and it is stored in one place.

The data and information is archived for each submission year. The archiving includes all input data, all estimated emissions, corresponding letters, all partly filled-in or final CRF, recalculations of previous estimates, submissions to UNFCCC and EC and NIR-s. The archiving system is located in EEIC server which undergoes a daily backup and the backups are securely saved. Also after inventory compilation the calculation results are archived on CD-ROM.

In addition to the main archive, the expert organizations contributing to the sectoral calculation archive the primary data used, internal documentation of calculations and sectoral CRF tables. These organizations keep records of their work on hard disks of individual expert's desktop workstations, with copies on backed up network servers. Also electronic copies on CD-ROMs are produced.

Estonia's archiving system is under development and it will be improved in line with the requirements for the national system.

1.6. Summary of the uncertainty analysis

The uncertainty estimate of the inventory 2009 has been done according to the Tier 1 method presented by the IPCC Good Practice Guidance 2000.

The uncertainty analysis is presented in Annex 7 and detailed information about uncertainty evaluation is described in the sectoral chapters.

1.7. General assessment of the completeness

Assessment of completeness is presented in Annex 2.

1.8. Information of implementation of flexible mechanisms of Kyoto Protocol

Information from the national registry, once established, on the issue, acquisition, holding, transfer, cancellation, withdrawal and carryover of assigned amount units, removal units, emission reduction units and certified emission reductions during the previous year (year x-1);

The European Commission, Member States and the secretariat of the United Nations Framework Convention on Climate Change (UNFCCC) completed the live connection between the CITL, the UNFCCC International Transaction Log (ITL) and Member State registries on 16th of October 2008, Estonia included. Estonia issued after establishing the live connection pursuant to Article 3.7 and 3.8 Kyoto units. More detailed information about year 2008 Kyoto unit holdings, transfers, cancellations, etc is available in report “SEF_EE_2009_3_14-10-15 25-3-2009” (submitted as a part of annual inventory).

Information on legal entities authorised to participate in mechanisms under Articles 6 (JI), 12 (CDM) and 17 (IET) of the Kyoto Protocol, in compliance with relevant national or Community provisions;

Estonian Ministry of the Environment as competent authority is authorised to trade with AAUs, RMUs, ERUs and CERs. Installations falling under the scope of the Directive 2003/87/EC are authorised to use ERUs and CERs for compliance according to the percentage set in National Allocation Plan for 2008-2012.

CHAPTER 2. ENERGY (CRF 1)

2.1. Overview of sector (CRF 1)

Energy sector is the main source of greenhouse gas emissions in Estonia. In 2007, the energy sector contributed about 86.7% of total emissions, totalling 19.09 Tg CO₂ eq. (Figure 2.1) Compared to the base year 1990, the emissions were about 49% below that level (41.94 Tg CO₂). Most of the energy sector emissions – 97.3% originate from fuel combustion and only 2.7% are contributed by fugitive emissions.

The substantial amount of energy related emissions are caused by extensive consumption of fossil fuels for power and heat production.

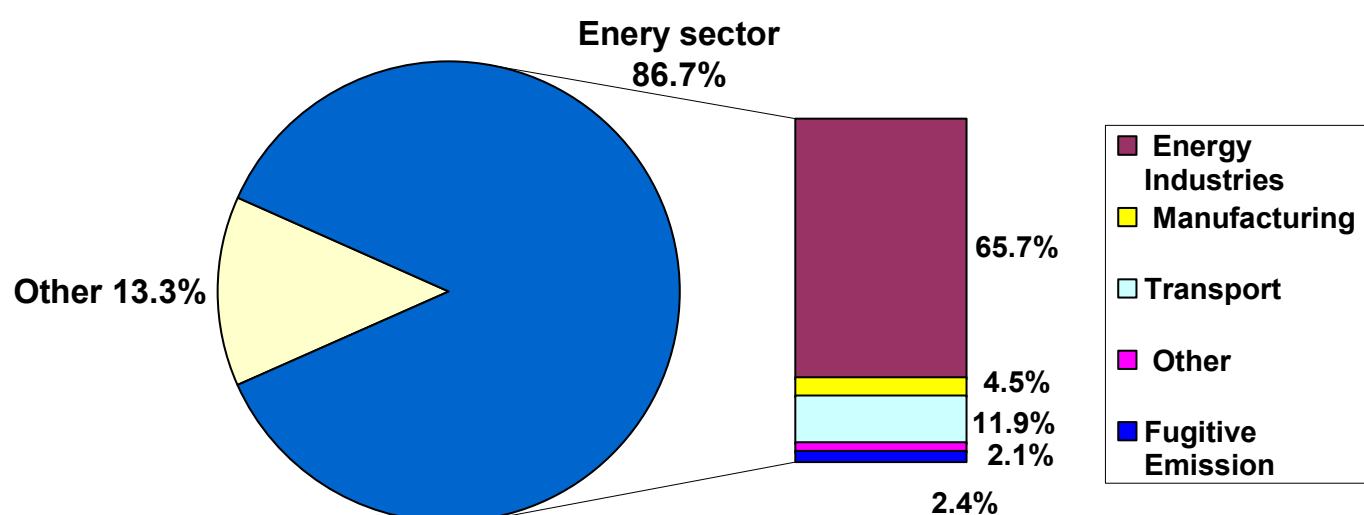


Figure 2.1. Emissions from the energy sector compared to the total emissions in 2007

The predominating part of primary energy utilized in Estonia is of domestic origin. Imported fuels (natural gas, fuel oils, coal, motor fuels and liquid gas) made up to 33% in the fuels utilized in 2007. The share of renewable energy in total consumption was about 10%, wood fuels formed the main part of it, the part of other sources remained on the level of 0.4%. From the energy of primary fuels (240 PJ) 45% was used for electricity production, 16% for heat production, 15% for the production of secondary fuels, about 3% as raw material in industry and 21% for

immediate final consumption (the rest of the energy used for final consumption was converted energy)¹.

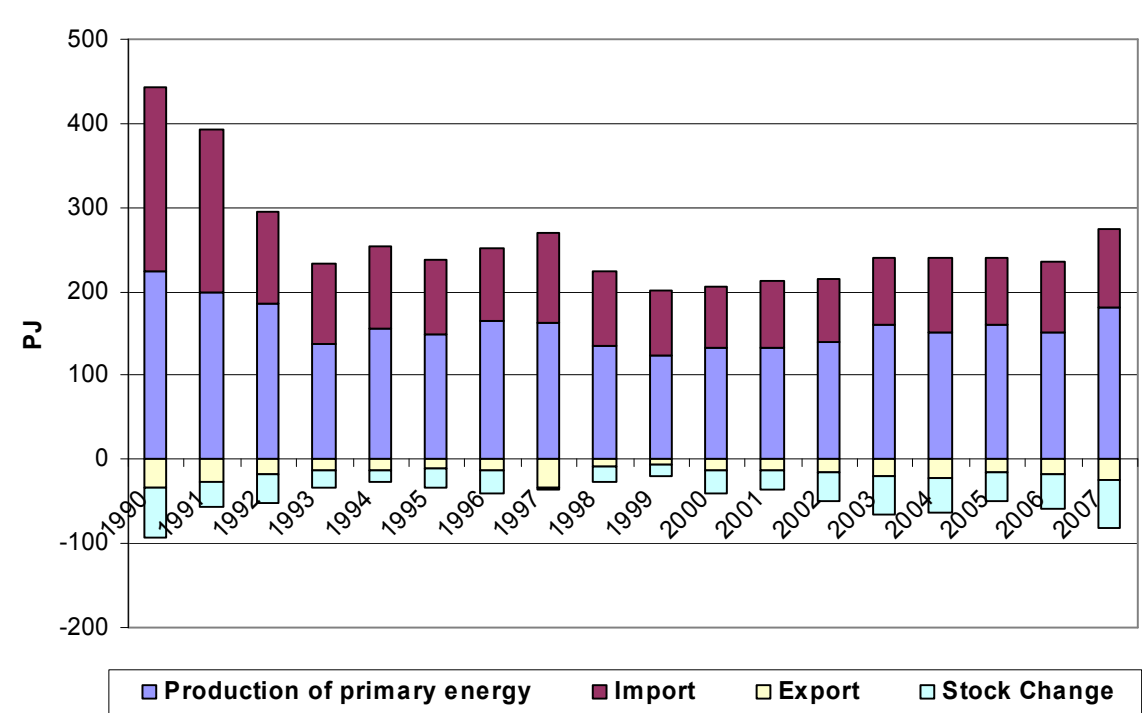


Figure 2.2. Development of Total Primary Energy Supply in Estonia, 1990 – 2007

The development of primary energy supply in Estonia is presented in Figure 2.2. The structure of primary energy supply in 1990 and 2007 accordingly is presented in Figure 2.3.

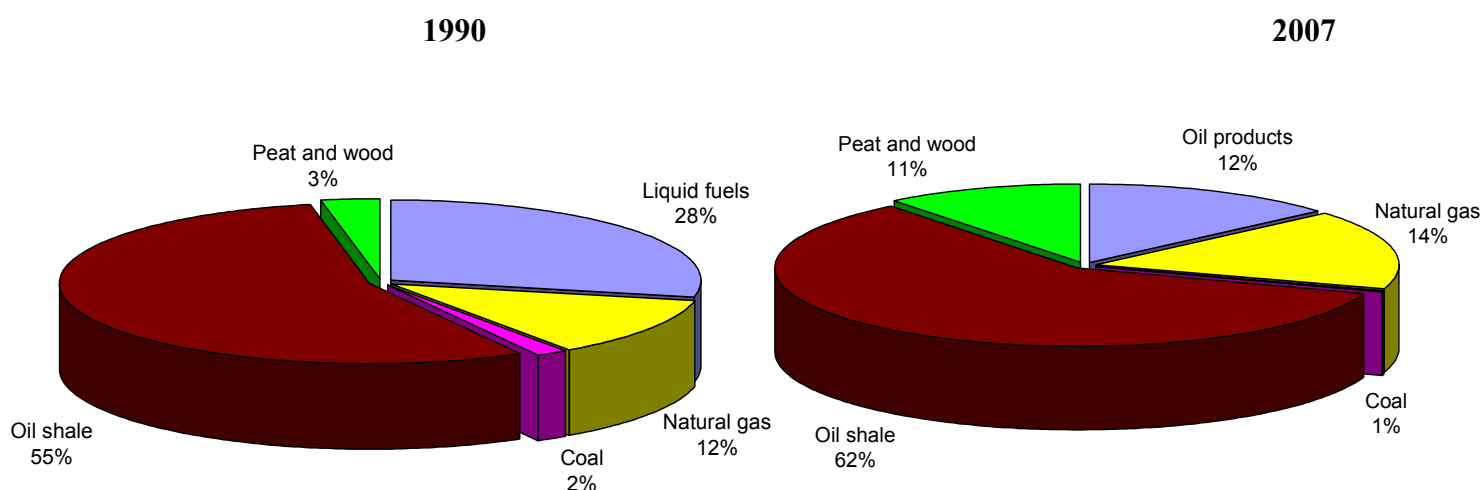


Figure 2.3. Structure of primary energy supply in Estonia in 1990 and 2007.

¹ Statistics Estonian. www.stat.ee

Analysing the structure of primary energy supply in 2007 we can see that the share of oil shale has risen from 55% in 1990 up to about 62% in 2007. The shares of other local fuels – wood and peat – have significantly increased, accounting for 3% and 11%, respectively. From among imported fuels, the share of coal has continued to decline (to 1%). The share of oil products has fallen drastically, from 28% up to 12%. That of natural gas has slightly risen, from 12% to 14%.

The efficiency of primary energy utilisation (the ratio of final energy consumption to the primary energy used) is relatively low in Estonia, making 29% in 2007. This index is lower than in neighbouring countries mainly because Estonia does not have large hydro power plants and over 90% power energy is produced by condensing steam power stations, whose efficiency is approximately 36%. The efficiency index of the energy sector is also reduced by losses in electricity and district heating networks and by the export of converted energy (electricity, shale oil and shale coke, peat briquette, wood chips). The national goal in this field is continuous rise of the efficiency of the energy sector and as efficient as possible use of energy.

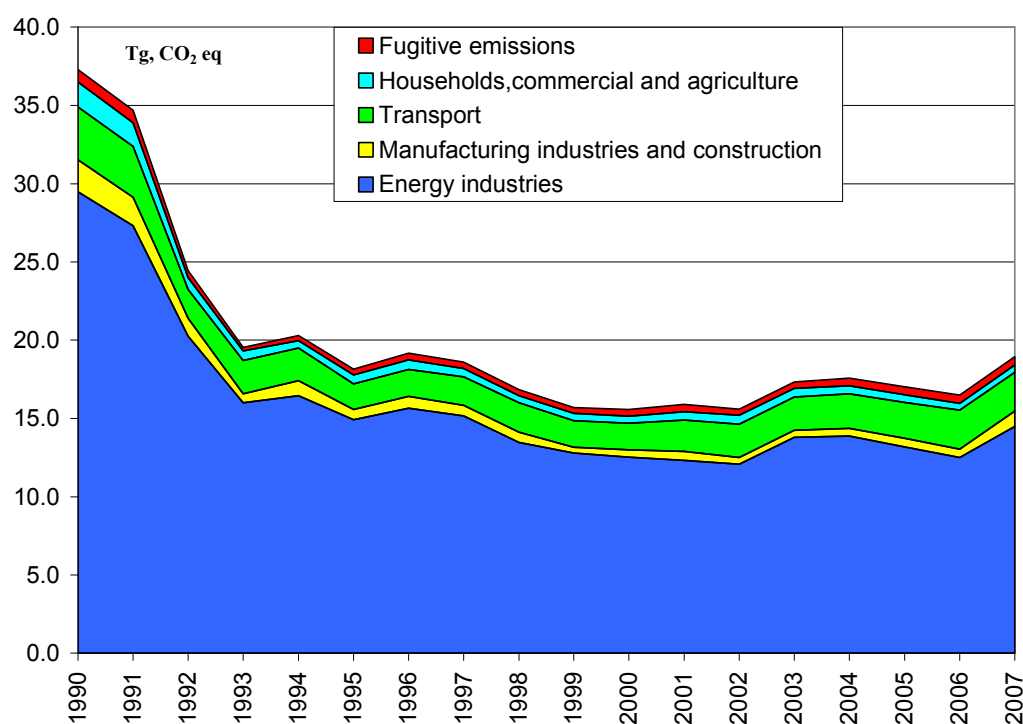


Figure 2.4. Emissions from the energy sector by subcategory in 1990-2007 (Tg CO₂ eq.)

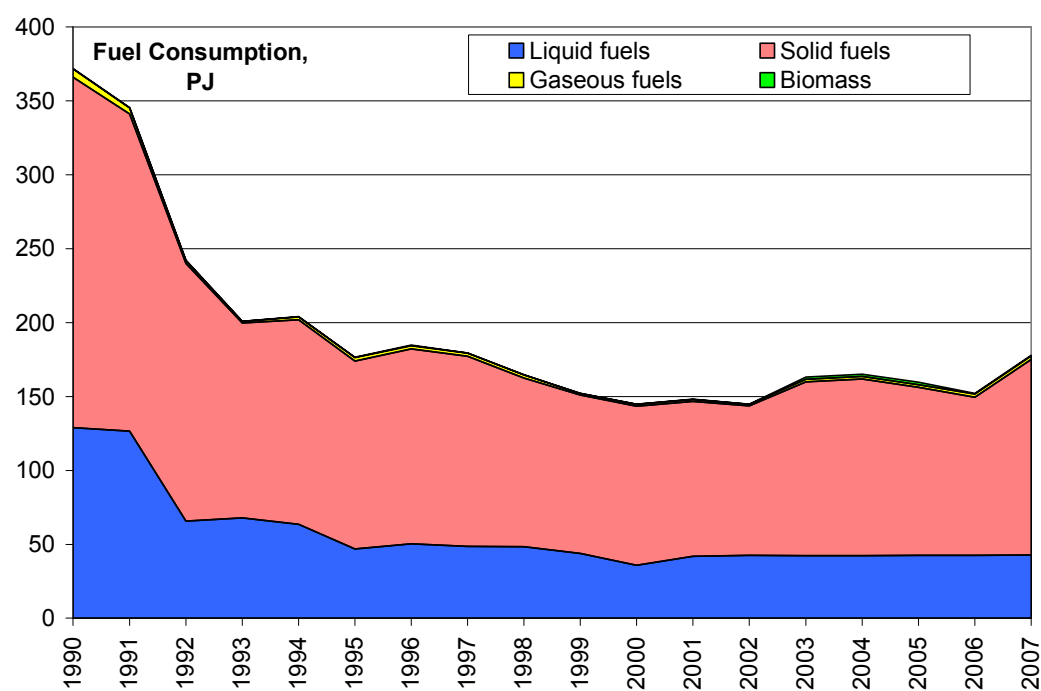


Figure 2.5. Consumption of fuels in 1990-2007, PJ

Table 2.1. Emissions from the energy sector in 1990–2007 by subcategory and gas (Tg, CO₂ eq).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1. Energy	37.29	34.68	24.45	19.54	20.29	18.15	19.16	18.59	16.84	15.70	15.57	15.90	15.59	17.33	17.58	17.03	16.48	19.09
A. Fuel combustion	36.49	33.89	23.98	19.31	19.96	17.78	18.74	18.18	16.45	15.33	15.14	15.44	15.20	16.91	17.08	16.51	15.96	18.57
CO ₂	36.34	33.75	23.88	19.21	19.84	17.60	18.54	17.98	16.28	15.16	14.97	15.25	15.02	16.71	16.88	16.31	15.76	18.34
CH ₄	0.09	0.09	0.07	0.06	0.08	0.13	0.14	0.14	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.10	0.10	0.12
N ₂ O	0.06	0.06	0.04	0.04	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.08	0.08	0.09	0.10	0.10	0.11
B. Fugitive fuel emissions, CH ₄	0.79	0.79	0.46	0.23	0.33	0.38	0.42	0.41	0.38	0.37	0.43	0.46	0.39	0.42	0.50	0.52	0.52	0.52

The energy sector releases three greenhouse gases, carbon dioxide (CO₂) and small amounts of methane (CH₄) and nitrous oxide (N₂O). Energy related CO₂ emissions vary mainly according to the energy supply structure and climate conditions. As suggested in the IPCC 1996 guidelines, the emissions in the energy sector are divided into emissions from fossil fuel combustion (CRF 1.A) and fugitive emissions from fuels (CRF 1.B).

2.2. Emissions from fuel combustion (CRF 1.A)

Description

The emissions from fuel combustion comprise all fuel combustion, including point sources, transport and other fuel combustion. Direct and indirect GHGs (CO₂, CH₄, N₂O, CO, NMVOC, NO_x) as well as SO₂ are reported. Emissions from fuel combustion in the energy sector are divided into four subcategories as follows:

CRF 1.A 1 - Energy Industries

CRF 1.A 2 - Manufacturing industries and construction

CRF 1.A 3 - Transport

CRF 1.A 4 - Other sectors (including Commercial, Residential and Agriculture/Forest/Fishery sectors)

Quantitative overview

CO₂ emissions from fossil fuel combustion (18.57 Tg) accounted for 97.3% of the energy sector's total emissions and 84.3% of total greenhouse gas emissions in 2007.

The portion of CH₄ emissions from fuel combustion in 2007 was about 0.65% and is mainly due to the incomplete combustion of wood fuels (small combustion). N₂O emissions from fuel combustion are relatively small - about 0.59%. N₂O emissions come mainly from energy industries and transport sectors (Table 2.2).

Table 2.2. Emissions from fuel combustion in Estonia in 1990-2007 (Tg CO₂ eqv.).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1. Energy	37.29	34.68	24.45	19.54	20.29	18.15	19.16	18.59	16.84	15.70	15.57	15.90	15.59	17.33	17.58	17.03	16.48	19.09
1.A Fuel combustion total	36.49	33.89	23.98	19.31	19.96	17.78	18.74	18.18	16.45	15.33	15.14	15.44	15.20	16.91	17.08	16.51	15.96	18.57
CO₂																		
1. Energy Industries	29.45	27.27	20.24	15.98	16.44	14.90	15.63	15.13	13.43	12.78	12.51	12.30	12.05	13.77	13.86	13.16	12.48	14.46
2. Manufacturing	2.03	1.84	1.14	0.58	0.95	0.65	0.76	0.68	0.66	0.36	0.47	0.58	0.42	0.44	0.47	0.54	0.54	1.00
3. Transport	3.35	3.21	1.81	2.09	2.06	1.62	1.68	1.79	1.84	1.66	1.64	1.93	2.08	2.09	2.15	2.22	2.41	2.54
4. Other Sectors	1.52	1.43	0.69	0.56	0.39	0.43	0.47	0.38	0.34	0.35	0.35	0.44	0.47	0.42	0.39	0.40	0.34	0.35
CH₄	0.09	0.09	0.07	0.06	0.08	0.13	0.14	0.14	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.10	0.10	0.12
N₂O	0.06	0.06	0.04	0.04	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.08	0.08	0.09	0.10	0.10	0.11

Methods

Emissions from fuel combustion (CRF 1.A 1-1.A 4) are in general calculated by multiplying fuel consumption with either a fuel type-specific emission factor or technology-specific emission factor. When calculating CO₂ emissions, adjustment the fraction of carbon oxidised is included. Calculations of all emissions from fuel combustion are done with the Excel Work Tables created by energy sector expert.

Key Categories

Several emission sources in the energy combustion sector are key categories. The key categories in 2007 by level and trend and with and without LULUCF are listed in the Table 2.3 (there are identical).

Table 2.3. Key categories in Energy combustion (CRF 1.A) in 2007 (L=Level, T=Trend without LULUCF) (quantitative method used: Tier 1).

IPCC code	IPCC source category	Fuel	Gas	Identification criteria
1 A 1 a	Public Electricity and Heat Production	Gaseous Fuels	CO ₂	T, L
1 A 1 a	Public Electricity and Heat Production	Liquid Fuels	CO ₂	T, L
1 A 1 a	Public Electricity and Heat Production	Solid Fuels	CO ₂	T, L
1 A 1 b	Petroleum refining	Solid Fuels	CO ₂	T, L
1 A 2 c	Manufacturing and Construction /Chemicals	Gaseous Fuels	CO ₂	T
1 A 2 e	Food Processing, Beverages and Tobacco	Liquid Fuels	CO ₂	T
1 A 2 f	Manufacturing and Construction /Other	Gaseous Fuels	CO ₂	T, L
1 A 2 f	Manufacturing and Construction /Other	Liquid Fuels	CO ₂	L
1 A 2 f	Manufacturing and Construction /Other	Solid Fuels	CO ₂	T, L
1 A 3 b	Transport/Road Transportation	Diesel oil	CO ₂	T, L
1 A 3 b	Transport/Road Transportation	Gasoline	CO ₂	T, L
1 A 3 b	Transport/Road Transportation	Gasoline	N ₂ O	T
1 A 3 c	Transport/Railways	Liquid Fuels	CO ₂	T, L
1 A 3 e	Other Transportation	Liquid Fuels	CO ₂	T, L
1 A 4 a	Other Sectors/Commercial/Institutional	Gaseous Fuels	CO ₂	T
1 A 4 b	Other Sectors/Residential	Biomass	CH ₄	T, L
1 A 4 b	Other Sectors/Residential	Gaseous Fuels	CO ₂	T, L
1 A 4 b	Other Sectors/Residential	Liquid Fuels	CO ₂	T
1 A 4 b	Other Sectors/Residential	Solid Fuels	CO ₂	T
1 B 2 b	Fugitive Emissions from Fuels / Natural Gas	Gaseous Fuels	CH ₄	T, L

Table 2.4. Key categories in Energy combustion (CRF 1.A) in 2007 (L=Level, T=Trend with LULUCF) (quantitative method used: Tier 1).

IPCC code	IPCC source category	Fuel	Gas	Identification criteria
1 A 1 a	Public Electricity and Heat Production	Gaseous Fuels	CO ₂	T, L
1 A 1 a	Public Electricity and Heat Production	Liquid Fuels	CO ₂	T, L
1 A 1 a	Public Electricity and Heat Production	Solid Fuels	CO ₂	T, L
1 A 1 b	Petroleum refining	Solid Fuels	CO ₂	T, L
1 A 2 c	Manufacturing and Construction /Chemicals	Gaseous Fuels	CO ₂	T
1 A 2 e	Food Processing, Beverages and Tobacco	Liquid Fuels	CO ₂	T
1 A 2 f	Manufacturing and Construction /Other	Gaseous Fuels	CO ₂	T, L
1 A 2 f	Manufacturing and Construction /Other	Liquid Fuels	CO ₂	T, L
1 A 2 f	Manufacturing and Construction /Other	Solid Fuels	CO ₂	T, L
1 A 3 b	Transport/Road Transportation	Diesel oil	CO ₂	T, L
1 A 3 b	Transport/Road Transportation	Gasoline	CO ₂	T, L
1 A 3 c	Transport/Railways	Liquid Fuels	CO ₂	L
1 A 3 e	Other Transportation	Liquid Fuels	CO ₂	L
1 A 4 b	Other Sectors/Residential	Liquid Fuels	CO ₂	T
1 A 4 b	Other Sectors/Residential	Solid Fuels	CO ₂	T
1 A 4 b	Other Sectors/Residential	Biomass	CH ₄	T
1 A 4 b	Other Sectors/Residential	Gaseous Fuels	CO ₂	T, L

2.2.1. Energy Industries and Manufacturing Industries and Construction (CRF1.A.1, CRF1.A.2)

2.2.1.1. Source category description

Energy Industries (CRF1.A.1) and Manufacturing Industries and Construction (CRF1.A.2) include emissions from fuel combustion in point sources in energy production and industrial sectors (power plants, boilers and industrial plants with boilers and/or other combustion). The emissions from energy industries by relevant subcategories and gases in 1990-2007 are presented in the Table 2.5. The Figure 2.6 presents the trend of GHG emissions from Energy Industries by relevant subcategories in 1990 to 2007.

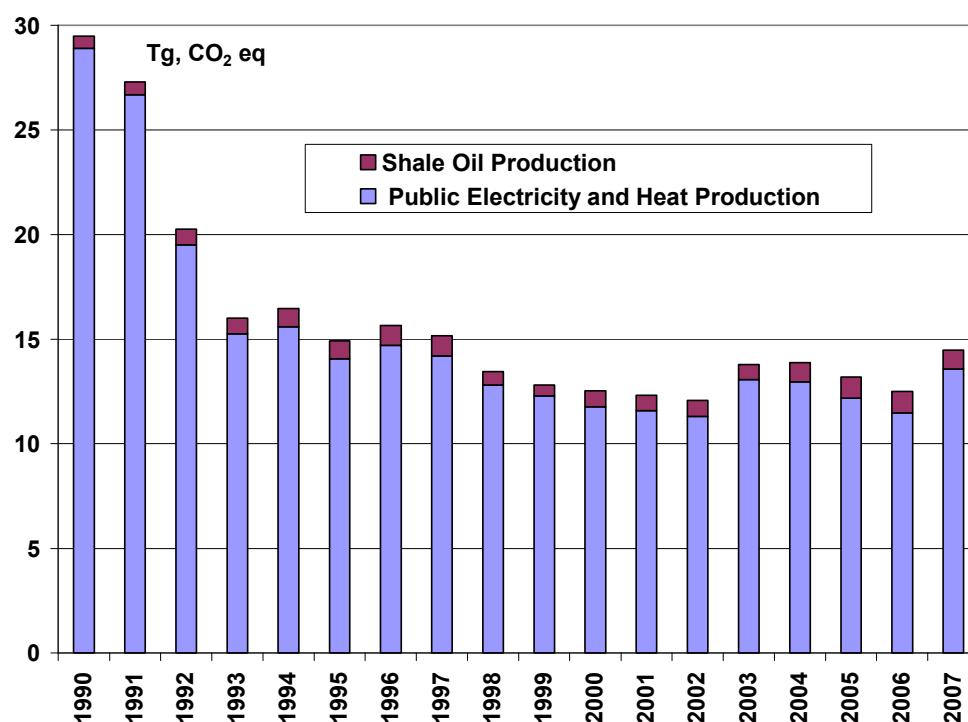


Figure 2.6. Trend of GHG emissions from Energy Industries by relevant subcategories in 1990-2007 (Tg CO₂ eq)

The emissions from manufacturing industries and construction by relevant subcategories and gases in 1990-2007 are presented in Table 2.6.

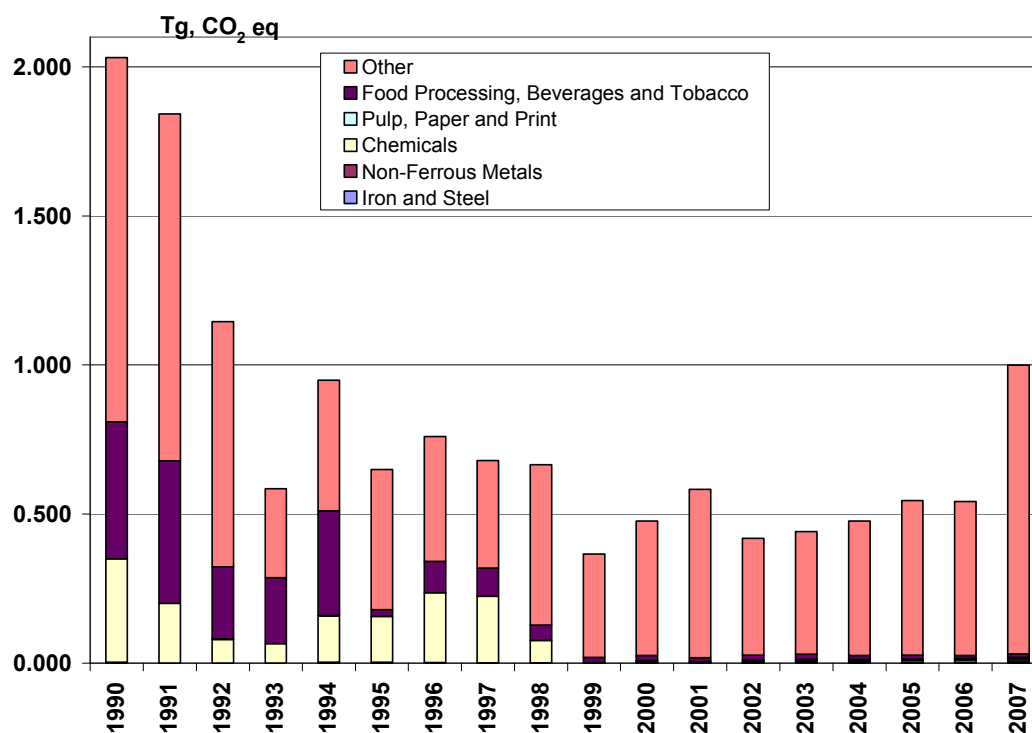


Figure 2.7. Trend of emissions GHG from manufacturing industries and construction by relevant subcategories in 1990-2007

In Estonia, the Manufacturing Industries and Construction sector's sub-category **1.A.2.f Other** includes following sub-sectors: "Production of other non-metallic minerals"; "Production of transport equipment"; "Machinery"; "Mining and quarrying"; "Production of wood and wood products construction"; "Textile, leather and clothing industry" and "Other industry".

Table 2.5. The emissions from Energy Industries by relevant subcategories and gases in 1990-2007 (Tg, CO₂ eq.)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
CO₂ eq.																		
1. Energy industries	29.48	27.29	20.26	15.99	16.46	14.92	15.65	15.15	13.45	12.80	12.53	12.32	12.07	13.79	13.88	13.19	12.50	14.48
CO ₂ a. Public Electricity and Heat Production	28.87	26.65	19.48	15.23	15.58	14.04	14.68	14.17	12.78	12.27	11.75	11.55	11.29	13.05	12.93	12.15	11.45	13.55
CO ₂ b. Shale Oil Production	0.58	0.62	0.76	0.74	0.86	0.86	0.94	0.96	0.65	0.51	0.76	0.74	0.75	0.72	0.93	1.02	1.03	0.91
CH ₄ 1. Energy Industries	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
N ₂ O 1. Energy Industries	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01

* Petroleum refining - there is no oil refining in Estonia. Under this sub-category emissions from oil shale processing for shale oil production are reported.

Table 2.6. The emissions from Manufacturing Industries and Construction by relevant subcategories and gases in 1990-2007 (Tg, CO₂ eq.)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
CO₂ eq.																		
2. Manufacturing Industries and Construction	2.03	1.84	1.14	0.59	0.95	0.65	0.76	0.68	0.66	0.37	0.48	0.58	0.42	0.44	0.48	0.54	0.54	1.00
CO ₂ a. Iron and Steel	0.003	0.000	0.000	0.000	0.004	0.003	0.002	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.002	0.001
CO ₂ b. Non-Ferrous Metals	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.002	0.000	0.002	0.001	0.001	0.006
CO ₂ c. Chemicals	0.346	0.200	0.079	0.065	0.155	0.154	0.233	0.223	0.075	0.001	0.004	0.002	0.004	0.006	0.006	0.006	0.007	0.007
CO ₂ d. Pulp, Paper and Print	0.000	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.004	0.003	0.004	0.005	0.005
CO ₂ e. Food Processing, Beverages and Tobacco	0.458	0.476	0.241	0.220	0.350	0.021	0.106	0.094	0.051	0.017	0.017	0.013	0.016	0.016	0.013	0.013	0.009	0.012
CO ₂ f. Other	1.218	1.161	0.820	0.298	0.437	0.469	0.418	0.360	0.537	0.346	0.449	0.562	0.390	0.407	0.446	0.515	0.514	0.965
CH ₄ 2. Manufacturing Industries and Construction	0.002	0.001	0.000	0.001	0.000	0.001	0.001	0.001	0.000	0.001	0.001	0.001	0.002	0.002	0.002	0.001	0.002	0.00
N ₂ O 2 Manufacturing Industries and Construction	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.003	0.003	0.001	0.003	0.00

2.2.1.2. Methodological issues

Methods

Emissions from fuel combustion are in general calculated by using the methodology of the IPCC 1996 Guidelines. Different tiers have been applied for different fuels and gases.

For imported fuels Tier 1 approach has been applied. For domestic fuel – Oil Shale Tier3 and all fuels made from Oil Shale (Shale Oil, Oil Shale Semi-coke and Oil Shale Gas) Tier 2 approaches were used.

Tier 1 for CO₂ emissions:

CO₂ EMISSIONS FROM STATIONARY COMBUSTION

$$Emission_{fuel} = Fuel\ Consumption_{fuel} \cdot Emission\ Factor_{fuel} \cdot Oxidation\ Factor_{fuel}$$

Where:

Emission _{fuel}	= emissions of CO ₂ by type of fuel (Gg)
Fuel Consumption _{fuel}	= amount of fuel combusted (TJ)
Emission Factor _{fuel}	= default emission factor of CO ₂ by type of fuel (tC/TJ)
Oxidation Factor _{fuel}	= fuel specific oxidation factor

For other GHG:

GREENHOUSE GAS EMISSIONS FROM STATIONARY COMBUSTION

$$Emission_{GHG, fuel} = Fuel\ Consumption_{fuel} \cdot Emission\ Factor_{GHG, fuel}$$

Where:

Emissions _{GHG, fuel}	= emissions of a given GHG by type of fuel (Gg)
Fuel consumption _{fuel}	= amount of fuel combusted (TJ)
Emission Factor _{GHG, fuel}	= <u>default</u> emission factor of a given GHG by type of fuel (tC/TJ).

Tier 2 for CO₂ emissions:

CO₂ EMISSIONS FROM STATIONARY COMBUSTION

$$Emission_{fuel} = Fuel\ Consumption_{fuel} \cdot Emission\ Factor_{fuel} \cdot Oxidation\ Factor_{fuel}$$

Where:

Emission _{fuel}	= emissions of CO ₂ by type of fuel (Gg)
Fuel Consumption _{fuel}	= amount of fuel combusted (TJ)
Emission Factor _{fuel}	= <u>country specific</u> emission factor of CO ₂ by type of fuel (tC/TJ)
Oxidation Factor _{fuel}	= fuel specific oxidation factor

GREENHOUSE GAS EMISSIONS FROM STATIONARY COMBUSTION

$$Emission_{GHG, fuel} = Fuel\ Consumption_{fuel} \cdot Emission\ Factor_{GHG, fuel}$$

Where:

Emissions _{GHG, fuel}	= emissions of a given GHG by type of fuel (Gg)
Fuel consumption _{fuel}	= amount of fuel combusted (TJ)
Emission Factor _{GHG, fuel}	= <u>country specific</u> emission factor of a given GHG by type of fuel (tC/TJ).

Tier 3 for CO₂ emissions:

CO₂ EMISSIONS FROM STATIONARY COMBUSTION

$$Emission_{fuel, technology} = Fuel\ Consumption_{fuel, technology} \cdot Emission\ Factor_{fuel, technology} \cdot Oxidation\ Factor_{fuel}$$

Where:

Emissions _{GHG, fuel, technology}	= emissions of a given GHG by type of fuel and technology (Gg)
Fuel consumption _{fuel, technology}	= amount of fuel combusted by each technology (TJ)
Emission Factor _{GHG, fuel, technology}	= <u>technology specific</u> emission factor of a given GHG by type of fuel (tC/TJ).
Oxidation Factor _{fuel}	= fuel specific oxidation factor

GREENHOUSE GAS EMISSIONS BY TECHNOLOGY

$$Emission_{GHG, fuel, technology} = Fuel Consumption_{fuel, technology} \cdot Emission Factor_{GHG, fuel, technology}$$

GREENHOUSE GAS EMISSIONS BY TECHNOLOGY

$$Emission_{GHG, fuel, technology} = Fuel Consumption_{fuel, technology} \cdot Emission Factor_{GHG, fuel, technology}$$

Where:

Emissions_{GHG, fuel, technology} = emissions of a given GHG by type of fuel and technology (Gg)

Fuel consumption_{fuel, technology} = amount of fuel combusted by each technology (TJ)

Emission Factor_{GHG, fuel, technology} = technology specific emission factor of a given GHG by type of fuel (tC/TJ).

Oil Shale

As oil shale is the main indigenous fuel of Estonia, its short description is given below. Estonian oil shale as fuel is characterised by a high ash content (45-47%), a moderate content of moisture (11-13%) and sulphur (1.5-1.7%), a low net calorific value (8.3-8.7 MJ/kg) and a high content of volatile matter in the combustible part (up to 90%). The dry matter of Estonian oil shale is considered to consist of three main parts: organic, sandy-clay and carbonate ([Arvo Ots, 2004](#)).

Oil shale is produced in two qualities: with the grain size of 0÷25 mm and 25÷125 mm. The enriched lumpy oil shale (25÷125 mm) with higher calorific value is used in oil shale industry to produce oil shale oil (shale oil) and as fuel in cement kilns. About 77% of the mined oil shale (grain size 0÷25 mm) with lower calorific value is used as boiler fuel in large power plants. The net calorific value of oil shale is decreasing, because oil shale layers of the best quality have mostly been exhausted already.

From the point of view of greenhouse gas emissions it is important that during combustion of pulverised oil shale CO₂ is formed not only as a burning product of organic carbon, but also as a decomposition product of the ash carbonate part. Therefore, the total quantity of carbon dioxide increases up to 25% in flue gases of oil shale.

Two different combustion technologies, the old pulverised combustion of oil shale (PC) and the new circulated fluidised bed combustion (CFBC) technology are at present used in the Estonian Power Plants.

The first CFBC power unit (215 MW_{el}) started at the Eesti Power Plant at the end of 2003. The conducted tests showed that the transition at an oil shale power plant from pulverised combustion boilers to circulating fluidised bed boilers is accompanied by several changes: the CFBC boiler CO₂ discharge is merely 82-84% of that figure for pulverised combustion boilers, the carbonate decomposition rate was about 0.75 (sometimes even less), the SO₂ atmospheric discharges stopped almost completely ($k_s=0.999$), the boiler efficiency increased from 81-82% to ~90-95%, thus also the fuel consumption decreased, power production efficiency at nominal load was in the range 35-36%, versus 29-30% at oil shale fluidised bed combustion.

The second CFBC power unit (215 MW_{el}) started at the Narva PP in 2004. The successful operation of the new CFBC units allows continuing the construction of additional units.

A formula for the calculation of Estonian (pulverised combustion) oil shale carbon emission factor, taking into consideration the decomposition of its ash carbonate part and CO₂ binding at ash fields, is as follows:

$$CEF_{oil\ shale} = 10 \cdot [C_i^r + k \cdot (CO_2)_M^r \cdot 12/44] / Q_i^r [tC / TJ] \quad (1)$$

where:

Q_i^r – lower heating value oil shale, MJ/kg;

C_i^r – carbon content of oil shale, %;

$(CO_2)_M^r$ – mineral carbon dioxide content of oil shale, %;

k – decomposition rate of ash carbon part ($k = 0.64$ for pulverised combustion of oil shale).

In 2004, a new regulation of the Minister of the Environment for calculation the amount of carbon dioxide discharged into the atmosphere at oil shale power plants was issued ([Method..., 2006](#)).

Formula (1) gives:

$$CEF_{oil\ shale\ PC} = 10 \cdot (20.7 + 0.64 \cdot 17.7 \cdot 12 / 44) / 8.4 = 27.85\ tC/TJ$$

Where:

$$\text{Average heating value } Q_i^r = 8.40\ \text{MJ/kg};$$

$$\text{Mineral carbon dioxide content of oil shale } (CO_2)_M^r = 17.7\%;$$

$$\text{Carbon content of oil shale } C_t^r = 20.7\%;$$

k , decomposition rate of ash carbon part = 0.64 for pulverised combustion of oil shale.

With the introduction in 2004 of new power units with circulating fluidised bed (CFB) boilers at the Eesti and Balti Power Plants, the situation concerning the carbon emission factor has changed. Firing temperatures in CFB boilers are lower (780 – 820°C) than those in pulverised combustion (PC) boilers (>1400 C). This circumstance exerts a considerable influence on the intensity of carbonate decomposition.

The researchers of the Department of Thermal Engineering (DTE) of TUT recommend to use a new value of k for CFB boilers (0.40 instead of the previously used 0.64) ([Emissions of..., 2006](#)).

$$CEF_{oil\ shale\ CFB} = 10 \cdot (20.7 + 0.4 \cdot 17.7 \cdot 12 / 44) / 8.4 = 26.94\ tC/TJ$$

Therefore, the value of carbon emission factor for oil shale CFB combustion is lower than that for pulverised combustion.

It means that for National GHG Inventories emissions of CO₂ from pulverised combustion and circulating fluidised bed combustion boilers are calculated separately.

Shale oil

In Estonia, the oil shale thermal processing for shale oil production takes place in three plants: in **Kiviõli Keemiatööstuse OÜ** (*Kiviõli Oil Shale Processing and Chemicals Plant Ltd.*), in **Viru Keemia Grupp AS** (*Viru Chemistry Group Ltd.* in Kohtla-Järve) and in **Narva Power Plants AS** at the Eesti Power Plant.

There are two different technologies in use - since 1924 up to the present: the technology of processing large-particle oil shale in vertical retorts with gaseous heat carrier, and since 1980 that of processing fine-grained oil shale with solid heat carrier (SHC) are in operation. In Kohtla-Järve and Kiviõli vertical retorts and in the Narva PP the solid heat carrier technology is used.

The technology of processing oil shale in **vertical retorts** with gaseous heat carrier is universal technology and suitable for retorting high-calorific oil shale. The vertical retort is a metal vessel lined from inside with refractory bricks. The oil shale charging device and spent shale discharge chute and extractor are arranged on the top and in the lower part of the retort vessel, respectively. Thermal processing of oil shale takes place in retorting chambers in the cross flow of gaseous heat carrier. By influence of gases oil shale is warmed and dried up and after achieving needful temperature for retorting, the organic part of oil shale starts quickly to decompose. The mixture of the heat carrier with oil and water vapour moves into collector chambers, semi-coke (retorted oil shale) moves downward to cooling chambers. Oil vapour and gas are let out of the retort via outlet connections to condensation system. (J. Soone, S. Doilov, 2003). Cleaned generator gas is delivered to heating boilers for burning. Thermal processing of oil shale in vertical retorts takes place without any contact with the ambient atmosphere; therefore no pollutants are emitted.

In **Solid Heat Carrier installation (SHC)**, hot oil shale dust as a heat carrier is used. Pre-dried fine-grained oil shale with hot oil shale dust (800°C) is delivered to a horizontal rotating reactor where during just a few minutes the retorting process is occurring. The mixture of heat carrier with oil and water vapours moves into dust separation chamber. Oil vapours and gas are sent to the condensing chamber where the condensed oil is separated and semi-coke gas is sent for burning to power plant. Mixture of semi-coke and dust will delivered to an aerofountain combustor chamber, where semi-coke is burned and flue gases separated. The flue gases are partly used for pre-heating of oil shale in dryer but partly emitted into atmosphere. Dust is delivered to ash fields but partly back to the reactor.

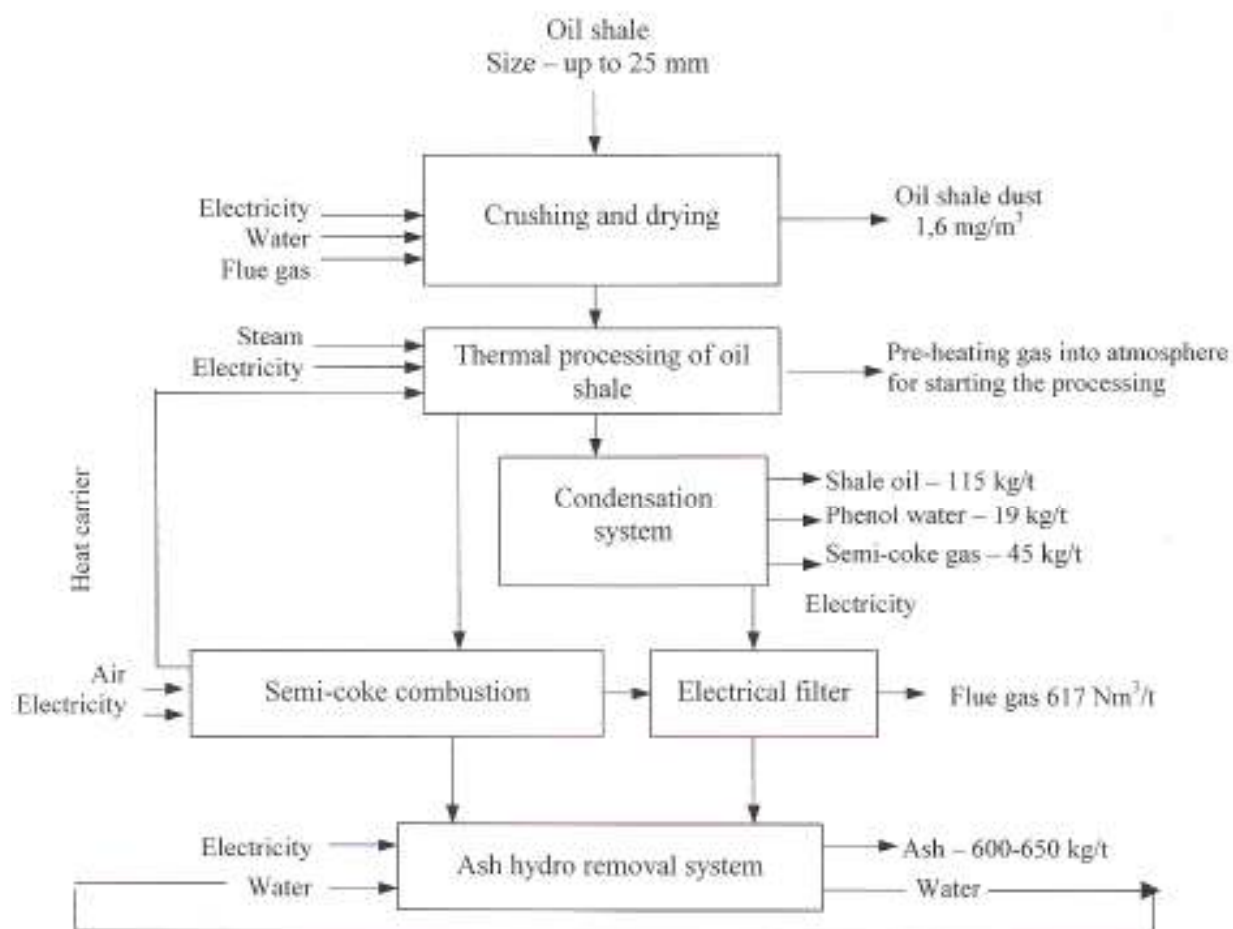


Figure 2.8 Thermal processing of oil shale for shale oil production in SHC

Therefore, in 2007, 33.27 PJ of shale oil was produced in total but only processing of 10.5 PJ of shale oil caused CO₂ emissions (see Table 2.7).

Table 2.7 Oil shale consumption for shale oil production by different technologies, PJ

Year	Oil shale for shale oil production	SHC Plant (Narva)	in vertical reactors (VKG)
1990	18.67	6.72	11.95
1991	19.89	7.16	12.73
1992	24.41	8.79	15.62
1993	23.85	8.59	15.26
1994	27.69	9.97	17.72
1995	27.70	9.97	17.73
1996	30.29	10.90	19.38
1997	30.85	11.10	19.74
1998	20.88	7.52	13.36

1999	16.44	5.92	10.52
2000	24.26	8.73	15.52
2001	25.67	8.58	17.10
2002	26.09	8.71	17.37
2003	29.03	8.27	20.75
2004	29.83	10.74	19.09
2005	31.73	11.74	19.99
2006	33.19	11.95	21.24
2007	33.27	10.50	22.73

Oil shale gas

Oil shale gas is a by-product of the thermal processing of oil shale. There are different types of oil shale gases depending on the technology used for oil shale processing. Oil shale gas as the by-product of oil shale thermal processing in solid heat carrier installation (SHC) is called as semi-coke gas and gas formed in the oil shale processing in vertical reactors (gas generators) called as generator gas. In the Table 2.8 the calorific values and CO₂ emission factors of different oil shale gases are presented.

Table 2.8. Calorific values and CO₂ emission factors of different oil shale gases

Plant/technology	Calorific value, MJ/nm³	Carbon Emission Factor, tC/TJ
Shale Oil Plant of Narva Power Plants		
Semi-coke gas (SHC -140 ² technology)	47.55	16.57
Viru Keemia Grupp AS (VKG), Kohtla-Järve		
Generator gas (vertical retort technology)	3.52	38.28

CO₂ emissions from the combustion of both oil shale gases are calculated separately and included into source-category CRF 1:A.1.a Energy Industry/Public Electricity and Heat Production.

CO₂ emission factors and other parameters

Both, country specific and IPCC default CO₂ emission factors are used in GHG emission calculations. CO₂ emission factors, oxidation factors and net caloric values of different fuels are

² SHC 140: solid heat carrier technology with oil yield 140 tons per hour

presented in Table 2.9 below. In order to improve the accuracy of the inventory, approximately some of the CO₂ factors were checked and updated for the current inventory.

Table 2.9. CO₂ emission factors, oxidation factors and net caloric values by fuel.

Fuels	NCV average	Unit	tC/TJ	Oxidation factor	Source
Liquid fuels					
LPG	45.52	GJ/t	17.2	0.99	D, IPCC 1996
Gasoline	43.99	GJ/t	18.9	0.99	D, IPCC 1996
Jet Kerosene, Aviation Gasoline	43.0	GJ/t	19.5	0.99	D, IPCC 1996
Other Kerosene (light fuel oil)	42.26	GJ/t	20.2	0.99	D, IPCC 1996
Shale Oil	39.22	GJ/t	21.1	0.99	CS, MoE 2006
Diesel Oil	42.26	GJ/t	20.2	0.99	D, IPCC 1996
Residual Fuel Oil (heavy fuel oil)	40.15	GJ/t	21.1	0.99	D, IPCC 1996
Solid fuels					
Anthracite	27.2	GJ/t	26.8	0.98	D, IPCC 1996
Oil Shale _{PC} *	8.87	GJ/t	27.85	0.98	CS, MoE 2006
Oil Shale _{FBC} **	8.87	GJ/t	26.94	0.98	CS, MoE 2006
Peat	8.7 – 12.0	GJ/t	28.9	0.98	D, IPCC 1996
Peat Briquette	16.0	GJ/t	28.9	0.98	D, IPCC 1996
Oil Shale Semi-coke	8.78	GJ/t	15.45	0.98	CS, Martins, A., 2007
Gaseous fuels					
Natural Gas	33.6	GJ/1000 m ³	15.3	0.995	D, IPCC1996
Oil Shale generator gas	3.52	GJ/1000 m ³	38.28	0.995	CS, Martins, A., 2007
Oil Shale semi-coke gas	47.55	GJ/1000 m ³	16.57	0.995	CS, Martins, A., 2007
Biomass fuels					
Solid Biomass (solid, includes e.g. firewood, bark, chips, sawdust and other industrial wood residues, pellets and briquettes)	6.13 – 16.92	GJ/m ³ s	29.9	0.98	D, IPCC 1996
Biogas (landfill gas)	19.73	GJ/1000 m ³	15.3	0.995	EE

* Oil Shale PC – pulverised combustion of oil shale

** Oil Shale FBC – fluidised bed combustion of oil shale

*** D - IPCC default value; CS – country specific

Sources:

EE: expert estimation

Martins, A., 2007: Research of Ants Martins, Tallinn University of Technology (not published).

IPCC 1996: Greenhouse ... Workbook, Vol. 2, 1996.

MoE 2006: Method for determining the amount of carbon dioxide discharged into the atmosphere. Regulation of the Minister of the Environment. State Gazette No 22, 11.2006, 85, 1546 (in Estonian).

The source of calorific values of different fuels is the Statistics Estonian (SE).

Emission Factors of non- CO₂ Gases from Fuel Combustion

The CH₄, N₂O, CO and NMVOC emission factors used in the Estonian inventory are mainly taken from the Revised 1996 IPCC Guidelines, but some emission factors and new data from national research were used as well. (Table 2.10 - Table 2.14).

Table 2.10. CH₄ from fuel combustion (kg/TJ)

	<i>Coal</i>	<i>Natural Gas</i>	<i>Oil</i>	<i>Wood</i>	<i>Coke</i>	<i>Peat/ Briquette</i>
Energy Industries	1	1	3	30	200	30
Manufacturing	10	5	2	30	200	30
Commercial	10	5	10	300	300	300
Residential	300	5	10	300	200	300
Agriculture (stationary)	300	5	10	300	200	300

Table 2.11. N₂O from fuel combustion (kg/TJ)

	<i>Coal</i>	<i>Natural Gas</i>	<i>Oil</i>	<i>Wood</i>	<i>Coke</i>	<i>Peat/ Briquette</i>
Energy Industries	1.4	0.1	0.6	4	4	4
Manufacturing	1.4	0.1	0.6	4	4	4
Commercial	1.4	0.1	0.6	4	1	4
Residential	1.4	0.1	0.6	4	1	4
Agriculture (stationary)	1.4	0.1	0.6	4	1	4

Table 2.12. NO_x from fuel combustion (kg/TJ)

	<i>Coal</i>	<i>Natural Gas</i>	<i>Oil</i>	<i>Wood</i>	<i>Oil Shale*</i>	<i>Peat/ Briquette</i>
Energy Industries	300	150	200	100		300
- pulverized combustion					110	
- fluidized bed combustion					0.06	
Manufacturing and Construction	300	150	200	100	110	300
Commercial	100	50	100	100		300

Residential	100	50	100	100		300
Agriculture (stationary)	100	50	100	100		300

Table 2.13. CO from fuel combustion (kg/TJ)

	<i>Coal</i>	<i>Natural Gas</i>	<i>Oil</i>	<i>Wood</i>	<i>Oil Shale*</i>	<i>Peat/ Briquette</i>
Energy Industries	20	20	15	1000	26	1000
Manufacturing and Construction	150	30	10	2000	87	4000
Commercial	2000	50	20	5000	87	5000
Residential	2000	50	20	5000	87	5000
Agriculture (stationary)	2000	50	20	5000	87	5000

Table 2.14. NMVOC from fuel combustion (kg/TJ)

	<i>Coal</i>	<i>Natural Gas</i>	<i>Oil</i>	<i>Wood</i>	<i>Oil Shale*</i>	<i>Peat/ Briquette</i>
Energy Industries	5	5	5	50		100
					60	pulverized combustion
					50	fluidized bed combustion
Manufacturing and Construction	20	5	5	50	50	100
Commercial	200	5	5	600		
Residential	200	5	5	600		
Agriculture (stationary)	200	5	5	600		

Source: IPCC 1996 Default values

* Country specific- (*Procedure...*, 2004)

Activity data

Activity data for GHG emission calculations are collected from several data sources. The main fuel consumption data by fuel types and final consumption sectors, including sub-sectors are received from the Energy Department of the Statistics Estonia. Those data are also presented in the Database of the Statistics Estonian www.stat.ee and added to the *Estonian National Inventory Report 1990-2007* (see Annex 3_I and Annex 3_II). Some detailed data (i.e. technology specific oil shale and semi-coke gas consumption in Narva power plants and shale oil production by the Narva Shale Oil Plant) are obtained from the energy company Eesti Energia AS. Fuel consumption in Energy Industries (CRF 1.A 1) and Manufacturing Industries and Construction (CRF 1.A 2) in 1990 - 2007 are presented in the Table 2.15 and on Figure 2.9 and Figure 2.10.

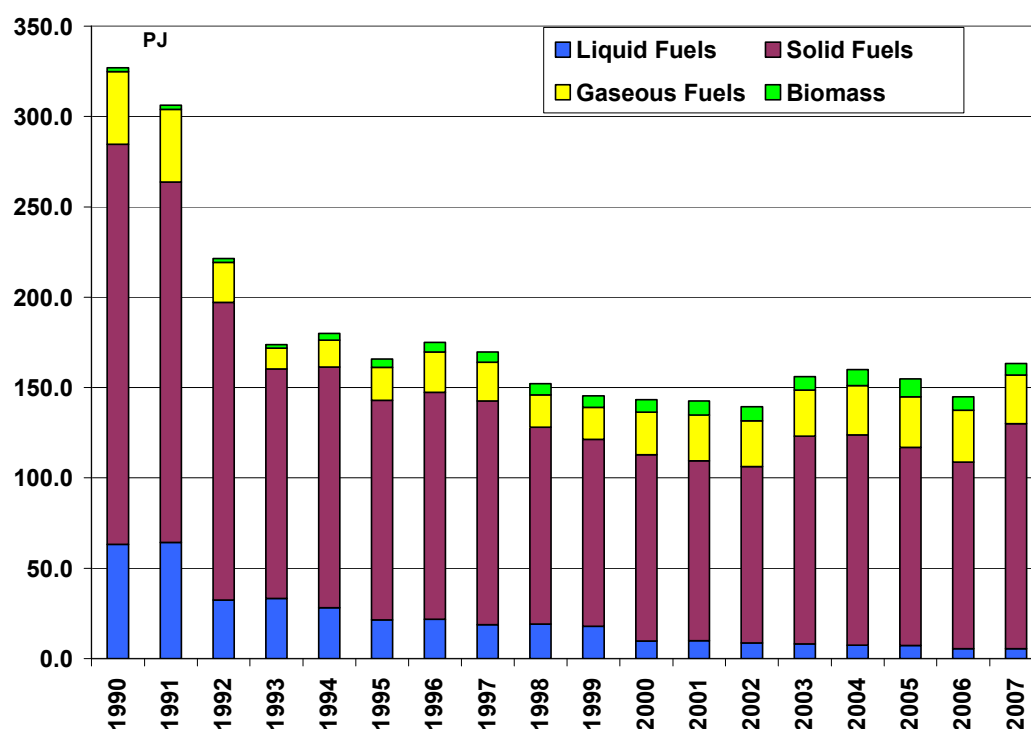


Figure 2.9. Trend of fuel consumption in Energy Industries, PJ

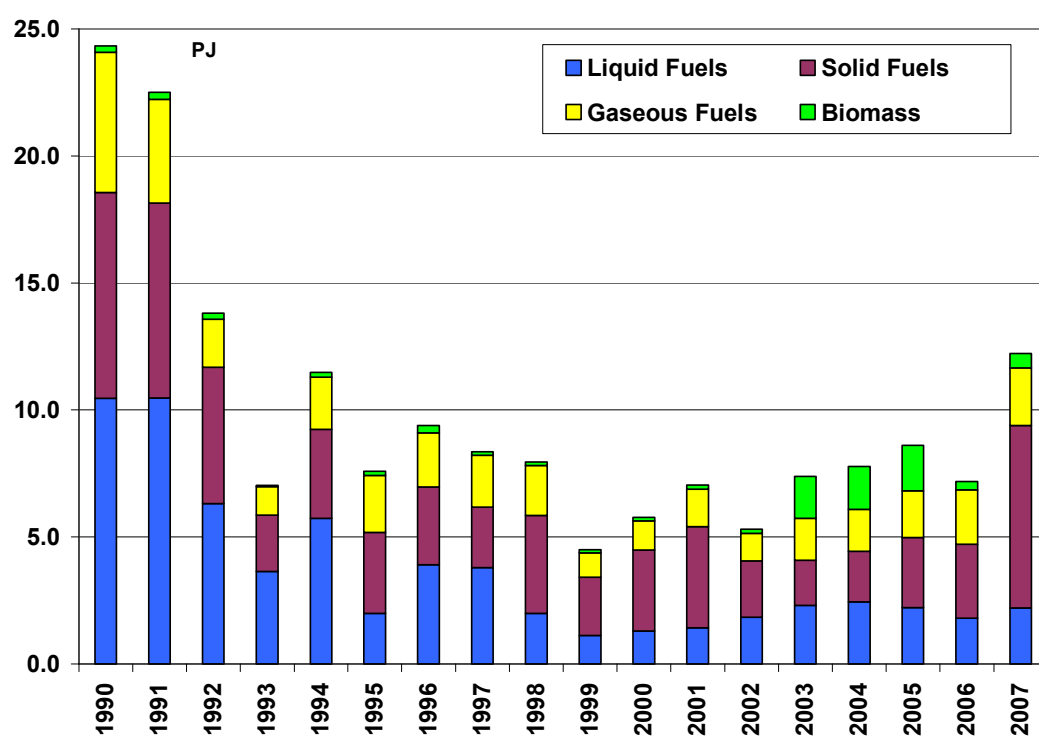


Figure 2.10. Trend of fuel consumption in Manufacturing Industries and Construction, PJ

Table 2.15. Fuel consumption in Energy Industries (CRF 1.A 1) and Manufacturing Industries and Construction (CRF 1.A 2) in 1990 - 2007 (PJ).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1.A.1 Energy Industries	327.1	306.3	221.5	173.8	179.9	165.7	174.9	169.6	152.1	145.3	143.2	142.5	139.4	156.2	159.8	154.7	144.9	163.4
Liquid Fuels	63.1	64.2	32.3	33.2	28.1	21.2	21.6	18.6	19.2	17.8	9.7	9.8	8.6	8.1	7.4	7.2	5.4	5.4
Solid Fuels	221.6	199.5	164.9	127.0	133.2	121.6	125.8	124.0	108.9	103.4	103.1	99.6	97.5	115.1	116.4	109.8	103.3	124.5
Gaseous Fuels	40.2	40.2	22.1	11.5	14.9	18.3	22.3	21.3	17.9	17.7	23.5	25.3	25.4	25.4	27.4	27.9	28.7	26.9
Biomass	2.2	2.3	2.2	2.0	3.7	4.6	5.2	5.6	6.2	6.4	6.9	7.8	7.8	7.6	8.7	9.9	7.5	6.5
1.A.2 Manufacturing Industries and Construction	24.3	22.5	13.8	7.0	11.5	7.6	9.4	8.4	8.0	4.5	5.8	7.0	5.3	7.4	7.8	8.6	7.2	12.2
Liquid Fuels	10.5	10.5	6.3	3.6	5.7	2.0	3.9	3.8	2.0	1.1	1.3	1.4	1.8	2.3	2.5	2.2	1.8	2.2
Solid Fuels	8.1	7.7	5.4	2.2	3.5	3.2	3.1	2.4	3.8	2.3	3.2	4.0	2.2	1.8	2.0	2.7	2.9	7.2
Gaseous Fuels	5.5	4.1	1.9	1.1	2.1	2.2	2.1	2.0	2.0	1.0	1.1	1.5	1.1	1.7	1.6	1.8	2.2	2.3
Biomass	0.2	0.3	0.2	0.0	0.2	0.2	0.3	0.1	0.1	0.1	0.1	0.2	0.2	1.7	1.7	1.8	0.3	0.6

2.2.1.3. *Uncertainties and time series consistency*

Uncertainty evaluation of CO₂ emission has been conducted for four fuel types used in Estonia in 2007: liquid, solid, gaseous fuels and other fuels. The availability of data allows the estimation of uncertainty by a fuel type rather than by a sector in fuel combustion in Estonia.

Incomplete details of source-specific measurement data of activities and emission factors lead to the approach to estimate quantitative uncertainty of CO₂ emission in Estonia in 2007 by using available estimates and the combination of available measured data;

Data has been obtained from database of Statistics of Estonia.³

In estimation of uncertainty two main components have been considered:

- Uncertainty component due to measurement procedure which provides the comparability of results.
- Uncertainty component due to spread (dispersion) of the input quantity which, in some cases, indicates the level of disaggregating of the data.

•

The calculation formula of combined uncertainty in emission u_E is

$$u_E = \sqrt{u_{AD}^2 + u_{EF}^2},$$

where u_{AD} is the uncertainty estimation of activity data and u_{EF} is the uncertainty estimation of emission factor. In obtaining expanded uncertainty the coverage factor $k=2$ has been used to provide approximately 95 % confidence level of the results

$$U_E = 2 \cdot u_E.$$

The uncertainty in CO₂ emission due to fuel combustion in category Energy was evaluated separately by fuel types. The key points of the evaluation are listed below

- Liquid Fuels

All liquid fuels, except shale oil and residual fuel are imported to Estonia. Quality requirements for liquid fuels and instrumentation were used in evaluation of uncertainty of activity data and emission factors.

³ Statistics Estonia / Endla 15, 15174 Tallinn / Statistical information: Tel: + 372 625 9300, e-mail stat@stat.ee/ Contact Centre of respondents: Tel: +372 625 9100, e-mail klienditugi@stat.ee

- Solid Fuels

There are two fuel types produced locally: oil shale and peat. The largest contribution to the uncertainty is caused by fluctuation in emission factors of those fuels.

- Gaseous Fuels

The gaseous fuels are imported to Estonia. Quality requirements for gaseous fuels and instrumentation were used in evaluation of uncertainty of activity data and emission factors.

- Other Fuels

Comparably large value of emission factor for type 'Other fuels' was used due to lack of more explicitly data. On the other hand, the contribution to total uncertainty of fuel combustion from this type is rather small, i.e. 0.8 %.

The relative uncertainty of CO₂ emission due to fuel combustion was 8.2% (see Table 2.16). The largest uncertainty contribution of 30 % was caused by incomplete data of emission factor of other fuels. The uncertainty of CO₂ emission from the combustion of solid, liquid and gaseous fuels were: 10.8%, 2.5% and 3.9%, respectively.

Table 2.16. Estimated relative uncertainties of CO₂ emission due to fuel combustion in Estonia in 2007.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Gas	Uncertainty of activity data, %	Uncertainty of emission factor, %	Combined relative uncertainty, %
1.A. Fuel Combustion		2.5	7.8	8.2
Liquid Fuels	CO ₂	1.7	1.8	2.5
Solid Fuels	CO ₂	3.3	10.3	10.8
Gaseous Fuels	CO ₂	1.4	3.6	3.9
Other Fuels	CO ₂	5	30	30.4

In estimation of uncertainties in greenhouse gases CH₄ and N₂O the IPCC⁴ default values for activity data and emission factors: 5% and 25-75% were used, respectively.

⁴ Intergovernmental Panel on Climate Change Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories

Table 2.17. Summary of uncertainty estimates non-CO₂ (CH₄ and N₂O) emission factors and activity data (95% confidence interval)

Source and Sink	GHG	Activity data uncertainty U _A	Emission factor uncertainty U _E	Reference U _A , U _E
1.A.1 Energy Industries				
	CH ₄	5%	50%	IPCC Good ..., p. 2.41
	N ₂ O	3%	75%	IPCC Good ..., p. 2.41
1.A.2. Manufacturing Industries and Constructions				
	CH ₄	5%	50%	2006 IPCC, p. 2.41
	N ₂ O	3%	75%	2006 IPCC, p. 2.41
1.A.3. Transport				
	CH ₄	5%	40%	IPCC Good ..., p. 2.49
	N ₂ O	5%	50%	IPCC Good ..., p. 2.49 „
1.A.4. Other Sectors				
	CH ₄	5%	50%	IPCC Good ..., Table 2.6, p. 2.41
	N ₂ O	5%	50%	IPCC Good ..., Table 2.6, p. 2.41
1.B. FUGITIVE EMISSIONS from FUELS				
1.B.2.a Oil	CH ₄	5%	25%	IPCC Good ..., p. 2.92
1.B.2.b. Natural Gas	CH ₄	5%	25%	IPCC Good ..., p. 2.92
1.B.2.c. Venting	CH ₄	5%	25%	IPCC Good ..., p. 2.92

2.2.1.4. Source-specific QA/QC and verification

A complete Quality Assurance (QA) and Quality Control (QC) for Energy sector according to IPCC Tier 1 method was carried out (see also Individual Source Category Checklists in Annex 1). Each year activity data are checked according to corrections made by Statistics Estonia and CO₂ emissions recalculated, if necessary.

2.2.1.5. Source-specific recalculations

1. Corrected activity data: Statistical Office of Estonia has a practice to correct statistical data of previous years. In current GHG submission practically all activity data (1990-2006) are over checked and updated if necessarily.

2. In source categories CRF 1.A.1.a: Energy Industry/Public Electricity and Heat production/Gaseous fuels and CRF 1.AA.2.c Chemicals/Gaseous fuels, CO₂ emissions from combustion of oil shale gas have been recalculated for whole period 1990-2006. The reason of

recalculations is the changed value of carbon emission factor of oil shale gas. In previous inventory submissions CEF of oil shale gas like CEF for natural gas was taken equal to 15.3 tC/TJ. According to the newest research CO₂ emission factor of oil shale gas depends from production technology and is equal to 34.47 tC/TJ (in gas generators) or 16.57 tC/TJ (solid heat carrier technology).

3. Recalculations are made in sector CRF 1.A1.b Petroleum Refining (in Estonian case - oil shale processing for shale oil production).

Table 2.18. Recalculations in sub category CRF 1.A.1.b Petroleum refining, Gg CO₂

Year	Reported emissions of CO ₂ in NIR 1990–2006 (the 2008 submission)	Recalculated emissions of CO ₂ NIR 1990–2007 (the 2009 submission)
1990	369.33	581.61
1991	393.39	619.49
1992	482.80	760.29
1993	471.79	742.95
1994	547.81	862.66
1995	547.89	862.79
1996	599.12	943.47
1997	610.22	960.95
1998	412.99	650.36
1999	325.14	512.02
2000	479.86	755.66
2001	471.21	742.04
2002	478.79	753.97
2003	454.59	715.87
2004	590.18	929.39
2005	645.08	1015.83
2006	593.00	1034.00

2.2.1.6. Source-specific planned improvements

No source specific improvements are under active consideration at the moment.

2.2.2. Transport (CRF 1.A 3)

2.2.2.1. Source category description

Emissions from Transport (CRF 1.A 3) include all domestic transport sectors:

- Civil Aviation (CRF 1.A.3.a)
- Road Transport ((CRF 1.A.3.b)
- Railways (CRF 1.A.3.c)
- Domestic navigation (CRF 1.A.3.d)and
- Other transportation (mobile sources in agriculture sector) (CRF 1.A.3.e).

Road transport includes all transportation on the roads in Estonia. The types of vehicles with combustion engines are: cars, vans, buses, lorries, motorcycles and mopeds. The source category does not cover farm and forest tractors driving occasionally on the roads because they are included in the source-category 1.A.3.e other transportation.

Railway transport in Estonia includes railway transport operated by diesel locomotives. Domestic navigation includes the most important domestic waterway transport in Estonia: seagoing ships, icebreakers, working boats and leisure boats.

The emissions from civil aviation include all domestic civil aviation transport within Estonian flight information regions (mostly islands). Helicopters are not included in the calculations due to the small number of flights and the lack of emission factors (Table 2.20).

The share of greenhouse gas emissions from the transport sector compared with the total GHG emissions has increased since 1990. In 1990, the emissions from the transport sector were 8.1% of the total greenhouse gas emissions in Estonia. In 2007, the corresponding figure was 11.9%.

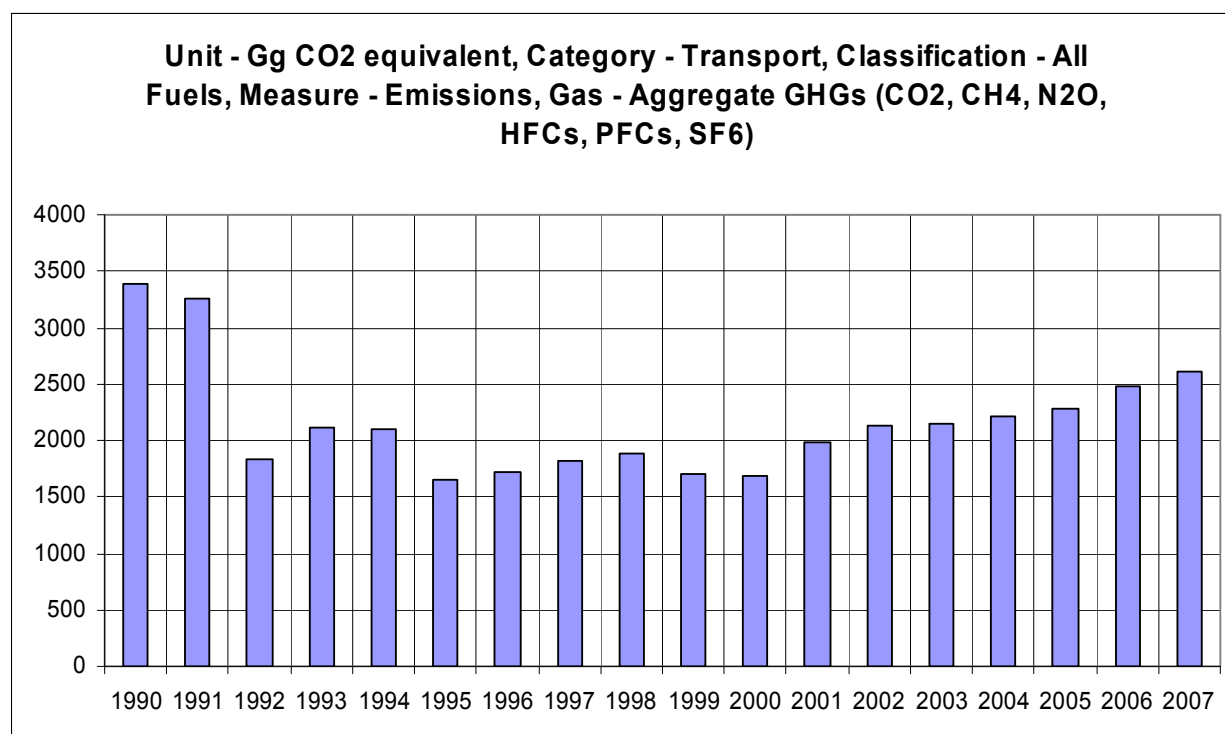


Table 2.19. Trend of GHG emissions from the Transport sector

Table 2.20. Emissions from the Transport sector in 1990–2007 by subcategories (Tg CO₂)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
CO₂ 3. Transport	3.35	3.21	1.81	2.09	2.06	1.62	1.68	1.79	1.84	1.66	1.64	1.93	2.08	2.09	2.15	2.22	2.41	2.54
a. Civil Aviation	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
b. Road transport	2.15	1.94	0.97	1.10	1.39	1.39	1.43	1.55	1.58	1.45	1.44	1.76	1.79	1.78	1.85	1.94	2.10	2.22
c. Railways	0.16	0.15	0.11	0.11	0.11	0.11	0.12	0.11	0.13	0.14	0.14	0.13	0.16	0.14	0.12	0.12	0.14	0.11
d. Navigation	0.58	0.68	0.40	0.63	0.41	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.05
e. Other transportation	2.15	1.94	0.97	1.10	1.39	1.39	1.43	1.55	1.58	1.45	1.44	1.76	1.79	1.78	1.85	1.94	2.10	2.22
CH₄, CO₂ eq	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
N₂O, CO₂ eq	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.07	0.07

Table 2.21. Fuel consumption in transportation sector, 1990-2007, PJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
a. Civil Aviation																		
Aviation																		
Gasoline	0.08	0.08	0.03	0.04	0.03	0.04	0.03	0.09	0.12	0.21	0.09	0.01	0.03	0.01	0.03	0.02	0.02	0.02
b. Road transport																		
Gasoline	21.31	19.17	8.98	9.57	12.40	10.61	11.68	12.98	12.46	11.92	12.01	14.33	13.15	12.61	12.15	12.40	13.48	14.15
Diesel Oil	9.21	8.36	4.76	5.98	7.24	9.02	8.50	8.95	9.86	8.57	8.37	10.54	12.10	12.45	13.80	14.79	16.01	17.10
LPG	0.14	0.09	0.09	0.03	0.17	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
Natural Gas	0.03	0.03	0.03	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0
c. Railways																		
Diesel Oil	1.95	1.84	1.36	1.41	1.45	1.43	1.54	1.41	1.78	1.96	1.84	1.70	2.20	1.91	1.69	1.53	1.85	1.53
Coal	0.12	0.14	0.05	0.05	0.06	0.04	0.06	0.04	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Other Fuels	0.11	0.09	0.05	0.00	0.02	0.02	0.01	0.01	0.00	0.00	0	0	0.01	0	0	0	0.00	0

d. Navigation																		
Residual Fuel																		
Oil	6.17	7.24	3.32	3.68	2.62	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0	0	0	0	0
Diesel Oil	1.44	1.72	2.04	4.64	2.88	0.17	0.30	0.26	0.25	0.23	0.32	0.30	0.45	0.35	0.36	0.34	0.47	0.74
e. Other transportation																		
Liquid Fuels	6.23	5.97	4.48	3.39	1.96	1.36	1.57	1.43	1.43	0.57	0.53	0.43	1.27	2.00	2.07	1.78	1.84	1.97
Biomass	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0	0.00	0	0	0	0	0	0	0	0

2.2.2.2. Methodological issues

Estimation of emissions from mobile sources is a very complex undertaking that requires consideration of many parameters, including transport class fuel consumed, operating characteristics, emission controls, maintenance procedures, fleet age etc.

Methods

Emissions can be estimated from either the fuel consumed (represented by fuel sold) or the distance travelled by the vehicles. In general, the first approach (fuel sold) is appropriate for CO₂ and the second (distance travelled by vehicle type and road type) is appropriate for CH₄ and N₂O.

In the current inventory report the emissions of CO₂ are calculated on basis of the amounts and type of fuel combusted and its carbon content. For calculation of CH₄ and N₂O emissions the second approach has been used.

The *Tier 1* approach calculates CO₂ emissions by multiplying the estimated fuel sold with a default emission factor. This approach can be expressed as:

$$\text{CO}_2 \text{ FROM ROAD TRANSPORT}$$

$$Emission = \sum_a [Fuel_a \cdot EF_a]$$

Where:

Emission = Emissions of CO₂ (Gg)

Fuel_a = fuel sold (TJ)

EF_a = emission factor (kg/TJ). This is equal to the carbon content of the fuel multiplied by 44/12.

a = type of fuel (e.g. petrol, diesel, natural gas, LPG etc).

The emission equation for Tier 3 is:

$$\text{TIER 3 EMISSIONS OF CH}_4 \text{ AND N}_2\text{O}$$

$$Emission = \sum_{a,b,c,d} [Distance_{a,b,c,d} \cdot EF_{a,b,c,d}] + \sum_{a,b,c,d} C_{a,b,c,d}$$

Where:

Emission = emission of CH₄ or N₂O (kg)

$EF_{a,b,c,d}$ = emission factor (kg/km)
 $Distance_{a,b,c,d}$ = distance traveled (VKT) during thermally stabilized engine operation phase for a given mobile source activity (km)
 $C_{a,b,c,d}$ = emissions during warm-up phase (cold start) (kg)
 a = fuel type (e.g., diesel, gasoline, natural gas, LPG)
 b = vehicle type
 c = emission control technology (such as uncontrolled, catalytic converter, etc.)
 d = operating conditions (e.g., urban or rural road type, climate, or other environmental factors).

Emission Factors

CO₂ emission factors used in Transport sector are the same as for fossil fuel combustion and given in the Table 2.8 and non-CO₂ emission factors are presented in the Table 2.10 and Table 2.11.

Activity data for calculation of CO₂ emissions from the Transport sector are received from the Statistics Estonian (www.stat.ee) and presented in the Table 2.21.

Road transportation

Methods

Emission estimations from road transportation are made using the IPCC Tier 1 method (for CO₂ emissions) model CH₄ and N₂O emissions and COPERT III model which corresponds to the IPCC Tier 3 method.

Calculation of CO₂ emissions from road transportation based is based on fuel consumption of road vehicles and fixed emission factors.

There has been a small amount of bioethanol and biodiesel blended in motor gasoline and diesel fuel in Estonia in recent years. In the present inventory these figures are included into total use of gasoline and diesel oil (as fossil origin). However, the share of non-fossil carbon is so small that

it has no effect on total GHGs. The subject will be studied further in the future, when there will be more significant amounts.

N₂O and CH₄ emissions are calculated for gasoline and diesel vehicles separately. The kilometrage (km/a) of each automobile type and model on different road types and in different speed classes are multiplied with corresponding CH₄ and N₂O emission factor. The calculation model COPERT III is located in the Environmental Information Centre.

Activity data

The activity data in CO₂ calculation is the amount fuel consumed in road traffic. Data on motor fuel consumption are received from the Statistics Estonia and are presented in the Table 2.21. For obtaining activity data for N₂O and CH₄ calculations, the Environmental Information Centre has concluded a contract to the Estonian Motor Vehicle Registration Centre.

Table 2.22. Number of vehicles in Estonia, thousand vehicles

	Cars	Vans	Lorries	Buses	MC and Mopeds	Vehicles total
1990	241	31	37	8	106	422
1991	261	35	42	9	100	447
1992	284	34	40	8	100	467
1993	317	34	40	9	97	497
1994	338	25	29	6	2	400
1995	383	30	35	7	3	459
1996	407	33	39	7	5	489
1997	428	35	41	6	5	516
1998	451	37	44	6	6	544
1999	459	36	45	6	7	553
2000	464	34	48	6	7	559
2001	407	37	44	6	9	502
2002	401	39	41	5	7	493
2003	434	41	42	5	8	531
2004	471	45	41	5	9	571
2005	494	47	39	5	10	595
2006	554	44	33	4	11	577
2007	524	46	33	4	15	622

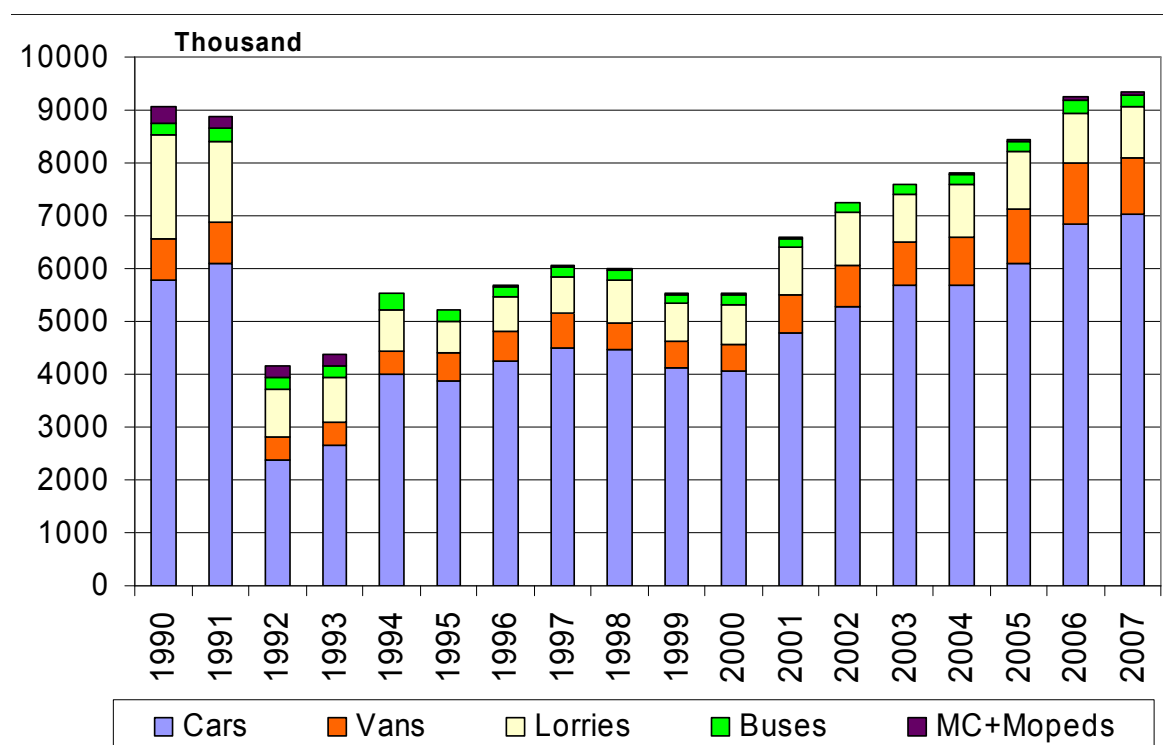


Figure 2.11. Number of vehicles, 1990-2007

Table 2.23. Road traffic kilometrage in Estonia (Million km/a)

	Cars	Vans	Lorries	Buses	MC+Mopeds	Vehicles total
1990	5791	765	1966	216	317	9055
1991	6104	777	1539	235	230	8886
1992	2378	450	885	227	230	4170
1993	2658	433	832	218	223	4365
1994	3995	435	796	313	5	5544
1995	3880	535	597	196	8	5215
1996	4236	587	656	193	11	5683
1997	4508	644	706	184	13	6055
1998	4455	504	835	182	14	5992
1999	4125	498	707	182	16	5528
2000	4060	497	752	204	16	5529
2001	4776	727	893	177	21	6596
2002	5274	799	1001	174	17	7265
2003	5689	822	892	179	21	7603
2004	5680	926	1001	186	24	7817
2005	6094	1030	1102	182	37	8445
2006	6830	1160	955	245	48	9238
2007	7034	1056	968	224	67	9348

Emission factors and other parameters

CO₂ emission factors are based on IPCC default values and presented in the Table 2.24.

Table 2.24. Emission factors, oxidation factors and net caloric values by fuel used in calculation of CO₂ emission from road transportation

Fuel type	NCV average	Unit	CO ₂ EF tC/TJ	Oxidation factor	Source
LPG	45.52	GJ/t	17.2	0.99	D, IPCC1996
Gasoline	43.99	GJ/t	18.9	0.99	D, IPCC1996
Diesel Oil	42.26	GJ/t	20.2	0.99	D, IPCC1996

Fuel type	CH ₄	N ₂ O	Source
LPG	5	0.2	D, IPCC1996
Gasoline	5	0.2	D, IPCC1996
Diesel Oil	5	0.2	D, IPCC1996

Civil Aviation

Methods

The *Tier 1* approach calculates CO₂ emissions by multiplying the estimated fuel (aviation gasoline) with a default emission factor. This approach can be expressed as:

$$\text{CO}_2 \text{ FROM NATIONAL AVIATION}$$

$$Emission = \sum_a [Fuel_a \cdot EF_a]$$

Where:

Emission = Emissions of CO₂ (Gg)

Fuel_a = fuel sold (TJ)

EF_a = emission factor (kg/TJ). This is equal to the carbon content of the fuel multiplied by 44/12.

a = type of fuel (e.g. aviation gasoline, jet kerosene).

For other GHG:

<p style="text-align: center;">GREENHOUSE GAS EMISSIONS FROM NATIONAL AVIATION</p> $Emission_{GHG, fuel} = Fuel\ Consumption_{fuel} \cdot Emission\ Factor_{GHG, fuel}$
--

Where:

Emissions_{GHG, fuel} = emissions of a given GHG by type of fuel (Gg)
 Fuel consumption_{fuel} = amount of fuel (TJ)
 Emission Factor_{GHG} = default emission factor of a given GHG (tC/TJ).

Activity data

The activity data on aviation gasoline used in national aviation are obtained from the Statistics Estonian and presented in the Table 2.21.

Emission factors and other parameters

Emission factors of the CO₂, CH₄, and N₂O used in the calculation of emissions from national aviation are taken from the Revised 1996 IPCC Guidelines are presented in the Table 2.25.

Table 2.25. Emission factors used in the calculation of emissions from national aviation

Fuel	NCV average, GJ/t	GHG	EF	Oxidation factor	Source
Jet Kerosene Aviation Gasoline	42.26	CO ₂	19.5 tC/TJ	0.99	D, IPCC1996
		CH ₄	0.5 kg/TJ		Table 1-7, v.3
		N ₂ O	2 kg/TJ		Table 1-8, v.3

Railway

All non-electric locomotives in Estonia use diesel oil or coal in Estonia. Since 2002 there is no coal burning locomotives in operation.

Methods

Emissions of railway transportation are calculated by multiplying the estimated fuel (diesel oil, coal, etc) with a default IPCC emission factor.

Activity data

The activity data on fuel consumption used in railway transportation are obtained from the Statistics Estonian and presented in the Table 2.21.

Emission factors and other parameters

Emission factors of the CO₂, CH₄, and N₂O used in the calculation of emissions from railway transportation are taken from the Revised 1996 IPCC Guidelines are presented in the Table 2.26.

Table 2.26. Emission factors used in the calculation of emissions from railway transportation

Fuel	NCV average, GJ/t	GHG	EF	Oxidation factor
Diesel Oil	42.26	CO ₂	20.2 tC/TJ	0.99
		CH ₄	5 kg/TJ	
		N ₂ O	0.6 kg/TJ	
Coal	27.2	CO ₂	26.8 tC/TJ	0.98
		CH ₄	5 kg/TJ	
		N ₂ O	1.4 kg/TJ	

Domestic Navigation

Methods

Emissions from domestic navigation are calculated by multiplying the estimated fuel (diesel oil, coal, etc) with a default IPCC emission factor.

Activity data

The activity data on fuel consumption used in domestic navigation are obtained from the Statistics Estonian and presented in the Table 2.21.

Emission factors and other parameters

Emission factors of the CO₂, CH₄, and N₂O used in the calculation of emissions from domestic navigation are taken from the Revised 1996 IPCC Guidelines are presented in the Table 2.27.

Table 2.27. Emission factors used in the calculation of emissions from domestic navigation

Fuel	NCV average, GJ/t	GHG	EF	Oxidation factor
Diesel Oil	42.26	CO ₂	20.2 tC/TJ	0.99
Residual Fuel Oil	40.15	CO ₂	21.1 tC/TJ	0.99
Gasoline	43.99	CO ₂	18.9 tC/TJ	0.99
		CH ₄	0.5 kg/TJ	
		N ₂ O	2 kg/TJ	

Other transportation

Under CRF Reporter sub-category 1.A.3.e GHG emissions from Agriculture mobile are reported (Table 2.20). Activity data are obtained from the Statistics Estonia and presented in the Table 2.21).

Emission factors of the CO₂, CH₄, and N₂O used in the calculation of emissions from other transportation are taken from the Revised 1996 IPCC Guidelines are presented in the Table 2.28.

Table 2.28. Emission factors used in the calculation of emissions from other transportation

Fuel	NCV average, GJ/t	GHG	EF	Oxidation factor
Diesel Oil	42.26	CO ₂	20.2 tC/TJ	0.99
Gasoline	43.99	CO ₂	18.9 tC/TJ	0.99
		CH ₄	0.5 kg/TJ	
		N ₂ O	2 kg/TJ	
Biomass	7.5	CH ₄	30 kg/TJ	
		N ₂ O	4 kg/TJ	

2.2.2.3. Source-specific recalculations

Recalculations in the Transport sector subcategory 1.A.3.b: Road transportation/Liquid fuels emissions of CH₄ and N₂O from combustion of gasoline and diesel oil is recalculated for whole time series (1990-2006). The reason of recalculations is the new method applied. In previous inventory submissions CH₄ and N₂O emissions from road transportations were calculated using fuel combustion emission factors for CH₄ and N₂O. In the current inventory report for calculation CH₄ and N₂O emissions from road transportation a special model COPERT III was used (Tier 3).

In CRF 1.A.3.d National aviation are made to specify fuel consumption in this subcategory. Activity data are obtained from the Statistics Estonia and presented in the Table 2.29. The second change in this sector is connected with reallocation of AD by fuel types. In previous NIR Aviation Gasoline for national aviation was reported wrongly in the Reporter source category Liquid Fuels/Jet Kerosene but in the current NIR under sub-category Liquid Fuels/Aviation Gasoline.

Table 2.29. Aviation Gasoline for National Aviation, TJ

Year	Reported AD in NIR 1990–2006 (the 2008 submission)	New AD in NIR 1990–2007 (the 2009 submission)
1990	197.8	78
1991	172	81
1992	43	26
1993	86	39
1994	86	32
1995	86	37
1996	86	34
1997	88	87
1998	118	118
1999	208	208
2000	91	91
2001	8	8
2002	34	34
2003	14	14
2004	30	30
2005	24	24
2006	132	17

2.2.2.4. Source-specific planned improvements

In next inventory there is planned to use COPERT model for calculation of CO₂ emissions from road transportation too. In the current inventory only N₂O and CH₄ emissions are calculated with this model.

In the current inventory GHG emissions from total landings and take off's (LTO) per year are not included into subcategory national aviation because of lack of activity data. The Environmental Information Centre has accurate data on aircraft types and operations per aircraft

type from all five Estonian airports since 2001 but earlier data have to be collected. In the next inventory emissions from LTO will be added into the total emissions from national aviation for whole time series.

2.2.3. Other Sectors (CRF 1.A.4)

2.2.3.1. Source category description

Sub-category CRF 1.A.4 includes emissions from the small combustion of fuels in the following sectors:

- 1.A.4.A Commercial/Institutional
- 1.A.4.B Residential (households)
- 1.A.4.C Agriculture/Forestry/Fisheries

2.2.3.2. Methodological issues

Methods

Emissions from sub-category CRF 1.A.4 are calculated by using the same methodology as for CRF 1.A.1 and 1.A.2 base on the IPCC 1996 Guidelines. See also chapter 2.2.1.2.

Activity data

The activity data for sub-category CRF 1.A.4 are taken from annual energy statistics (see Annex 3_I and Annex 3_II). It covers fuel used in commercial, institutional and residential and agricultural sectors. Motor fuels (*diesel oil and gasoline*) used in Residential sector are included into the sector CRF 1.A.3. b Road transportation and *diesel oil and gasoline* used in the Agriculture sector (Agriculture Mobile) in CRF 1.A.3. e Other Transportation.

The fuel consumption data for CRF 1.A.4 is presented in the Table 2.31.

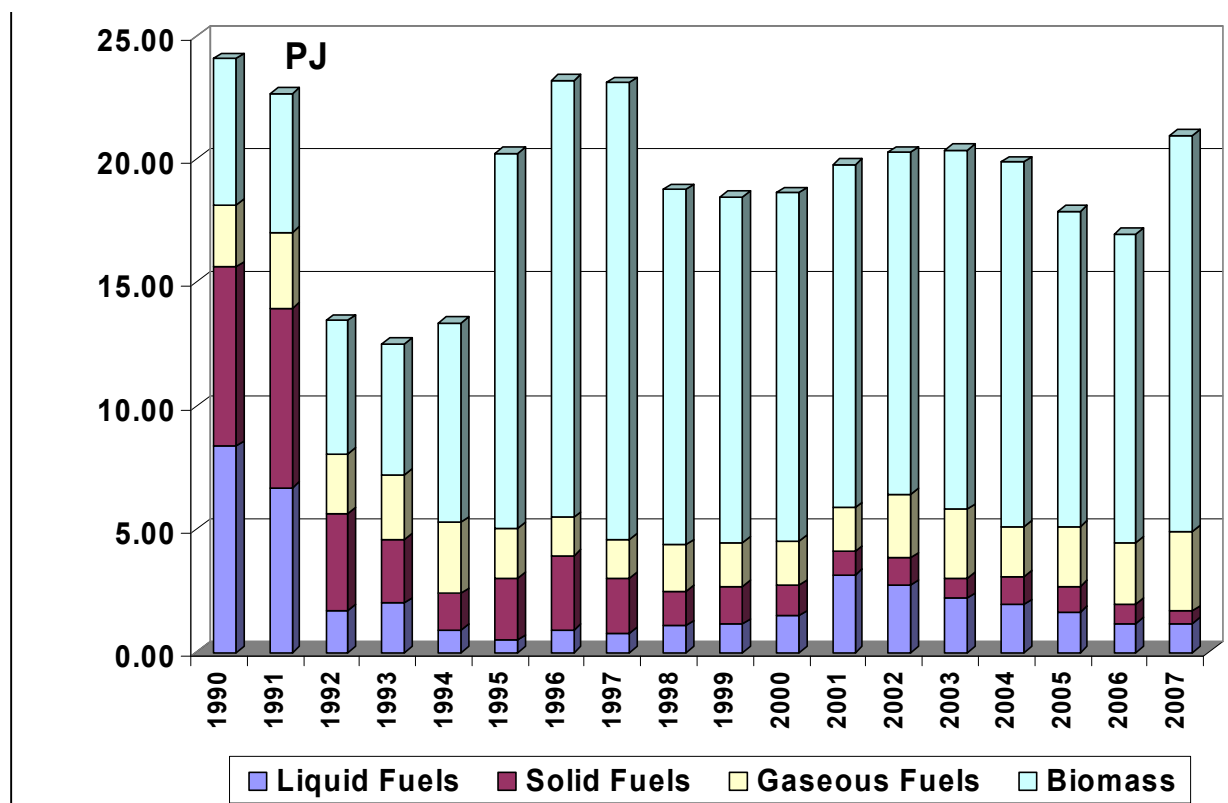


Figure 2.12. Fuel Consumption in the CRF categories 1.A.4 Other Sectors, PJ

Table 2.30. Emissions from Other Sectors (incl. Commercial/Institutional, Residential and Agriculture/Forestry/Fisheries) in 1990-2007, Tg CO₂ eqv.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
CO₂ eqv.																		
4. Other Sectors	1.60	1.51	0.75	0.62	0.46	0.56	0.62	0.53	0.45	0.46	0.46	0.55	0.58	0.53	0.51	0.49	0.43	0.47
CO ₂																		
Commercial/Institutional	0.09	0.09	0.04	0.01	0.02	0.03	0.02	0.02	0.03	0.03	0.03	0.04	0.09	0.11	0.09	0.10	0.08	0.11
CO ₂ Residential	1.36	1.27	0.60	0.47	0.35	0.38	0.43	0.34	0.28	0.31	0.28	0.23	0.24	0.20	0.23	0.23	0.21	0.18
CO ₂																		
Agriculture/Forestry/ Fisheries	0.07	0.07	0.04	0.08	0.02	0.02	0.02	0.02	0.03	0.01	0.04	0.17	0.14	0.10	0.08	0.07	0.05	0.05
CH ₄ , CO ₂ eq	0.06	0.06	0.05	0.05	0.06	0.11	0.12	0.12	0.10	0.09	0.09	0.09	0.09	0.09	0.10	0.08	0.08	0.10
N ₂ O, CO ₂ eq	0.02	0.01	0.01	0.01	0.01	0.02	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

Table 2.31. Fuel consumption in CRF categories 1.A 4 Other Sectors, TJ.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1.A.4. Other Sectors	24.7	23.4	13.9	12.7	13.5	20.6	23.4	23.3	19.0	18.7	18.9	20.1	20.5	20.6	20.3	18.4	17.4	21.4
Liquid Fuels	8.9	7.4	2.2	2.1	1.1	0.9	1.1	1.0	1.3	1.4	1.7	3.4	3.0	2.5	2.4	2.2	1.7	1.6
Solid Fuels	7.3	7.2	3.9	2.6	1.5	2.5	3.0	2.2	1.4	1.5	1.3	1.0	1.1	0.8	1.1	1.1	0.8	0.5
Gaseous Fuels	2.5	3.1	2.4	2.6	2.9	2.0	1.6	1.5	1.8	1.8	1.8	1.8	2.6	2.8	2.0	2.4	2.5	3.2
Biomass	5.9	5.6	5.4	5.3	8.1	15.2	17.7	18.5	14.4	14.0	14.1	13.9	13.8	14.6	14.8	12.7	12.5	16.1

Emission Factors

Both, IPCC and national (country specific) emission factors are used (see Table 2.9).

2.2.3.3. Source-specific recalculations

No source specific improvements are under active consideration at the moment.

2.3. Fugitive Emissions from Fuels (CRF 1.B)

2.3.1. Overview of the sector

Description

Under fugitive emissions from fuels, Estonia reports CH₄ emissions from: oil and natural gas handling, including the following activities:

- transmission and distribution of natural gas and oil products
- consumption of natural gas and
- CH₄ emissions from venting from oil production.

In 2007, fugitive emissions from natural gas and oil were 24.82 Gg CH₄ (521.14 Gg CO₂ eq.).

Table 2.32. Fugitive emission from oil and gas (Gg CO₂ eq.)

Year	Oil			Natural Gas		Venting (1.B.2.e)	Total CO ₂ eq
	Shale Oil production (1.B 2 a.2)	Oil transport (1.B 2 a.3)	Oil storage (1.B 2 a.4)	Natural gas transmission and distribution (1.B 2 b.3)	Other leakage (1.B 2 b.5)		
1990	0.02	0.20	0.05	23.47	14.02	0.02	793.17
1991	0.02	0.10	0.03	23.53	13.98	0.02	791.05
1992	0.04	0.06	0.02	13.75	8.06	0.04	461.32
1993	0.04	0.06	0.02	6.82	3.80	0.04	226.38
1994	0.05	0.07	0.02	9.79	5.58	0.05	326.83
1995	0.05	0.07	0.02	11.17	6.54	0.05	375.84
1996	0.05	0.07	0.02	12.32	7.30	0.05	416.03
1997	0.06	0.09	0.02	11.97	7.09	0.06	405.22
1998	0.03	0.09	0.02	11.36	6.68	0.03	382.60
1999	0.02	0.09	0.03	11.06	6.51	0.02	372.37
2000	0.04	0.04	0.01	12.71	7.51	0.04	427.16
2001	0.04	0.04	0.01	13.65	8.09	0.04	459.22
2002	0.04	0.05	0.01	11.43	6.76	0.04	385.01
2003	0.05	0.04	0.01	12.60	7.48	0.05	424.80

2004	0.05	0.05	0.02	14.87	8.85	0.05	501.52
2005	0.05	0.05	0.01	15.33	9.10	0.05	516.58
2006	0.06	0.06	0.02	15.52	9.21	0.06	523.27
2007	0.06	0.09	0.02	15.44	9.14	0.07	521.14

2.3.2. Oil and Natural Gas (CRF 1.B.2)

2.3.2.1. Source category description

Sources of fugitive emissions within oil and gas systems include releases during normal operation, such as emissions associated with venting, chronic leaks or discharge from process vents, emissions during maintenance, and emissions during system upsets and accidents. In Estonia, liquid fossil fuels and natural gas are mainly imported. Only shale oil is produced in Estonia.

2.3.2.2. Methodological issues

Methods

The equation for calculating CH₄ emissions from oil and gas activities is following:

$$CH_4 \text{ Emissions (Gg CH}_4) = \{Activity (PJ) \times Emission Factor (kg CH_4/PJ)\} / 10^6$$

Activity data

The activity data for sub-category CRF 1.B.2 are taken from the annual energy statistics (see Annex 3_I and Annex 3_II).

Emission factors and other parameters

Emission factors for calculating emissions of oil and gas activities are based on the default factors given in the Revised IPCC 1996 Guidelines (see Table 2.33).

Table 2.33. CH₄ emission factors for fugitive emissions from oil and gas activities

	Emission Factor	Unit	Source
OIL			
Production of Shale Oil	4 000	kg CH ₄ /PJ	D
Transport of oil products	745	kg CH ₄ /PJ	D
Storage of oil products	200	kg CH ₄ /PJ	D

GAS			
Transmission and distribution of natural gas	458 000	kg CH ₄ /PJ	D
Other Leakage			
Non-residential gas consumed	279 500	kg CH ₄ /PJ	D
Residential gas consumed	139 500	kg CH ₄ /PJ	D
Venting from oil production			
Oil (Shale Oil)	4000	kg CH ₄ /PJ	D

2.3.2.3. Quantitative overview

Table 2.34. CH₄ emissions from Oil and Gas activities, Gg

	1.B.2.A.2 Oil Production	1.B.2.A.3 Oil Transport	1.B.2.A.4 Oil Storage	1.B.2.A Total Oil	1.B.2.B.5 Other Leakage	1.B.2.B.3 Trans- mission	1.B.2.B Natural Gas	1.B.2.C Venting	1.B.2 Oil and Natural Gas	Fugitive emissions Gg CO₂ eq
1990	0.02	0.20	0.05	0.27	14.02	23.47	14.02	0.02	37.77	793.17
1991	0.02	0.10	0.03	0.15	13.98	23.53	13.98	0.02	37.67	791.05
1992	0.04	0.06	0.02	0.12	8.06	13.75	8.06	0.04	21.97	461.32
1993	0.04	0.06	0.02	0.12	3.80	6.82	3.80	0.04	10.78	226.38
1994	0.05	0.07	0.02	0.14	5.58	9.79	5.58	0.05	15.56	326.83
1995	0.05	0.07	0.02	0.14	6.54	11.17	6.54	0.05	17.90	375.84
1996	0.05	0.07	0.02	0.14	7.30	12.32	7.30	0.05	19.81	416.03
1997	0.06	0.09	0.02	0.17	7.09	11.97	7.09	0.06	19.30	405.22
1998	0.03	0.09	0.02	0.15	6.68	11.36	6.68	0.03	18.22	382.60
1999	0.02	0.09	0.03	0.14	6.51	11.06	6.51	0.02	17.73	372.37
2000	0.04	0.04	0.01	0.09	7.51	12.71	7.51	0.04	20.34	427.16
2001	0.04	0.04	0.01	0.09	8.09	13.65	8.09	0.04	21.87	459.22
2002	0.04	0.05	0.01	0.10	6.76	11.43	6.76	0.04	18.33	385.01
2003	0.05	0.04	0.01	0.10	7.48	12.60	7.48	0.05	20.23	424.80
2004	0.05	0.07	0.02	0.14	8.85	14.87	8.85	0.05	23.88	501.52
2005	0.05	0.05	0.01	0.11	9.10	15.33	9.10	0.05	24.60	516.58
2006	0.06	0.06	0.02	0.13	9.21	15.52	9.21	0.06	24.92	523.27
2007	0.07	0.09	0.02	0.18	9.14	15.44	9.14	0.07	24.82	521.14

2.3.2.4. Uncertainty and time series' consistency

To estimate the uncertainties of this category the IPCC Tier1 method was used.

Uncertainties of activity data (± 5) and emission factors (± 25) were taken from the IPCC, 2000. Good Practice Guidance (see also Table 2.17).

Combined uncertainty in the category fugitive emissions from fuel as % of total national emissions in year 2007 was around $\pm 0.7\%$.

2.3.2.5. Source-specific recalculations

A previous CH₄ emission source category 1.B.1.A Oil Shale mining and Handling is deleted from the current inventory report. After consultancy with leading researchers of the Mining Department of Tallinn University of Technology become clear, that there is not CH₄ emissions from Oil Shale mines as oil shale is located very close to the surface of the earth and the methane is already emitted. This resulted decreases of CO₂ emissions as follows (see Table 2.35):

Table 2.35. Fugitive emissions from Oil Shale mining (CRF 1.B.1.A)

	CH ₄	CO ₂ eq
1990	19.41	407.61
1991	17.55	368.55
1992	16.25	341.25
1993	13.4	281.40
1994	13.17	276.57
1995	12.13	254.73
1996	13.47	282.87
1997	13.02	273.42
1998	10.76	225.96
1999	9.74	204.54
2000	11.25	236.25
2001	11.02	231.42
2002	10.63	223.23
2003	10.92	229.32
2004	11.26	236.46
2005	12.29	258.09
2006	12.48	262.08

3.3.2.6. Source-specific planned improvements

It is planned to find country specific emission factors for fugitive CH₄ emissions from shale oil production.

2.4. Reference Approach

Reference approach (RA) is carried out using import, export, production and stock change data from the Energy Balance (EB) annual proceeding published by Statistics of Estonia. However, the RA table requires liquid fuels reported to a more disaggregated level than in the EB sheet. This data was taken from the background data of the EB.

In the 2007 inventory, the difference of CO₂ emissions between RA and Sectoral Approach (SA) was 1.62%, which is acceptable.

2.5. International Bunkers

International bunkers cover international aviation and navigation according to the IPCC Guidelines.

In 2007, GHG emissions from marine bunkers were 779.47 GgCO_{2eqv} and aviation bunkers 149.88 GgCO_{2 eq}.

The emissions were calculated using the IPCC metrology and default emission factors. Fuel consumption data for marine bunkering and aviation bunkering was obtained from the Statistics of Estonia.

Recalculations

Some corrections have been made in Activity Data – amounts of Jet Kerosene used in International Aviation are corrected. The reason of these changes is mainly connected with specification of the Jet Kerosene calorific value and also data processing mistakes.

Table 2.36. Jet Kerosene for International Aviation, TJ

	Previous submission 1990-2006	Current submission 1990-2007
1990	1349	1490
1991	1392	1530
1992	479	502
1993	696	748
1994	566	612
1995	696	695
1996	609	648
2004	1195	1192
2005	2017	2015
2006	1348	1332

No uncertainty estimation for international bunkers has been carried out.

CHAPTER 3. INDUSTRIAL PROCESSES (CRF 2)

3.1. Overview of sector

3.1.1. Description

Estonia's emissions from Industrial Processes sector are divided into following emission categories: Mineral products (CRF 2.A), Chemical industry (CRF 2.B), Consumption of halocarbons and SF₆ (CRF 2.F) and other production (CRF 2.D). Under Mineral products Estonia reports emissions from cement production and lime production. Emissions from ammonia production are reported under Chemical industry. CRF category 2.F covers emissions of F-gases from refrigeration and air conditioning, foam blowing, aerosols and electrical equipment, as well as some smaller sources, such as fire extinguishers and other. Under Other production (CRF 2.D) Estonia reports NMVOC emissions from the pulp and paper and food industries.

The CRF categories 2.C.1 Iron and Steel Production and 2.A.7.1 Glass Production are under investigation. Estonia will present results of the investigation next year (2010 submission).

3.1.2. Quantitative overview

Industrial greenhouse gas emissions contribute about 4.09% of the total anthropogenic greenhouse gas emissions in Estonia (Figure 3.1). The most important greenhouse gas emissions from industrial processes in Estonia's inventory in 2007 are the CO₂ emissions from the cement, ammonia and lime production with the 2.7%, 0.57% and 0.16% and HFC emissions from Refrigeration and Air Conditioning Equipment and Foam Blowing with the 0.49% and 0.15% shares of the total greenhouse gas emissions, respectively. F-gas emissions comprised together about 0.66% of the total greenhouse gas emissions in Estonia.

Industrial CO₂ emissions have decreased considerably since 1990 having the lowest value in 1993 (see Figure 3.2). The decrease in the emissions during early 1990's was caused by the transition from planned economy to a market economy after 1991 when Estonia became

independent. This led to emissions decrease in industrial production, and to an overall decrease in emissions from industrial processes between 1991 and 1993. In 1994 the economy began to recover and also production increased. Sudden increase in 2007 emissions is mainly caused by increase of cement production (see Table 3.1).

In accordance with Article 3.8 of the Kyoto Protocol Estonia has set 1995 as the base year for F-gases. The contribution of emitted F-gases to the overall CO₂ emission level is very small, thus the fluctuations in their emissions have minimum influence to the overall CO₂ emission trends.

Table 3.1 Trend in greenhouse gas emissions from industrial processes (Gg CO₂ eqv.)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
CO ₂																		
A. Mineral Products	628	634	387	245	344	361	375	411	429	379	396	403	389	363	396	402	445	631
B. Chemical Industry	317	292	150	60	202	207	211	222	242	217	188	203	28	93	171	144	135	125
HFCs	NO	NO	NO	NO	NO	25.70	30.94	36.75	47.52	57.01	70.79	86.21	87.24	93.04	105.71	118.7	139.53	144.73
SF ₆	NO	NO	NO	NO	NO	3.22	3.51	3.0	2.98	3.01	2.73	1.74	1.43	1.31	1.08	1.08	1.15	0.97
PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.07	0.06

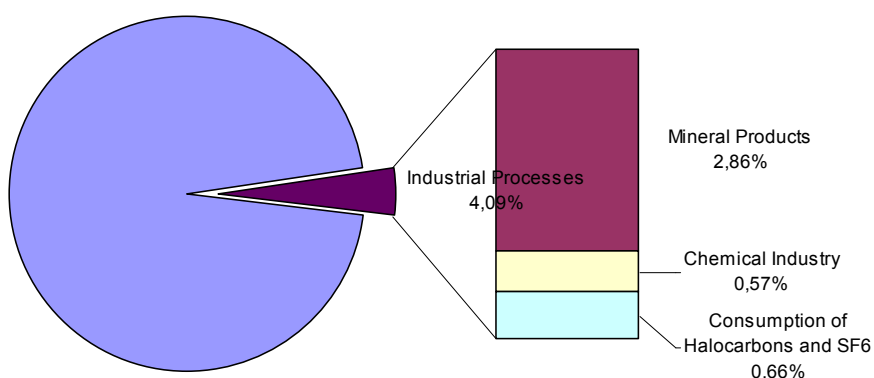


Figure 3.1 Emissions from industrial processes in Estonia in 2007.

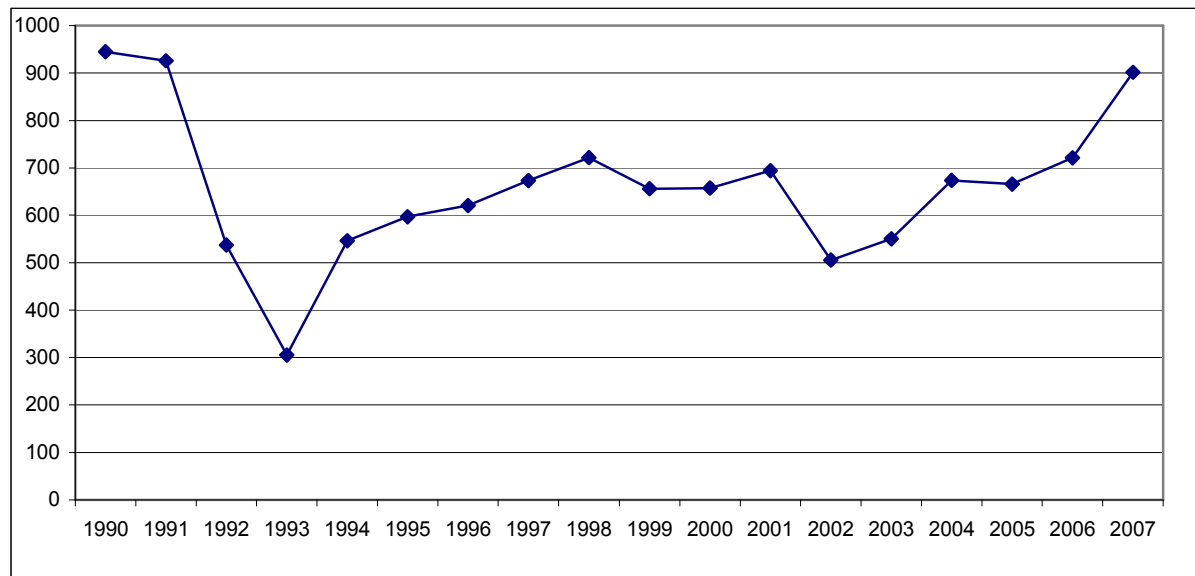


Figure 3.2 Emission from industrial processes in 1990-2007 in Estonia (Gg CO₂ eq.).

Key categories

Key categories in industrial processes in 2007 are summarised in Table 3.2 (without LULUCF) and Table 3.3 (with LULUCF) in accordance with IPCC Tier 1 method.

Table 3.2 Key categories in Industrial processes (CRF 2) in 2007 (L=Level, T=Trend without LULUCF).

IPCC code	IPCC source category	Gas	Identification criteria
2.A.1	Cement Production	CO ₂	L, T
2.A.2	Lime Production	CO ₂	T
2.B.1	Ammonia Production	CO ₂	L, T
2.F.1	Refrigeration and Air Conditioning Equipment	HFCs	L, T

Table 3.3 Key categories in Industrial processes (CRF 2) in 2007 (L=Level, T=Trend with LULUCF).

IPCC code	IPCC source category	Gas	Identification criteria
2.A.1	Cement Production	CO ₂	L, T
2.B.1	Ammonia Production	CO ₂	L
2.F.1	Refrigeration and Air Conditioning Equipment	HFCs	T

3.2. Mineral Products (CRF 2.A)

3.2.1. Source category description

In this category the non-fuel emissions from cement and lime production are reported (Table 3.4).

CO₂ emissions from cement and lime production have decreased considerably since 1990 having the lowest value in 1993 and after small increase in 1994 the trend of CO₂ emissions have stabilized (except a rise in 2007). The decrease in the emissions during early 1990's was caused by the transition from planned economy to a market economy after 1991 when Estonia became independent. This led to emissions decrease in industrial production, and to an overall decrease in emissions from industrial processes between 1991 and 1993. In 1994 the economy began to recover and also production increased. Sudden increase in 2007 emissions is caused by increase of cement production (in 2007 AS Kunda Nordic Cement renovated third kiln).

Table 3.4 CO₂ emissions from mineral products (Gg).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
2.A 1 Cement production	483	471	315	228	330	348	361	396	404	361	379	387	364	339	369	373	414	597
2.A 2 Lime Production	145	163	72	17	14	13	14	15	25	18	17	16	25	24	27	29	31	34
Total	628	634	387	245	344	361	375	411	429	379	396	403	389	363	396	402	445	631

3.2.2. Cement Production

3.2.2.1. Source category description

In cement production CO₂ is emitted when an intermediate product, clinker, is produced. In that process limestone is heated to high temperature, which results in emissions, as the main component of limestone, calcium carbonate, breaks down, calcinates, into calcium oxide and carbon dioxide. Limestone contains also small amounts of magnesium carbonate (MgCO₃), which will also calcinate in the process causing CO₂ emissions. The activity data and emission factors used in calculations are from AS Kunda Nordic Cement.

3.2.2.2. Methodological issues

Methods

Emissions from cement production are calculated by multiplying emission factors with activity data. Activity data is collected directly from the industry. Emission factors are calculated by the industry. The methods for calculating emissions from cement production are consistent with Tier 2 level method.

Emission factors

Emission factors used in calculation of emissions from cement production are plant-specific provided by the industry (i.e. production plant). Emission factors vary slightly, since the parameters affecting them vary slightly from year to year (Table 3.5).

Emission factor of cement production is based on the CaO and MgO contents of clinker. Cement kiln dust and by pass dust as well as the amounts of CaO and MgO that are already calcinated before the process (and therefore do not cause emissions) are taken into account at plant.

Activity data

In calculating the emissions from cement production the amount of clinker produced annually is used as activity data. Activity data (Table 3.5) for cement production is collected directly from the industry.

3.2.2.3. Uncertainties and time-series consistency

Since the activity data was prepared in cooperation with manufacturer the rate of emissions is considered sufficiently precise. The listed uncertainties were determined via experts' assessment pursuant to Tier 1 of the IPCC GPG rules.

The uncertainty estimation for the activity rates used for cement was $\pm 7\%$. This expert assessment took into account the following error sources:

- Uncertainty of collection and transferring data,
- Uncertainty of determination of activity data.

The emission factor was estimated as 0.546 t/t. The uncertainty estimation for the emission factor used was $\pm 10\%$. This expert assessment took into account the following error sources:

- The uncertainty related to the average fractions of limestone and other raw materials.

3.2.2.4.Source-specific QA/QC and verification

General (Tier 1) Quality Control (QC) procedures applied to category Mineral products (CRF 2.A)

- a) Assumptions and criteria for the selection of activity data and emission factors are documented.
- b) For subcategory CRF 2.A 1 the whole time serie of emissions, correctness of the calculation formulas, and use of appropriate units have been checked.
- c) The consistency of input data and methods over the time series has been checked.

3.2.2.5.Source-specific recalculations including changes made in response to the review process

There are no recalculations made for the cement production sector in 2009 (on 2007 data) inventory submission.

3.2.2.6.Source-specific planned improvements

No source-specific improvements have been planned.

3.2.3. Lime Production

3.2.3.1. Source category description

CO₂ emissions from lime production are due to calcination of calcium and magnesium carbonates at high temperatures. The activity data and emission factors used in calculations are from industrial statistics and from IPCC's 1996 Revised Guidelines through time series.

3.2.3.2. Methodological issues

Methods

Emissions from lime production are calculated by multiplying emission factors with activity data. Activity data is collected from industrial statistics. Emission factors are based on IPCC's default factors. The methods for calculating emissions from lime production are consistent with IPCC Tier 1 level method.

Emission factors

Emission factor for lime production is taken from the IPCC's 1996 Revised Guidelines. More than 99% of lime produced in Estonia is produced by AS Nordkalk, which uses the same EF.

Activity data

In calculating the emissions from lime production the amount of lime produced is used as activity data. Activity data (Table 3.5) for lime production is collected from industrial statistics.

Table 3.5 Activity data and emission factor for mineral products (Gg).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
2. A.1. Clinker production, kt	790	773	517	378	540	571	591	651	659	590	620	629	591	560	623	635	705	1043
Efclinker (t/t)	0.549	0.547	0.548	0.542	0.549	0.547	0.546	0.543	0.546	0.546	0.545	0.548	0.549	0.545	0.544	0.547	0.547	0.546
Cement kiln dust, kt	120	117	78.5	57.4	82	86.7	95.8	105.5	107	95.7	100.5	102.5	96.1	84.8	74.9	61.9	69	71
Efowen dust (t/t)	0.410	0.415	0.409	0.405	0.410	0.408	0.408	0.406	0.408	0.408	0.408	0.409	0.410	0.407	0.406	0.408	0.408	0.385
2. A.2. Lime production, kt	185	207	92	21	18	16.8	17.4	19.5	32.1	23.3	21.2	20	32	31	34	37	39.7	43.5
EFlime(t/t)	0.7857	0.7857	0.7857	0.7857	0.7857	0.7857	0.7857	0.7857	0.7857	0.7857	0.7857	0.7857	0.7857	0.7857	0.7857	0.7857	0.7857	0.7857

3.2.3.3. Uncertainties and time-series consistency

Since the activity data was prepared in cooperation with manufacturers and taken from industrial statistics as well, the rate of emissions is considered sufficiently precise. The listed uncertainties were determined via experts' assessment pursuant to Tier 1 of the IPCC GPG rules.

The uncertainty estimation for the activity rates used for lime was $\pm 10\%$. This expert assessment took into account the following error sources:

- Uncertainty of collection and transferring data,
- Uncertainty of determination of activity data.

The emission factor was estimated as 0.7857 t/t. The uncertainty estimation for the emission factor used was $\pm 7\%$.

3.2.3.4. Source-specific QA/QC and verification

General (Tier 1) Quality Control (QC) procedures applied to category Mineral products (CRF 2.A)

- a) Assumptions and criteria for the selection of activity data and emission factors are documented.
- b) For subcategory 2.A 2 the whole time series of emissions, correctness of the calculation formulas, and use of appropriate units have been checked.
- c) The consistency of input data and methods over the time series has been checked.

3.2.3.5.Source-specific recalculations including changes made in response to the review process

The amount of produced lime was corrected for years 1997 (emissions increased by 0.47 Gg), 1998 (emissions increased by 0.47 Gg), 2000 (emissions increased by 1.1 Gg), 2002 (emissions increased by 2.99 Gg) and 2003 (emissions increased by 0.32 Gg).

3.2.3.6.Source-specific planned improvements

No source-specific improvements have been planned.

3.3. Chemical Industry (CRF 2.B)

3.3.1. Source category description

In Estonia's inventory this category includes the non-fuel emissions from ammonia production (Table 3.6). All ammonia currently produced in Estonia is produced in one company AS Nitrofert.

CO₂ emissions from ammonia production have decreased considerably since 1990 having the lowest value in 1993 and after small increase in 1994 the trend of CO₂ emissions have stabilized (except sudden decrease in 2002-2003). The decrease in the emissions during early 1990's was caused by the transition from planned economy to a market economy after 1991 when Estonia became independent. This led to emissions decrease in industrial production, and to an overall decrease in emissions from industrial processes between 1991 and 1993. In 1994 the economy

began to recover and also production increased. In 2002 and 2003 there were reconstructions in AS Nitrofert (the only ammonia industry in Estonia) and this strongly affected production.

Table 3.6 Emissions of CO₂ from ammonia production (Gg).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
2.B.1 Ammonia production	317	292	150	60	202	207	211	222	242	217	188	203	28	93	171	144	135	125

3.3.2. Methodological issues

Emissions of CO₂ will depend on the amount and composition of gas used in the technological process. It is assumed that all carbon will be emitted to air. In the Estonia's ammonia production factory Nitrofert a different ammonia production technology is in use. Not all CO₂ emissions are emitted into air, part of them are used as raw material for carbamide production and an other part of is sold to other companies (Annex 4).

Methods

There are two different methods in the IPCC 1996 Guideline for calculation of CO₂ emissions from ammonia production: Tier 1a and Tier 1b method.

According to the Tier 1a method:

$$\text{Emissions (Gg)} = \text{Consumption of gas (kt)} \times \text{carbon content} \times 44/12$$

where carbon content of natural gas = 0.5568 kg/m³

Tier 1b: An alternative is to calculate the emissions from the ammonia production:

$$\text{Emissions (Gg)} = \text{Production of ammonia (kt)} \times \text{Emission factor}$$

In the current inventory calculations the tier 1b method has been used. In the Annex 4, CO₂ emissions from ammonia production using Tier1a are presented.

Emission factors

The emission factor for calculation of CO₂ emissions from ammonia production is country specific and based on technology used in the factory.

In the IPCC 1996 Guideline, Vol.3, p. 1.16 same example for used emission factor is given for Canada and Norway. These emission factories are equal to 1.5 – 1.6 tCO₂/tonne NH₃ produced. In Estonia, ammonia production emission factors are, depending on the year, between 1.407 – 1.572 6 tCO₂/tonne NH₃ produced.

Activity data

The annual ammonia production figures 1990-2007 have been obtained from the production plants and presented in (Table 3.7)

Table 3.7 Production ammonia (1000 tonnes).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Ammonia production, kt	294	270	140	55	180	201	203	206	211	199	177	183	47	98	202	213	211	202
Emission factor	1.564	1.572	1.572	1.572	1.580	1.485	1.458	1.417	1.396	1.428	1.431	1.487	1.469	1.529	1.366	1.407	1.412	1.419
CO ₂ , kt	460	425	220	86	284	299	296	292	294	285	253	272	69	150	276	299	299	286
CO ₂ for carbamide production	143	133	70	27	82	91	85	69	53	68	65	70	41	57	104	156	164	162
Total CO ₂ emissions, Gg	317	292	150	60	202	207	211	222	242	217	188	203	28	93	171	144	135	125

3.3.4. Uncertainties and time-series consistency

The annual ammonia production figures for year 2007 have been obtained from the production plants, so the rate of emissions is considered sufficiently precise. The listed uncertainties were determined via experts assessment pursuant to country specific methods. The uncertainty estimation for the activity rates used for ammonia was $\pm 5\%$.

In Estonia, ammonia production emission factors are depending on the year between 1.407 – 1.572 tCO₂/tonne NH₃ produced, and determined for year 2007 as 1.419 based on statistics. The uncertainty estimation for the emission factor used was $\pm 20\%$.

3.3.5. Source-specific QA/QC and verification

General (Tier 1) Quality Control (QC) procedures applied to category Chemical industry (CRF 2.B)

- Assumptions and criteria for the selection of activity data and emission factors are documented.
- For whole time series the emission calculation formulas have been checked.
- For whole time series the use of appropriate units throughout the calculations has been checked.
- Several interviews to describe and explain production technology with factory technologist have been carried out.
- The consistency of input data and methods over the time series has been assessed.

3.3.6. Source-specific recalculations including changes made in response to the review process

There are no recalculations made for the chemical industry sector in 2009 (on 2007 data) inventory submission.

3.3.7. Source-specific planned improvements

Change of method from Tier 1b to Tier 1a as according to the Revised 1996 IPCC Guidelines and the IPCC good practice guidance, the most accurate method of estimation is to calculate the amount of natural gas used and the plant-specific carbon content of the natural gas (tier 1a).

3.4. Other Consumption (CRF 2.D)

3.4.1. Source category description

This source category includes the NMVOC emissions from the pulp and paper (2.D.1) and food (2.D.2) industries. The non-fuel based CO₂ emissions from pulp and paper industry are estimated to be negligible in Estonia. All N₂O emissions from the pulp and paper and food industry are reported as fuel based emissions under CRF 1.

3.4.2. Methodological issues

NMVOC emissions from the pulp and paper and food industry are calculated at Estonian Environmental Research Centre. Activity data of the years 1990 – 2002 is obtained from the annual proceeding of the Statistics Estonia “Industry” and of the years 2003-2007 from the electronic database on the web site of statistical office. Emission factors are taken from the IPCC 1996 Guideline. All SO₂ emissions of different sulphur compounds are calculated as SO₂ equivalents.

3.4.3. Source-specific recalculations including changes made in response to the review process

The amount of produced food and drink was corrected for year 1991.

3.4.4. Source-specific planned improvements

No source specific improvements are under active consideration at the moment.

3.5. Consumption of Halocarbons and SF₆ (CRF 2.F)

3.5.1. Source category description

In 2007, greenhouse gas emissions under the category CRF 2.F Emissions of consumption of halocarbons and SF₆ amounted to 145.761 Gg CO₂ equivalent, which is about 0.66% of the total greenhouse gas emissions in Estonia.

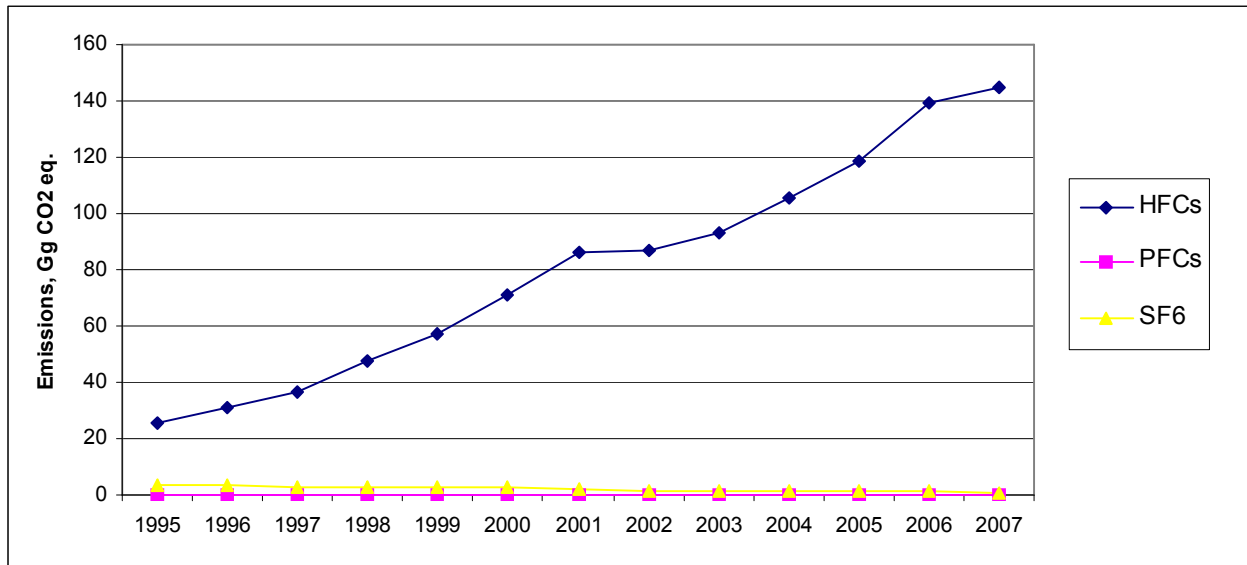
Under this category, Estonia reports HFC emissions from all refrigeration and air conditioning equipment (CRF 2.F.1), HFC emissions from foam blowing and use of HFC-containing foam products (CRF 2.F.2), HFC emissions from fire extinguishers (CRF 2.F.3), HFC emissions from aerosols (CRF 2.F.4), SF₆ emissions from electrical and other electrical equipment (CRF 2.F.8 and 2.F.9) and PFC emissions from sport shoe soles (CRF 2.F.9).

The consumption of Halocarbons and SF₆ in Estonia depends on import. F-gases are imported either in bulk by trade or industry for domestic productive consumption (manufacturing) – filling of newly manufactured products, refilling of equipment – or in imported preliminary and final products respective equipment already filled with F-gases.

The total emissions of F-gases have increased significantly since 1995 (see Table 3.8 and Figure 3.3), especially HFC emissions from refrigeration and air-conditioning equipment, which is the major source of halocarbons in Estonia (see Figure 3.4). A key driver behind the growing emission trend in refrigeration and air conditioning sector has been substitution of ozone depleting substances (ODS) by HFCs. The second largest source is foam blowing which shows relatively steady increase of emissions throughout the years, except 2 major decreases (in 2001 one of two big Estonian producers of One Component Foam replaced HFC-134a with HFC-152a, followed by the other producer in 2007. Due to much lower GWP of HFC-152a the emissions decreased suddenly in the corresponding years.) All remaining sources are comparatively small emitters of fluorinated greenhouse gases.

Table 3.8 Actual emissions of HFCs, PFCs and SF₆, 1995-2007 (CO₂ equivalent Gg).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HFCs	NO	NO	NO	NO	NO	25.70	30.94	36.75	47.52	57.01	70.79	86.21	87.24	93.04	105.71	118.7	139.53	144.73
SF₆	NO	NO	NO	NO	NO	3.22	3.51	3.0	2.98	3.01	2.73	1.74	1.43	1.31	1.08	1.08	1.15	0.97
PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.07	0.06
Total	NO	NO	NO	NO	NO	28.92	34.45	39.75	50.5	60.02	73.52	87.95	88.67	94.35	106.79	119.78	140.76	145.76

**Figure 3.3 Actual emissions of HFCs, PFCs and SF₆, 1995-2007 (CO₂ equivalent Gg).**

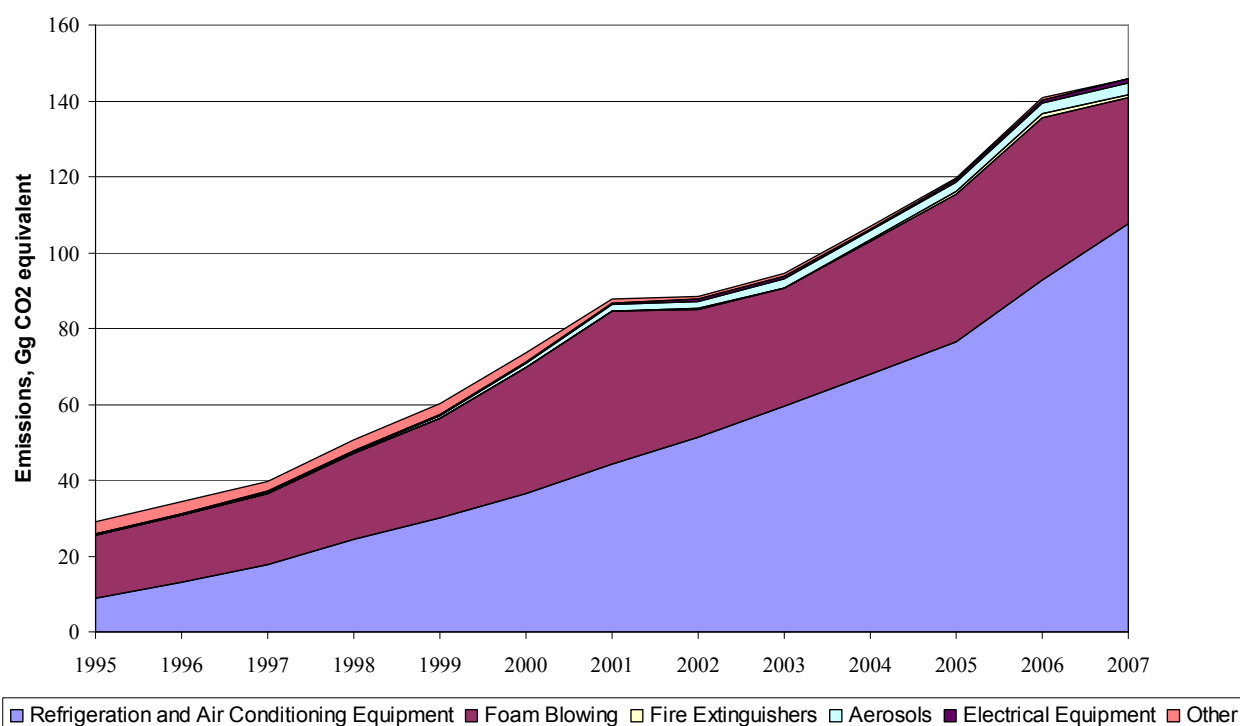


Figure 3.4 Actual emissions of F-gases by subcategory, 1995-2007 (CO₂ equivalent Gg).

In 2006, the first assessment of F-gas consumption in Estonia based on results from the Twinning Project EE2005/IB/EN/01 “Enhancing the capacity to reduce the emissions of fluorinated greenhouse gases in Estonia” (Twinning project between the Estonian Ministry of Environment and the German Ministry for the Environment, Nature Conservation and Nuclear Safety) was made. Within the project all sectors of possible F-gas consumption as described in the IPCC Guidelines for National Greenhouse Gas Inventories (2006 edition) were investigated.

The research has been bottom-up orientated. Manufacturers of and traders with F-gas containing goods, domestic and international suppliers of the Estonian market as well as consumers of such goods in industry and tertiary sector and the F-gas trade itself are the main sources of information, including experts from domestic and international companies, from associations, from academia and from public institutions (e.g. statistical office, car register, ship register etc.). Data collection and examination of data quality is carried out in a direct contact with the sources including visits at companies, factories etc. By this activity data, emission factors and emissions

are determined methodologically as far as possible in a country specific way (Tier 2a and Tier 3 according to IPCC guidelines 2006).

Quality control of activity data, emission factors and data on measured emissions was made by the data collecting experts from the Estonian Environmental Research Centre.

3.5.2. Refrigeration and Air Conditioning Equipment

Refrigeration and Air Conditioning Equipment are responsible for about 73.9% of the Estonian F-gas emissions (107.658 Gg CO₂ equivalents). The big sub sectors are:

- a) Domestic Refrigeration (fridges and freezers for domestic use),
- b) Commercial Refrigeration (refrigeration units for supermarkets and smaller shops, restaurants etc.),
- c) Transport Refrigeration (refrigerated vehicles and reefer containers),
- d) Industrial Refrigeration (refrigeration units in the food and other industries),
- e) Stationary Air Conditioning (heat pumps and room air-conditioning systems),
- f) Mobile Air Conditioning (AC systems for passenger cars, trucks, buses, ships, railcars, wheel tractors/mobile machinery).

3.5.2.1. Domestic Refrigeration

Small sub sector with less than 0.25% of the Estonian F-gas emissions (0.3575 Gg CO₂ equivalents).

3.5.2.1.1. Source-category description

Refrigerators (fridges and freezers) for domestic use are not manufactured in Estonia but imported (new and second hand). To some degree HFC-134a is used as refrigerant and as foam insulating gas. HFC-134a as refrigerant was introduced by industry at the end of 1993 as replacement of CFC-12. In the following years, its replacement by R600A (isobutane) started in some countries (Germany) but not in all countries in Europe and North-America. Today only a small part of imported new domestic refrigeration equipment operates with HFC-134a (1%

according to Estonian experts). The share of HFC-134a in the Estonian stock of fridges/freezers is (depending on imports from different manufacturers) bigger and is estimated 12.5%.

3.5.2.1.2. Methodological issues

In 2007 Estonia had – according to the statistical office – 583,735 households with 558,800 refrigerators. The number of newly imported fridges/freezers in 2007 is estimated at 64,340, about 5% of which are freezers (data from importers and EES Ringlus [Estonian Association for Recycling of Electrical and Electronic Equipment]). The share of fridges/freezers with HFC-134a in the stock is estimated by Estonian experts at 61,800 (12.5%) à 150 g HFC-134a refrigerant, in total 9,270 kg HFC-134a. In newly imported/bought systems – annually 64,340 units – some 1% contains HFC-134a, 90 kg per annum in total. Lifetime of domestic refrigeration equipment in Estonia is calculated by industry at not less than 15 years.

Emission factors: EES Ringlus reports that in 2007 5% of 20,500 fridges (1,025 units) collected for recycling contained HFC-134a as refrigerant with a loss of 25-30% of the original charge. The annual operating emission rate is, following this information, 2%/year (EF_{op}). This country specific emission factor is higher than the IPCC 2006 guidelines default value of max. 0.5%/year.

The number of refrigerators decommissioned per annum can be calculated (based on 15 years lifetime) at 37,200 from which 20,500 are collected by the recycling companies and sent for treatment to foreign countries (mostly Finland); the remaining 16,700 are disposed without refrigerant recovery. If we assume (i) that 5% of these 16,700 non-collected refrigerators contain R-134a, and (ii) that in each of them 70% of the original 150 gram charge is left (30% already emitted), the disposal HFC-134a emissions are 88 kg ($EF_{disposal} = 100\%$).

Method according to IPCC guidelines 2006: Tier 2a with country specific EF.

- Country specific average refrigerant charge per unit: 150 g R-134a
- Country specific operating emission factor: 2%

The total 2007 amount of R-134a emissions is 0.275 tons (stock emissions: 187 kg, end-of-life emissions: 88 kg) representing 357.5 tons CO₂ equivalent.

3.5.2.1.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts according to approach 1 of the 2006 IPCC Guidelines.

The data are based on direct information from industry, so that the UN of the activity data on the number of units (stock, annual importation, annual decommissioning) can be estimated relatively low ($\pm 10\%$). The UN of the emission factor is assessed $\pm \sim 10\%$, so that the combined UN of the emissions (operating and disposal) is estimated $\pm 15\%$.

Time series 1995-2006 were established in 2008.

3.5.2.1.4. Source-specific quality assurance/quality control and verification

The data for this report was partly collected within the framework of the Twinning Project EE2005/IB/EN/01. QC was carried out by the data collecting experts.

3.5.2.1.5. Source-specific recalculations

As 2007 is the first year of reporting domestic refrigeration, data was recalculated through time series.

3.5.2.1.6. Planned improvements (source-specific)

No source specific improvements are under active consideration at the moment.

3.5.2.2. Commercial Refrigeration

Important sub sector with 20.38% of the Estonian F-gas emissions (29.712 Gg CO₂ equivalent).

3.5.2.2.1. Source-category description

Commercial refrigeration and its main sub sector, supermarkets, is one of the big application sectors of fluorinated refrigerants and emissions in Estonia. This report distinguishes between:

- Supermarkets and other food retail shops with mostly on-site assembled centralized systems; main HFC refrigerant: R-404A.
- Small shops and institutions with comparable refrigeration units (only one compressor and/or less than 15 kg refrigerant; this sub sector includes small shops with less than 3 kg refrigerant); HFC-refrigerants in use: mostly R-404A and R-134a.
- Refrigeration equipment for restaurants, hotels, pubs, canteens etc. (mostly small stand alone equipment for kitchens and cold rooms, 0.75 kg average refrigerant charge); HFC-refrigerants: 1/3 R-404A, 2/3 R-134a.
- Stand alone or plug-in equipment (mostly vending machines for shops, filling stations etc., on average 250 g R-134a/device).

The commercial refrigeration sector is dominated by the refrigerants R-404A, which make 88% of the 2007 HFC stock (mostly used in supermarket systems) and R-134a (more than 11%, mainly used in vending machines and small shops). Other HFC refrigerants (R-407C, R-507A, R-410A or the R-152a containing mixture R-401A) are only of less importance.

The Estonian refrigeration equipment in general is quite modern because the change from the formerly so called open market system to the present-day supermarket system occurred during the last 15 years. The biggest sector with older equipment including second hand cabinets is the small shop sector.

The 2007 number of food retail supermarkets in Estonia – hypermarkets, supermarkets, discounters, department stores – was according to the Estonian Traders Association about 530, the number of small commercial and public customer orientated service institutions with refrigeration equipment (like small shops, medical institutions, hotels, restaurants, canteens etc.) according to other statistical sources (e.g. www.eniro.ee) more than 10,000. This includes according to expert calculation from refrigeration service companies about 7,000 small shops

with less than 3 kg refrigerant charge plus about 3,250 hotels, bars, restaurants, pubs, canteens etc. with 0.75 kg refrigerants on average. The number of vending machines for cooling of beverages and other goods (stand alone equipment) was calculated at about 15,000 units at maximum.

3.5.2.2.2. Methodological issues

Supermarkets: The refrigeration systems of supermarkets are maintained by specialised service companies. Most of them install and service the systems, some are specialised on service activities. Six service companies provided the activity data (stock, new installations in 2007, refilling data) on the HFC refrigerant consumption of their clients in the supermarket sector. Three service companies provided only 2006 stock data and new installations had to be added by their estimations. The 2007 stock data compilation from the service companies (43.1 tons HFC) had to be completed in two cases by assessment of the stock (summing 2007 HFC stock of 49.115 tons). This assessment was based on the refilling data provided by the two service companies. In this case the amount of HFC used for refilling is estimated to be in the order of 10% of the stock. The assessment is conservative and low with the aim not to overestimate the stock (the country specific emission rate EF_{op} is calculated higher [15%], see below).

According to Estonian experts the service companies covered – in terms of quantity of refrigerants – 90% of the supermarket HFC consumption. Thus 10% was added resulting in a total amount of 54.026 tons of HFC for the 2007 stock of supermarkets.

Small shops: Nine service companies (seven of them also active in the supermarket sector) submitted activity data about smaller shops. In one case the 2006 stock data had to be estimated by the inventory compilers (same method as with the supermarkets, based on a low refilling ratio of 10%). In one case 2007 new installations had to be added by service companies estimations. In this sub sector also a 10% surcharge was added resulting in a total stock of 6.017 tons HFC.

Restaurants etc.: The companies installing and servicing refrigeration equipment for restaurants, canteens and similar institutions did not provide stock data. The respective 2006 stock was

estimated based on a number of 3,250 possible clients with on average 0.75 kg refrigerant quantity resulting in about 2.4 tons HFC-refrigerant. In 2007 the companies sold new equipment 215 kg refrigerants, which were added to 2006 stock. The percentage of R-134a is estimated by Estonian experts at 2/3 (1.768 tons), the percentage of R-404A with 1/3 (0.885 tons).

The number of vending machines in Estonia (15,000 à 250 g refrigerant) was extrapolated on basis of data from the two biggest manufacturers of beer and other beverages delivering such machines to Estonian shops. The HFC-charge amounts to 3.712 tons R-134a and 0.038 tons of R-404A.

The lifetime of refrigeration systems for supermarkets and small shops including kitchen systems in Estonia is according to experts from the mentioned companies on average about 15 years (vending machines shorter, 5-10 years).

Emissions: The service companies were asked for 2007 stock data and refilling data of their clients. In supermarket sub sector R-404A refilling ratio from companies who reported refilling data and stock data is about 14.8%. The refilling ratio of R-404A (refilling compared to stock) for the commercial refrigeration sector in total is about 14.3%.

Normally emissions are higher than the refilling ratio. A certain fraction of emissions is never replenished by refilling. On the other hand the Estonian data base is still too small to allow a more detailed emission rate calculation. Therefore an EF_{op} of 15% is applied to all sectors covering emissions from operating and servicing with the only exception for vending machines. The vending machines in the Estonian market are modern and should be very tight; the emission rate EF_{op} is estimated at 1.5%/year. These emission factors are in the range of the IPCC guidelines 2006 (10-35% for medium and large commercial refrigeration and 1-15% for stand alone commercial refrigeration).

The EF_{manu} (filling of new equipment) is estimated at a low value of 0.5%, which is likewise in accordance with the IPCC Guidelines 2006.

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country specific EF_{manu} (filling): 0.5%.
- Country specific operating emission factor EF_{op} : 15% (vending machines: 1.5%).

The total quantity of HFC filled into new commercial refrigeration equipment in 2007 amounts to 13.483 tons (13.28 tons R-404A and a small amount of R-134a, R-407C and R-410A). The manufacturing emissions from this filling are 67.41 kg. The HFC stock amounts to 66.446 tons (58.554 tons R-404A, 7.478 tons R-134a and small amounts of R-407C, R-152a and R-410a). The stock emissions are in total 9.461 tons. The biggest part of them is HFC-404A (8.778 tons) and HFC-134a (0.621 tons), the emissions of the other HFC are only 62 kg. The CO₂ equivalent of all 2007 HFC emissions is 29.712 Gg (29,712 tons).

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

3.5.2.2.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. The combination of the individual uncertainties follows the approach 1 of the 2006 IPCC Guidelines.

The UN of the two activity data “Filled in new manufactured products” and “HFC stock in operating systems” is estimated $\pm 20\%$ (0.2).

The combination of this value with the respective emission factors ($\pm 10\%$) results in the UN of both manufacturing and operating HFC emissions of $\pm \sim 22\%$.

Time series 1995-2006 were established in 2008.

3.5.2.2.4. Source-specific quality assurance/quality control and verification

The data for this report was partly collected within the framework of the Twinning Project EE2005/IB/EN/01. QC was carried out by the data collecting experts.

3.5.2.2.5. *Source-specific recalculations*

As 2007 is the first year of reporting commercial refrigeration, data had to be recalculated through time series.

3.5.2.2.6. *Planned improvements (source-specific)*

No source specific improvements are under active consideration at the moment.

3.5.2.3. *Transport Refrigeration*

This group includes refrigerated vehicles and refrigerated (reefer) containers. It is responsible for about 9.08% of the Estonian F-gas emissions (13.23 Gg CO₂ equivalents).

3.5.2.3.1. *Refrigerated Vehicles*

3.5.2.3.1.1. Source category description

By 31.12.2007, about 1300 refrigerated vans and trucks and 900 refrigerated trailers were registered in Estonia. Most of these vehicles are second hand vehicles imported from Western Europe. Approx. half the refrigeration units fitted to the imported second-hand trucks and trailers are empty and are charged with refrigerant within the country. Only a small number of new vans are fitted with refrigeration units first in Estonia, and as a consequence, first-filled in the country. The refrigerants in use are R-134a in case of vans and smaller trucks, and the blend R-404a in case of bigger trucks and of trailers. Refrigeration units of older vehicles still operate with HCFC R-22.

3.5.2.3.1.2. Methodological issues

The Estonian Motor Vehicle Registration Centre (ARK) provided a list of all refrigerated vehicles registered at the end of 2007, subdivided in weight classes (N1, N2, and N3 according to 2001/16/EC), makes, models and production years dating back to 1995 and beyond.

Information on the types of refrigeration units of the Estonian vehicles, the HFC-types they are charged with, the refrigerant charges, the emissions and the frequency of refilling based on findings of the 2006 investigation (information provided by the two biggest service companies for refrigerated vehicles, both linked to the leading international manufacturers of refrigeration units for trucks and trailers).

The share of older refrigeration units with non-HFC-refrigerants was estimated max. 7%. Vans and smaller trucks (class N1 and half of class N2 according to 2001/16/EC) run R-134a systems (average charge 2.0 kg/unit), bigger trucks (half of class N2 and the class N3) run R-404a systems (average charge 5.8 kg/unit). For trailers an average charge of 8.0 kg R-404a is supposed.

The Estonian experts estimate the emissions at first domestic filling (empty units of imported new and second-hand vehicles) at 1%. These emissions are equated to the CRF emission category “emissions from manufacturing”. The annual losses from the operating systems (emissions from stocks) including service emissions on refilling amount to average 30% (EF_{op} – operating emission factor) of the refrigerant stock in the refrigerated vehicles.

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country-specific average refrigerant charges per unit: weight classes N1 and half N2: 2 kg; N3 and half weight class N2: 5.8 kg; trailers: 8.0 kg.
- Country-specific manufacturing emission factor: 1%
- Country-specific operating emission factor: 30%.

The total 2007 quantity of HFCs filled in empty units of refrigerated vehicles in Estonia amounts to 139 kg R-134a and 1138.9 kg R-404a, the “manufacturing” emissions on these first fills are 1.39 kg R-134a and 11.39 kg 404a. The HFC stock in refrigerated vehicles amounts to 784 kg R-134a and 12 444.6 kg R-404a; the stock emissions are 235.2 kg R-134a and 3733.4 kg R-404a. The CO₂ equivalent of all 2007 HFC emissions is about 12 515.6 tons (12.526 Gg).

3.5.2.3.1.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. The combination of the individual uncertainties follows the approach 1 of the 2006 IPCC Guidelines.

The UN of the two activity data “First fill of empty systems” and “HFC stock in operating vehicles” is estimated $\pm 8.5\%$, which is the combination of the individual UN of a) total registrations (new or operating) by weight categories in 2007 ($\pm 1\%$), b) refrigerant charges ($\pm 6\%$) and c) refrigerant split into R-134a and R-404a ($\pm 6\%$).

The combination of the UN of new fill or of stock ($\pm 8.5\%$) with the UN of the respective emission factors ($\pm 5\%$) results in the UN of both manufacturing and operating HFC emissions of $\pm 10\%$.

Time series 1995-2005 were established in 2008.

3.5.2.3.1.4. Source-specific quality assurance/quality control and verification

The data for this report was collected partly within the framework of the Twinning Project EE2005/IB/EN/01. QC by the data collecting experts.

3.5.2.3.1.5. Source-specific recalculations

No recalculation of preceding data (of the year 2006) was deemed necessary.

3.5.2.3.1.6. Planned improvements (source-specific)

In the future, attempts should be made to determine more precisely the share of second hand imports with empty refrigeration units.

3.5.2.3.2. *Reefer Containers*

3.5.2.3.2.1. Source category description

Reefer containers are being transported on sea ships around the world, and HFC emissions from their refrigeration systems do not occur inside a particular country. As a consequence, it is plausible to attribute the emissions of the worldwide reefer container fleet to a particular nation according to the share of this country in world trade. Estonia's share in the world trade amounted according to the Statistical Office to 0.1% (0.097%), so that it is responsible of 0.097% of HFC stock and HFC emissions of the worldwide reefer container fleet.

3.5.2.3.2.2. Methodological issues

The starting point of the estimation is not country-specific but worldwide data. As this data for the 1995-2006 period was already available in the German F-gas inventory, own research on worldwide HFC stock and emissions was not necessary. Only the share of Estonia in the world trade had to be identified.

The worldwide HFC stock (German F-gas inventory) was estimated in three steps:

1. Annual number of 20 feet units (new manufactured, decommissioned, total stock).
2. Refrigerant charge per set (6 kg of 134a or 4 kg of 404a).
3. HFC-split between R-134a and R-404a (80% to 20%).

The emissions of R-134a and R-404a are calculated by means of emission factors. The operating emission factor is 10%, the disposal emission factor is 30%. (Manufacturing emissions are not distributed by world trade shares but are estimated in the (few) countries of container manufacturing).

Information about the 2007 share of Estonia in the world trade (both export and import) was given by the Statistical Office.

From 2007 onwards, the annual updating of the worldwide data does no longer rely on the German inventory. Data on the worldwide reefer production are annually published by the information service World Cargo News.

Method according to IPCC Guidelines 2006: Tier 2a with international default EF.

The 2007 HFC stock emissions from reefer containers attributable to Estonia are 408.2 kg R-134a (530.66 t CO₂ equ.) and 49.6 kg R-404a (161.7 t CO₂ equ.). The 2007 emissions from the decommissioning of reefer containers attributable to Estonia are 17 kg R-134a (22.1 t CO₂ equ.). The total is 714.46 t or 0.715 Gg CO₂ equivalent.

3.5.2.3.2.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. The combination of the individual uncertainties follows the approach 1 of the 2006 IPCC Guidelines.

The UN of the basic activity data “worldwide HFC stock” is the same as in the German inventory: $\pm 8.4\%$, which is the combination of the individual UN of a) number of units ($\pm 3\%$), b) HFC-charges ($\pm 5\%$), c) HFC-split ($\pm 6\%$).

The UN of the Estonia share in world trade is estimated $\pm 3\%$, and the UN of the operating emission factor $\pm 5\%$. The combined UN of the HFC emissions (both 134a and 404a) can be calculated $\pm 10.2\%$.

Time series 1995-2005 were established in 2008.

3.5.2.3.2.4. Source-specific quality assurance/quality control and verification

The data for this report was collected partly within the framework of the Twinning Project EE2005/IB/EN/01.QC by the data collecting experts.

3.5.2.3.2.5. Source-specific recalculations

No recalculation of preceding data (of the year 2006) was deemed necessary.

3.5.2.3.2.6. Planned improvements (source-specific)

No requirement.

3.5.2.4. Industrial Refrigeration

Important sub sector with 13.58% of the Estonian F-gas emissions (19.801 Gg CO₂ equivalent).

3.5.2.4.1. Source-category description

Industrial refrigeration is a big application sector of fluorinated greenhouse gases, mainly of HFC R-404A. The dominant application is the food industry (fish, meat, dairy, beverage industries, breweries, etc), which is Estonia's most important industrial sector. The food industry's dynamic may be exemplified by the fact that its output has tripled in the 1995-2005 decade. The HFC consumption of other industries (e.g. chemical industry) is comparably small.

In contrast to commercial refrigeration, in industrial refrigeration non-HFC/HCFC refrigerants – especially NH₃ – play a major role than HFC. With regard to the HFC stock R-404A is the prevailing refrigerant with about 94%. Other HFC refrigerants (R-134a, R-402A, R-407C, R-507A or the R-152a containing mixture R-401A) are of minor importance.

The refrigeration systems are very often served by bigger service companies; however, self maintenance and cooperation with smaller (locally based) service companies is of more importance than in the supermarket and food retail sector.

3.5.2.4.2. Methodological issues

Information on potential HFC users in the food and other industries was compiled in cooperation with experts from refrigeration service companies specialized on industrial application. Food industry's basic data can be found in the statistics of the Veterinary and Food Board (VTA; cf. www.vt.agri.ee) because companies wishing to handle foodstuff must be approved by the VTA. Approved enterprises: Fish industry - more than 60 plants with chilling/freezing equipment; meat industry - 120 plants; dairy industry – 38 plants.

Eleven service companies provided the activity data (stock, new installations in 2007, refilling data) on the HFC consumption of their industrial clients. In two cases the service companies could not report on 2006 stock data. These data had to be completed by our assessment. (The assessment is based on the refilling data provided by the service companies, and the stock is assumed to be 10 times higher than the annual refills; same method as with the supermarket sector).

In addition to the service companies, approx. seventy companies from the fish, meat, dairy, bakery, beverages and other food-industries, and from several non-food industries (including e.g. ice rinks) were directly interviewed by dedicated questionnaires about their HFC refrigerant consumption.

As the refrigerant stock based on the data from service companies and directly interviewed industry covers the total stock to a certain part only, the remaining stock had to be estimated by us in cooperation with national sector experts. The thus assessed HFC stock in industrial refrigeration is 21.826 tons (44.457 tons, reported and assessed). Two thirds of the estimated HFC stock amount is attributable to one big service company who could not provide stock data

for 2006 but only 2007 newly installed systems. Better stock data from this company will significantly enhance the overall quality of the stock data in the future.

The average lifetime of industrial refrigeration systems in Estonia is about 15 years or more, according to experts from the mentioned companies.

Emissions: The service companies and the industrial companies surveyed by questionnaires were asked for 2007 stock and refilling data. Complete stock and refilling data for HFC-404A are available for 18 individual companies in the fish, meat, milk, and beverage industry, with an HFC-404A stock of 10.5 tons. The refilling ratio of the individual companies range from 0 to 46%. The average refilling rate is 8.9%. As refilling ratio from service companies was higher (about 22%) and there is no longer research over refilling ratios, 2006 ratio 14% was adapted.

As in the case of commercial refrigeration the emission factor (EF_{op}) for the stock is country specific, i.e. is based on the year 2006 average refilling ratio in the industry, with 14%. This emission factor is in the range of the IPCC guidelines 2006 (7-25% of the stock).

The EF_{manu} (filling of new equipment) is estimated at a low value of 0.5%, which is likewise in accordance with the IPCC Guidelines 2006.

Method according to IPCC Guidelines 2006: Tier 2a with country specific EF.

- Country specific EF_{manu} (filling): 0.5%.
- Country specific operating emission factor EF_{op} : 14%.

The total quantity of HFCs filled into new industrial refrigeration equipment in 2007 amounts to 3.566 tons (1.531 tons HFC-143a, 1.384 tons HFC-125, 0.569 tons HFC-134a and 0.081 tons of HFC-32). The manufacturing emissions from filling are 17.83 kg. The HFC stock amounts to 44.457 tons (21.954 tons HFC-143a, 19.053 tons HFC-125, 3.152 tons HFC-134a, 0.297 tons HFC-32 and small amount of HFC-152a). The stock emissions total 6.224 tons. The biggest parts of them are HFC-143a (3.074 tons), HFC-125 (2.668 tons) and HFC-134a (441 kg); the

emissions of the other HFCs are only 42 kg. The CO₂ equivalent of all 2007 HFC emissions is 19.801 Gg (19,801 tons).

3.5.2.4.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. The combination of the individual uncertainties follows the approach 1 of the 2006 IPCC Guidelines.

The UN of the two activity data “Filled in new manufactured products” and “HFC stock in operating systems” is estimated $\pm >25\%$ (26%) This high value mainly results from the high share of estimations in the determination of total HFC stock. The combination of this value with the UN of the respective emission factors ($\pm 15\%$) results in the UN of both manufacturing and operating HFC emissions of $\pm 30\%$.

Time series 1995-2006 were established in 2008.

3.5.2.4.4. Source-specific quality assurance/quality control and verification

The data for this report was partly collected within the framework of the Twinning Project EE2005/IB/EN/01.QC by the data collecting experts.

3.5.2.4.5. Source-specific recalculations

As 2007 is the first year of reporting industrial refrigeration, recalculations were made through time series.

3.5.2.4.6. Planned improvements (source-specific)

More detailed research of refilling ratios.

3.5.2.5. Stationary Air Conditioning

Stationary Air Conditioning includes the sub-applications heat pumps and equipment for stationary and room air conditioning with HFC-134a, R-407C and R-410A. Important sub sector with 10.58% of the Estonian F-gas emissions (15.415 Gg CO₂ equivalent).

3.5.2.5.1. Heat Pumps

3.5.2.5.1.1. Source category description

The use of heat pumps with HFC refrigerants – ground and air heat pumps – started in Estonia in 1993. Decommissioning has not yet occurred because the bulk of the systems were installed in the last years. Ground heat pumps generally operate with HFC-407C, air heat pumps with HFC-410A. In general, heat pumps are imported to the country and already charged with refrigerant. Only a small number of ground heat pumps was manufactured and filled with refrigerant in Estonia itself.

3.5.2.5.1.2. Methodological issues

The leading expert of the Estonian Heat Pump Association provided information on heat pumps in Estonia in cooperation with the three biggest suppliers of heat pumps in the country. In order to avoid double counting, the classification of heat pumps on the one hand and stationary respective room air conditioning systems on the other hand was discussed together with experts from the Estonian Refrigeration Association. According to the experts the stock of installed heat pumps in Estonia amounts to approx. 18,709 systems in 2007 (4,100 ground, 14,500 air and 109 other heat pumps), nearly half of them were installed in 2007 (8,709). The average charge was estimated at 2.0 kg for ground and 1.0 kg refrigerant for air HP. The discussion with Estonian experts resulted in emission factors for manufacturing (EF_{manu}) of 2.0% and for operating systems (EF_{op}) of 2.5%.

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country-specific EF_{manu} : 2%
- Country-specific EF_{op} : 2.5%.

The domestic consumption filled in new ground HP is 180 kg R-407C, the manufacturing emissions 3.6 kg R-407C. The 2007 operating stock amounts to 8,418 kg R-407C (ground and other HP) and 14,500 kg R-410A (air HP). The 2007 operating emissions total 210.5 kg R-407C and 362.5 kg R-410A.

All global warming emissions together amount to 951.8 t CO₂ equivalent (0.9518 Gg).

3.5.2.5.1.3. Uncertainties and time-series consistency

Öko-Recherche experts assessed the emissions uncertainty (UN) pursuant to approach 1 of the 2006 IPCC Guidelines. The data on heat pumps are deemed precise because the relevant associations, companies and experts for heat pumps and refrigeration systems in Estonia, provided them.

The UN of the activity data HFC consumption and HFC stock is estimated at $\pm 9\%$. The emission factors are estimated $\pm 5\%$. The combination of the UN of the stock/consumption with the UN of the emission factors results in the UN of the HFC emissions of $\pm 10.3\%$.

Time series 1995-2005 were established in 2008.

3.5.2.5.1.4. Source-specific quality assurance/quality control and verification

The data for this report was partly collected within the framework of the Twinning Project EE2005/IB/EN/01. QC was carried out by the data collecting experts.

3.5.2.5.1.5. Source-specific recalculations

Recalculations were made for years 1995-2005.

3.5.2.5.1.6. Planned improvements (source-specific)

No source specific improvements are under active consideration at the moment.

3.5.2.5.2. Stationary and Room Air-Conditioning

3.5.2.5.2.1. Source category description

Stationary and room air-conditioning systems including chillers, ventilation and split systems are generally imported. Split systems are imported with HFC charge, newly installed chillers and ventilation systems are first-filled inside the country. In these cases emissions from filling (manufacturing) have to be considered. Refrigerants in use for chillers are HFC-134a and the blend R 407C, for ventilation systems and split systems the blends 407C and R 410A.

3.5.2.5.2.2. Methodological issues

The 2006 newly installed systems, the total 2006 equipment stock, the refrigerant charges by weight and HFC types, and the EF for domestic manufacturing and operating stock were determined in cooperation with the experts from the Estonian Refrigeration Association and companies (manufacturers, traders, service companies) belonging to this association. As mentioned in the heat pump section, the heat pumps on the one hand, and stationary and room air conditioning systems on the other hand were discussed together with the Estonian Heat Pump Association to avoid double counting. The interviews revealed for 2006 the following numbers of operating systems: 400 chillers, 2,800 ventilation systems and 16,000 split systems (“mini-splits”). The EF_{manu} (first filling loss) was established at 20g/system for chillers (0.019%) and 40g/system (factor: 0.24%) for ventilation systems, the EF_{op} (Product Life Factor) at 1% (chillers), 12.5% (ventilation systems) and 3% (split systems). Chillers and split systems are industrially manufactured and tighter than ventilation systems that are assembled on site.

The 2007 newly installed systems are not included in this year Report and have to be reported in future, as there was no data available yet. 2007 stock data includes only 2006 stock data.

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country-specific EF_{manu} : 20g and 40g per system;
- Country-specific EF_{op} : 1% (chillers), 12.5% (ventilation) and 3% (split).

The operating stock amounts to 63.034 t R-134a, 19.131 t R-32 and 20.555 t R-125. Operating emissions: 6.492 t R-134a, 1.644 t R-32, 1.77 t R-125.

All global warming emissions together amount to 14.463 Gg CO₂ equivalent (14,463 t CO₂ equivalent).

3.5.2.5.2.3. Uncertainties and time-series consistency

Öko-Recherche experts assessed the emissions uncertainty (UN) pursuant to approach 1 of the 2006 IPCC Guidelines. The relevant associations, companies and experts in Estonia very roughly estimated the data on stationary A/C systems, especially on emission factors of split systems and chillers. The UN of the activity data HFC consumption and stock is estimated at $\pm 15\%$. The UN of the ventilation emission factors is $\pm 10\%$. The UN of the EF for chillers and split systems are more uncertain ($\pm 26\%$); they are supposed to be too low. The combination of the UN of stock/consumption with the UN of the (given) emission factors results in the UN of the HFC emissions of $\pm 30\%$ (chillers, splits), and $\pm 18\%$ (ventilation systems).

Time series 1995-2005 were established in 2008.

3.5.2.5.2.4. Source-specific quality assurance/quality control and verification

The data for this report was collected within the framework of the Twinning Project EE2005/IB/EN/01. QC was done by the data collecting experts.

3.5.2.5.2.5. Source-specific recalculations

Recalculations were made for years 1995-2005.

3.5.2.5.2.6. Planned improvements (source-specific)

The emission factors of split systems and chillers estimated by the national sector experts are deemed by far too low compared with values discussed in other countries. They should be reviewed in the next years.

Next year 2007 newly installed chillers, ventilation systems and split systems have to be reported, 2007 emissions have to be recalculated.

3.5.2.6. Mobile Air Conditioning

This group includes passenger cars, trucks, buses, ships, railcars and wheel tractors/mobile machinery. The sector is responsible for little less than 20% of the Estonian F-gas emissions (29.142 Gg CO₂ equivalents).

3.5.2.6.1. Passenger Cars

3.5.2.6.1.1. Source category description

In 2007, there were about 524 000 passenger cars in traffic register of Estonia. In Western Europe systematic air-conditioning of passenger cars with the refrigerant HFC-134a had started in 1994. As 314 000 vehicles of the Estonian passenger cars have been manufactured from 1994 onwards approx. 60% the vehicles are potentially air-conditioned. Equipment of these younger vehicles with air-conditioners is high – reaching over 90% in most recent years. The relevant MAC properties (equipment quota, refrigerant charge, leakage rate) depend on car makes and models. The refrigerant charge of passenger car MAC systems ranges from 0,39 kg to 1,24 kg, the emission rate is estimated 10%.

3.5.2.6.1.2. Methodological issues

The Estonian Motor Vehicle Registration Centre (ARK) provided a list of all passenger cars registered at the beginning of 2008, subdivided in production years (dating back to 1994 and beyond). No official data about air conditioning were obtainable.

MAC data depends on specific car models. While making the 2006 investigation the experts were facing the problem that the essential information for the estimation of the HFC stock in the cars of Estonia was available only for the most recent registration year. Thus a model for estimating the MAC data for the registration years 1994-2005 was elaborated and applied. This model was based on the fact that the predominant origin of the Estonian cars is Western Europe (Germany is the biggest source of second hand cars in Estonia), suggesting the conjecture that the average MAC data of the Estonian car park does not significantly differ from the analogous West European figures. In order to validate this hypothesis the quantitative model composition of the Estonian registration year 2006 was compared with the quantitative 2006 model composition of the German car park. As a result it emerged that the Estonian average figures indeed only marginally deviate from the German ones.

This substantial congruence in the 2006 MAC figures made the assumption plausible that such congruence also exists for the previous and the next registration years. Consequently, the German 1994-2005 and 2007 average figures were applied to respective registration years in the Estonian car park. This approach allows that the individual Estonian registration years do not need to be divided into the numerous models they consist of. The Estonian MAC quotas are considered equal to the German MAC quotas, the Estonian MAC charges are considered 2% smaller than the analogous German charges.

The emissions from the refrigerant stock in the car park are estimated applying the leakage rate established in the 2003 EU study , which the authors of this study claim to be representative of EU countries.

Method according to IPCC Guidelines 2006: Tier 2a with Europe specific determination of EF.

- Country-specific average refrigerant charge: 644 grams.
- Emission factor: 10%.
- MAC quotas: In the total fleet, the MAC quotas vary by the production years.

The total HFC-134a stock in passenger car MACs in Estonia amounts to 154 176 kg in the year 2007. The HFC-134a emissions from the Estonian passenger car fleet in 2007 total 15 418 kg (10%), the CO₂ equivalent of which is about 20 043.4 tons.

3.5.2.6.1.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. For the combination of individual uncertainties approach 1 of the 2006 IPCC Guidelines was applied.

The UN of the basic activity data “HFC stock” is estimated $\pm 8,5\%$, which is the combination of the individual UN of a) total registrations in 2006 ($\pm 1\%$), b) MAC quotas ($\pm 6\%$), c) refrigerant charges ($\pm 6\%$) – with most quotas and charges being taken from Germany.

The combination of the UN of the stock ($\pm 8,5\%$) with the UN of the operating emission factors ($\pm 5\%$) result in the UN of the HFC emissions of $\pm 10\%$.

Time series 1995-2005 were established in 2008.

3.5.2.6.1.4. Source-specific quality assurance/quality control and verification

The data for this report was collected partly within the framework of the Twinning Project EE2005/IB/EN/01. QC by the data collecting experts.

3.5.2.6.1.5. Source-specific recalculations

Recalculations were made for the years 1995-2005. No recalculation of preceding data (of the year 2006) was deemed necessary.

3.5.2.6.1.6. Planned improvements (source-specific)

No requirement.

3.5.2.6.2. Trucks**3.5.2.6.2.1. Source category description**

In 2007, there were about 77 900 trucks of the weight classes (according to 2002/16/EC) N1, N2, and N3 in traffic register of Estonia, 61% of which are younger than 13 years. In Western Europe systematic air-conditioning of trucks with the refrigerant HFC-134a had started in 1994/95. As a consequence, more than of half Estonian trucks are potentially air-conditioned. Equipment of these younger vehicles with air-conditioners is relatively high - reaching 90% in case of N3 trucks. The relevant MAC properties (equipment quota, refrigerant charge, leakage rate) depend on truck makes and models. The refrigerant charge of truck MAC systems ranges from 0.65 kg to 1,2 kg, the emission rate is 10-15% depending on the weight class.

3.5.2.6.2.2. Methodological issues

The Estonian Motor Vehicle Registration Centre (ARK) provided a list of all trucks registered at the beginning of 2008, subdivided in weight classes (N1, N2, and N3), makes, models and production years dating back to 1995 and beyond. No official data about air conditioning were available.

As the 2006 investigation results had showed congruence between Estonian and German passenger car fleets and their MAC data (based on the high share of imported used vehicles from Germany) the following approach was applied to establish necessary truck MAC data. The

German F-gas inventory treats the MAC quotas and charges of certain vehicles (12 truck models altogether) as representatives of their respective weight classes and extrapolates their specific figures to the total N1, N2, and N3 trucks in the country. The same truck models as in Germany were identified in the Estonian truck park for each weight category (N1, N2, N3). The German MAC quotas and refrigerant charges of these representative models were applied to the same models in the Estonian truck fleet. The total values of N1, N2 and N3 trucks in Estonia result from extrapolation of the particular model values pursuant to the share that these models have in the total Estonian fleet, by the three different weight classes N1, N2 and N3.

Method according to IPCC Guidelines 2006: Tier 2a with Europe specific determination of EF.

- Country-specific average refrigerant charges: weight class N1: 0.87 kg; weight class N2: 0.88 kg; and weight class N3: 1.1 kg.
- Emission factors : weight class N1: 10%; weight classes N2 and N3: 15%.
- MAC quotas: In the total fleet, the MAC quotas vary by the production years.

The total HFC-134a stock in truck MACs in Estonia amounts to 16 866.9 kg in the year 2007. The HFC-134a emissions from the Estonian truck fleet in 2007 total 2188.1 kg (13%), the CO₂ equivalent of which is about 2844.5 tons.

3.5.2.6.2.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. For the combination of individual uncertainties approach 1 of the 2006 IPCC Guidelines was applied.

The UN of the basic activity data “HFC stock” is estimated $\pm 8.5\%$, which is the combination of the individual UN of a) total registrations by weight categories in 2006 ($\pm 1\%$), b) MAC quotas ($\pm 6\%$), c) refrigerant charges ($\pm 6\%$) – with quotas and charges being taken from Germany.

The combination of the UN of the stock ($\pm 8.5\%$) with the UN of the operating emission factors ($\pm 5\%$) results in the UN of the HFC emissions of $\pm 10\%$.

Time series 1995-2005 were established in 2008.

3.5.2.6.2.4. Source-specific quality assurance/quality control and verification

The data for this report was collected partly within the framework of the Twinning Project EE2005/IB/EN/01. QC by the data collecting experts.

3.5.2.6.2.5. Source-specific recalculations

Recalculations were made for the years 1995-2005. No recalculation of preceding data (of the year 2006) was deemed necessary.

3.5.2.6.2.6. Planned improvements (source-specific)

No requirement.

3.5.2.6.3. Buses

3.5.2.6.3.1. Source category description

In 2007, about 3300 buses were operated in Estonia, 1300 of which were less than 15 years old (built as of 1992). Equipment of these younger vehicles with air-conditioners is relatively high (approx. 50%). This is because most of them are second-hand vehicles from Western Europe where also most of the few new buses were manufactured. In Western Europe large-scale air-conditioning of buses with the refrigerant HFC-134a had started in 1995 and has reached a high level, now. The relevant MAC properties (equipment quota, refrigerant charge, leakage rate) depend on whether a bus is a city, intercity or a tourist bus. City buses can be subdivided into single and articulated buses; intercity and tourist buses are usually single vehicles, with a small part of tourist buses being double deckers. The refrigerant charge of bus MAC systems is large,

ranging from 7 kg to 20 kg, the emission rate is high mainly because of the up to 50 metres long refrigerant piping.

3.5.2.6.3.2. Methodological issues

The Estonian Motor Vehicle Registration Centre (ARK) provided a list of all buses registered at the beginning of 2008 (M3 category), subdivided in makes, models and production years dating back to 1992 and beyond. Data on the city-intercity-tourist bus split were not included, nor are there official data available about air conditioning.

Several big national and local bus operators (TAK, Taisto, SEBE, Hansabuss, GoBus) were interviewed about the MAC data of their own fleet and of the countrywide bus fleet – resulting in two conclusions. Firstly, the shares of the three main bus types are even thirds of the total registrations. Secondly, the average Estonian data on quota, charge, and leakage (refills) largely match the data of Western Europe (see the 2007 bus study for the European Commission) in consequence of the extensive importation of second-hand vehicles from there. In addition, an essential quantity of air-conditioned buses turned out to be manufactured before 1995 so that the decision was made to shift the starting point for the reporting to the years 1992/1993.

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country-specific average refrigerant charges: Single buses (city, intercity, tourist): 10 kg; articulated buses and double deckers: 18 kg.
- Country-specific emission factors: Single buses (city, intercity, tourist): 1,5 kg/a; Articulated buses and double deckers: 3 kg/a.
- MAC quotas: In the total fleet, the MAC quotas vary by the production years.

The total HFC-134a stock in bus MACs in Estonia amounts to 7432.6 kg in the year 2007. The HFC-134a emissions from the Estonian bus fleet in 2007 total 1133.9 kg (15.3%), the CO₂ equivalent of which is about 1474.1 tons.

3.5.2.6.3.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. For the combination of individual uncertainties approach 1 of the 2006 IPCC Guidelines was applied.

The UN of the basic activity data “HFC stock” is estimated $\pm 8.7\%$, which is the combination of the individual UN of a) total registrations in 2006 ($\pm 1\%$), b) bus split ($\pm 5\%$), c) MAC quota ($\pm 5\%$), d) refrigerant charge ($\pm 5\%$).

The combination of the UN of the stock ($\pm 8.7\%$) with the UN of the operating emission factor ($\pm 5\%$) results in the UN of the HFC emissions of $\pm 10\%$.

Time series 1995-2005 were established in 2008.

3.5.2.6.3.4. Source-specific quality assurance/quality control and verification

The data for this report was collected partly within the framework of the Twinning Project EE2005/IB/EN/01. QC by the data collecting experts.

3.5.2.6.3.5. Source-specific recalculations

Recalculations were made for the years 1995-2005. No recalculation of preceding data (of the year 2006) was deemed necessary.

3.5.2.6.3.6. Planned improvements (source-specific)

No requirement.

3.5.2.6.4. Ships

3.5.2.6.4.1. Source category description

Usually, merchant ships >100 Gross Tonnage (GT) are equipped with air-conditioning systems and provision refrigeration, tugs with air-conditioning only, and fishing vessels >18 m with refrigeration. Ship air-conditioning with HFC started from 1996 onwards substituting HCFC-22. In Estonia, 36 ships with air-conditioning are registered. Refrigerants in use are HCFC-22, HFC 407C (mixture), HFC 404A (mixture) and HFC-134a as the new standard refrigerant. By far most HFC-refrigerants are used for air-conditioning (R-134a); only a small part is used for provision cooling (R-134a, R-404A, R-407C). The cooling and freezing systems of the Estonian deep-sea freezer trawlers operate without HFC (refrigerants: R-22 and ammonia).

3.5.2.6.4.2. Methodological issues

Ships under Estonian flag built in 2000 or later with GT 100 or more and fishing vessels >18 m are listed in the Estonian Ship Register (Estonian Maritime Authority). Data on AC and provision cooling systems of these ships – except for seven tugboats – were collected from the operating companies, additionally data on all ferries of the two relevant Estonian ferryboat companies – altogether 36 vessels. (The oldest ship with HFC air-conditioning and provision cooling was built in 1968.) The data on type of refrigerant, charge and refilling in 2007 were provided directly by the ship owners. The estimation of the stock emissions is based on direct measurement (refilling data 2007).

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country-specific HFC refrigerant stock: 6494 kg R-134a (thereof 110 kg in refrigeration); 417,6 kg R-404a and 50 kg R-407c (only refrigeration).
- Country-specific stock emissions (refills), EF = 30%: 1948.2 kg R-134a; 125.3 kg R-404a and 15 kg 407c.

The CO₂ equivalent of the stock emissions (all HFC together) is 2964 tons.

3.5.2.6.4.3. Uncertainties and time-series consistency

The data on refills are reliable and complete. As a consequence, the uncertainty of the HFC emissions is nevertheless estimated $\pm 5\%$, considering that tugboats and naval ships are not yet investigated.

Time series 1995-2005 were established in 2008.

3.5.2.6.4.4. Source-specific quality assurance/quality control and verification

The data for this report was collected partly within the framework of the Twinning Project EE2005/IB/EN/01. QC by the data collecting experts.

3.5.2.6.4.5. Source-specific recalculations

Recalculations were made for the years 1995-2005.

3.5.2.6.4.6. Planned improvements (source-specific)

Tugboats >100 GT are still under investigation as well the Estonian naval ships.

3.5.2.6.5. Railcars

3.5.2.6.5.1. Source category description

In 2007, there were 34 railcars (restaurant cars, sleeping cars, passenger coaches) of the Estonian fleet equipped with a working air conditioner. All systems had been retrofitted from CFC-12, and the refrigerant in use was R-401a. It is a blend containing 13% of HFC-152a by weight, in addition to R-22 (53%) and R-124 (34%); the latter are HCFCs and out of the scope of this report. The relevant MAC properties (refrigerant charge, leakage rate) do not depend on the type of the railcars. The refrigerant charge of railcar MAC systems ranges from 28 kg to 30 kg. The emission rate is high and the losses demand refilling after each arrival at the station in case of the long trips (10 to 17 hrs) between Estonia and Russia.

3.5.2.6.5.2. Methodological issues

Estonian Technical Surveillance Authority (Tehnilise Järelevalve Amet) was contacted to establish the size of the countrywide fleet. For obtaining MAC data all three local rail operators involved in passenger transport (GoRail, Edelaraudtee, Elektri-raudtee) and one service company (Ühinenud Depood) were interviewed. The results revealed that there are 34 air-conditioned and regularly maintained railcars. Although usually MAC charges depend on the type of a railcar (dining cars and sleeping cars having much higher charges than coaches) it became evident that this rule does not apply in case of Estonia, the refrigerant charges of MAC systems being around 30 kg in all types of railcars. The refrigerant quantity refilled annually into the railcar stock amounts to 200 kg. This corresponds to the experience of local experts that the MAC systems release 20 grams of refrigerant per operating hour.

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country-specific average refrigerant charges: all types of railcars 30 kg/a of R-401A (4.5 kg of HFC-152a).
- Country-specific emission factors: calculation based on annual losses of R-401a (200 kg) and the amount of refrigerant stock leads to the implied emission factor of 0.1961 for all types of railcars.

The total HFC-152a stock in railcar MACs in Estonia amounts to 153 kg in the year 2007. The HFC-152a emissions from the Estonian railcars in 2007 total 30 kg (19,6%), the CO₂ equivalent of which is 4200 kg based on the GWP 140 of HFC-152a.

There were 95 trams in Estonia; newer ones of these are potentially air-conditioned. However, according to the only Estonian operator (TTTK) none of the vehicles is equipped with a MAC.

3.5.2.6.5.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. For the combination of individual uncertainties approach 1 of the 2006 IPCC Guidelines was applied.

The UN of the basic activity data “HFC stock” is estimated $\pm 8.5\%$, which is the combination of the individual UN of a) number of operating vehicles with air conditioning in 2006 ($\pm 0\%$), and b) refrigerant charges ($\pm 3\%$).

The combination of the UN of the stock ($\pm 3\%$) with the UN of the operating emission factors ($\pm 5\%$) results in the UN of the HFC emissions of $\pm 5.8\%$.

Time series 1995-2005 were established in 2008.

3.5.2.6.5.4. Source-specific quality assurance/quality control and verification

The data for this report was collected partly within the framework of the Twinning Project EE2005/IB/EN/01. QC by the data collecting experts.

3.5.2.6.5.5. Source-specific recalculations

Recalculations were made for the years 1995-2005. No recalculation of preceding data (of the year 2006) was deemed necessary.

3.5.2.6.5.6. Planned improvements (source-specific)

No requirement.

3.5.2.6.6. *Wheel Tractors and Mobile Machinery*

3.5.2.6.6.1. Source category description

First agricultural machines (wheel tractors, combine harvesters) equipped with mobile air conditioners on Estonian market were manufactured in 1997/1998. With regard to construction machines (excavators, loaders) and other mobile machinery (forestry vehicles, roadwork machines) this equipment appeared later, in 2000. Thus only 15% of the 33,000 operating agricultural machines, 32% of the 5,000 construction machines, and 20% of the 1,100 other mobile machines in use in Estonia are potentially air conditioned, in 2007. Air conditioning of these machines is rapidly growing. The equipment quota of the new agricultural machines has reached 75% in recent years. Among new construction and other mobile machines this quota is still lower (40%) but also increasing. The refrigerant in use is HFC-134a. The relevant MAC properties (equipment quota, refrigerant charge, leakage rate) depend on the type and purpose of a specific machine. The refrigerant charge of tractors and mobile machinery MAC systems ranges from 1.0 kg to 2.0 kg. The emission rate is high due to powerful vibration of these machines causing amongst others the connections in the MAC system to become loose.

3.5.2.6.6.2. Methodological issues

The Estonian Motor Vehicle Registration Centre (ARK) published in the yearbook of 2007 the number of wheel tractors and mobile machinery registered in the beginning of 2008. The vehicles were classified according to the production years into 4 categories of up to 2 years, 3 to 5 years, 6 to 10 years, and over 10 years old machines. Official data about air conditioning of the vehicles were not available.

The main seller of agricultural and construction machines on the Estonian market (Mecro) was interviewed about the relevant MAC data. It shows that the average charges and quotas of Estonian agricultural machines match the respective values of Western Europe. The authors of this report taking into account the particularities of the Estonian vehicle fleet estimated the amount of leakages and refills.

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country-specific average refrigerant charges: wheel tractors, construction machines, forestry and roadwork machines 1,0 kg/a; combine harvesters: 1,6 kg/a.
- Country-specific emission factors: wheel tractors 20%; combine harvesters, construction machines, forestry and roadwork machines 25%.
- MAC quotas: In the total fleet, the MAC quotas vary by the production years. As the historical quotas of 1997-2005 cannot be gathered in 2007, the values as estimated by the local experts were applied.

In 2007, the total HFC-134a stock in tractor and mobile machinery MACs in Estonia amounts to 6527,5 kg in the year 2007. The HFC-134a emissions from the entire Estonian fleet total 1393.6 kg (21,4%) the CO₂ equivalent of which is about 1811.7 tons.

3.5.2.6.6.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. For the combination of individual uncertainties approach 1 of the 2006 IPCC Guidelines was applied.

The UN of the basic activity data “HFC stock” is estimated $\pm 14.5\%$ for every vehicle type, which is the combination of the individual UN of a) total registrations by vehicle types in 2006 ($\pm 3\%$), b) MAC quotas ($\pm 10\%$), c) refrigerant charges ($\pm 10\%$).

The combination of the UN of the stock ($\pm 14.5\%$) with the UN of the operating emission factors ($\pm 10\%$) results in the UN of the HFC emissions of $\pm 17.6\%$.

Time series 1995-2005 were established in 2008.

3.5.2.6.6.4. Source-specific quality assurance/quality control and verification

The data for this report was collected partly within the framework of the Twinning Project EE2005/IB/EN/01. QC by the data collecting experts.

3.5.2.6.6.5. Source-specific recalculations

Recalculations were made for the years 1995-2005. No recalculation of preceding data (of the year 2006) was deemed necessary.

3.5.2.6.6.6. Planned improvements (source-specific)

No requirement.

3.5.3. Foam Blowing

This group, which is responsible for about 22.7% of the Estonian F-gas emissions (33.05 Gg CO₂ equivalent), includes PU insulation panels, spray and injection PU foam, PU integral skin foam, XPS insulation foam and One Component PU foam.

3.5.3.1. PU Insulation Panels

3.5.3.1.1. Source category description

In 2007 HFC blown and containing insulation panels made of polyurethane rigid foam were neither manufactured nor used in Estonia; however, imported products had been applied for several years. In 2001, one Estonian company manufacturing PU sandwich panels (consisting of facings and a rigid polyurethane foam core) had substituted the blowing agent CFC directly by the water/CO₂ reaction. The only manufacturer of industrially prefabricated insulation panels for buildings (some type of sandwich element) combining PU spray foam with polystyrene changed in 2004 from the blowing agent HCFC-141b to CO₂/water and methyl formate. From 1998 onwards, a certain amount of PU sandwich elements manufactured with HFC-134a as blowing agent had been imported from abroad. Although the use of these products in Estonia stopped in 2006, the HFCs enclosed in the foam cells of these panels form a small bank that is a source of emissions in the long run.

3.5.3.1.2. Methodological issues

The present bank of HFC-134a as insulating gas in imported sandwich elements was assessed by a model (because the import/export data from the Estonian customs only indicate origin and total weight of sandwich elements without information on the insulating gases). The model is based on information from the Statistical Board (annual import of sandwich elements minus export), Estonian experts/importers (average quota of imported sandwich elements with PU-core 1998-2001: 15%, 2002-2006: 40%), and foreign manufacturers of sandwich elements (average quota of PU-foam with HFC-134a: 1998/99: 100%, 2000: 50%, 2001: 10%, 2002ff: 5%; PU core: 30% of the sandwich elements weight). As a result, the bank of HFC containing PU panels (about 760 t) in 2006 was estimated to contain approx. 230 tons PU with HFC-134a with the HFC-134a content in the foam-stock of 6,75%.

The annual use-phase HFC-134a emissions from the bank (EF_{op}) are estimated according to experts from manufacturing companies at 0.5% (cf. UBA 2005: 142).

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country specific EF_{op} : 0.5%.

The 2007 Estonian HFC-134a bank in PU insulation panels amounts to 15,3 tons, the annual use-phase emissions are 0,077 tons (100 tons or 0.1 Gg CO₂ equivalent).

3.5.3.1.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. For the combination of individual uncertainties approach 1 of the 2006 IPCC Guidelines was applied.

The UN of the basic activity data “HFC stock” is estimated at $\pm >10\%$ because it is based on both official statistical data and expert judgment.

The combination of the UN of the stock ($\pm >10\%$) with the UN of the operating emission factor ($\pm 10\%$) results in the UN of the HFC emissions of $\pm 15\%$.

Time series 1998-2005 were established in 2008. In 1995 (base-year) HFC emissions from the PU panel application did not yet arise.

3.5.3.1.4. Source-specific quality assurance/quality control and verification

The data for this report was collected partly within the framework of the Twinning Project EE2005/IB/EN/01. QC by the data collecting experts.

3.5.3.1.5. Source-specific recalculations

Recalculations were made for the years 1995-2005. No recalculation of preceding data (of the year 2006) was deemed necessary.

3.5.3.1.6. Planned improvements (source-specific)

No requirement.

3.5.3.2. Spray and Injection PU Foam

3.5.3.2.1. Source category description

This sector of on-site insulation with spray respectively injection foam blown with the new-developed HFC-365mfc (with HFC-227ea add-on to reduce the flammability) is small. However, there must not only use-phase emissions be considered but also emissions upon manufacturing. The manufacturing emissions are relatively high because the foaming process is an open application. It should be mentioned that HFC-free (water based) PU spray foam systems are also in use, namely for in-site insulation of soil-laid heating pipes, up to some tons/year.

3.5.3.2.2. Methodological issues

In the EU, for on-site applied foam the hardly inflammable blowing agent HCFC-141b was no longer permitted as of 2004 at the latest. Difficulties with alternative blowing agents arose from

two sides. On the one hand the application of HFC-365mfc is not trivial from a technical point of view. On the other hand the manufacturer of this fluid could not satisfy the demand for HFC-365mfc in 2004 because of problems in his production plant. As a consequence, in the EU the HCFC-141b was still in use after 2004 - according to PU system suppliers also in Estonia.

In 2007, one company in Estonia used HFC-365mfc/HFC-227ea (in addition to a small amount of HFC-134a) as blowing agent for on-site applied PU foam. HFC quota in this mixture: HFC-365mfc = 93%, HFC-227ea = 7%.

According to chemical suppliers, the HFC content in the spray foam system before application is 7,5%. On application (manufacturing), a blowing agent loss (EF_{manu}) must be considered which includes two HFC fractions: one released directly upon application and another being released within one year after application. Both fractions together are called first year loss (FYL). The FYL amounts to 20%; 80% of the original blowing agent remain in the foam cells during the use-phase. The product life factor (EF_{op}) is according to chemical suppliers 1%.

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country specific EF_{manu} : 20%.
- Country specific EF_{op} : 1%.
- 2007 domestic consumption: 320 kg HFC-365mfc/227ea and HFC-134a.

Manufacturing emissions: 64 kg HFCs ($EF = 20\%$), thereof 55,6 kg HFC-365mfc and 4,4 kg HFC-227ea and 4 kg HFC-134a, which is 67,5 t CO₂ equivalent.

In 2007 emissions from the stock occurred for the first time ($EF = 1\%$). The bank constituted of 166,8 kg HFC-365mfc, 26,4 kg HFC-227ea and 24 kg HFC-134a. Stock emissions: 1,7 kg HFC-365mfc, 0,3 kg HFC-227ea and 0,2 kg HFC-134a which is 2,7 t CO₂ equivalent.

Total global warming emissions: 70,2 t CO₂ equivalent (0.07 Gg).

3.5.3.2.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. The UN of the basic activity data “HFC consumption” is estimated at $\pm >10\%$ because it is based on sales data and expert judgment. The combination of the UN of the consumption ($\pm >10\%$) with the UN of the manufacturing emission factor (FYL) of $\pm 10\%$ results in the UN of the HFC emissions of $\pm 15\%$.

A time series from 1995 to 2005 cannot be established because 2006 is the first year of HFC use in this application.

3.5.3.2.4. Source-specific quality assurance/quality control and verification

The data for this report was collected partly within the framework of the Twinning Project EE2005/IB/EN/01. QC by the data collecting experts.

3.5.3.2.5. Source-specific recalculations

No requirement as 2006 was the first year of HFC use in this application.

3.5.3.2.6. Planned improvements (source-specific)

No requirement.

3.5.3.3. PU Integral Skin Foam

3.5.3.3.1. Source category description

In 2007, one company in Estonia used HFC-365mfc and HFC-227ea for manufacturing of a very small amount of PU integral skin products.

3.5.3.3.2. Methodological issues

For manufacturing of PU integral skin foam small quantities (1-2%) of HFC are added as auxiliary blowing agent in order to improve product quality. As integral skin is open-cell foam, upon foaming the blowing agent is released almost completely within one year (according to the industrial foam system supplier, and UBA 2005, p. 144). The EF manu (First Year Loss) is 100%. This means methodologically that there is no need for estimating an HFC bank and operating emissions from this bank. Information on the 2007 consumption of HFC-365mfc was provided by the manufacturer of integral skin products in Estonia.

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country specific EF_{manu}: 100%.
- 2007 consumption and manufacturing emissions of HFC-365mfc: 28 kg. Since the blowing agent always contains small amount of HFC-227ea to reduce the flammability of the substance this amount of the add-on was estimated to be 2,1 kg. Emissions total 31 tons CO₂ equivalent (0,031 Gg).

3.5.3.3.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. The UN of the activity and emissions data “HFC consumption” is estimated at only $\pm 3\%$ because it is based on information of the only user.

A time series from 1995 to 2005 cannot be established because 2006 is the first year of HFC use in this application.

3.5.3.3.4. Source-specific quality assurance/quality control and verification

The data for this report was partly collected within the framework of the Twinning Project EE2005/IB/EN/01. QC by the data collecting experts.

3.5.3.3.5. Source-specific recalculations

No requirement as 2006 was the first year of HFC use in this application.

3.5.3.3.6. Planned improvements (source-specific)

No requirement.

3.5.3.4.XPS Insulation Foam

3.5.3.4.1. Source category description

The 2006 basic research showed that XPS foam was not manufactured in Estonia whereas imported XPS board for thermal insulation was of some importance in the country. The European manufacturers have stepwise shifted from HCFC blowing agents to HFC-134a/152a and to CO₂. The main XPS suppliers to the Estonian market are using CO₂. One international manufacturer currently using both CO₂ and HFC-134a blowing agents supplies the Estonian market from a Scandinavian factory with CO₂ blown foam. From 2001 to 2006, this company sold a considerable amount of HFC-134a containing XPS panels to Estonia where these panels were used. It is generally accepted that in case of HFC-134a some 27% of the blowing agent release to the atmosphere on manufacturing (EFmanu = 27%). As a consequence, 73% of the blowing agent remains in the panels as insulating cell gas, in the long term. Thus, in Estonia an HFC bank in the XPS board stock was considered as a source of domestic emissions.

3.5.3.4.2. Methodological issues

Seven international chemical companies gave data on the XPS foam market in Estonia. Based on this information, both the year-on-year growth in the domestic XPS-foam bank and the HFC content in the annual sales quantities were assessed for the 2001-2005 periods. From 12.5% (2001) a gradual decrease in the HFC-134a content to 0% (2006) was established, resulting in 5% HFC content of the final 2006 XPS stock (72 000 m³ XPS, thereof 3600 m³ HFC-containing XPS). As the HFC quantity used for the production of one m³ XPS foam is known (3,3 kg), the

HFC bank was calculated from the volume of XPS sold to Estonia. A use-phase emission factor (EF_{op}) of 0,66% was applied to this long-term bank of enclosed HFC-134a.

- Country specific EF_{op} : 0.66%.
- 2007 HFC-134a bank: 8,6 tons.
- 2007 use-phase emissions: 56,8 kg (0,66%) which is 73,84 t (0.074 Gg) CO₂ equivalent.

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

3.5.3.4.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts.

No official statistical data on the XPS board consumption in Estonia is available. Thus the annual sales and the current stock of XPS foam with HFC-134a had to be calculated with sector experts. The UN of the activity data “HFC stock” is estimated at $\pm 20\%$. The uncertainty of the emission factor is estimated 10% so that the UN of the annual use-phase emissions is $\pm 22,34\%$

Time series 2001-2005 were established in 2008. In 1995 (base-year) HFC emissions from XPS foam did not yet arise.

3.5.3.4.4. Source-specific quality assurance/quality control and verification

The data for this report was collected partly within the framework of the Twinning Project EE2005/IB/EN/01. QC by the data collecting expert and co-operators.

3.5.3.4.5. Source-specific recalculations

Recalculations were made for the years 2001-2005. No recalculation of preceding data (of the year 2006) was deemed necessary.

3.5.3.4.6. Planned improvements (source-specific)

No requirement.

3.5.3.5. One Component PU Foam**3.5.3.5.1. Source category description**

Estonia is amongst the four biggest EU countries manufacturing polyurethane one-component foam (OCF). To a considerable part, the propellant gases in the foam cans are HFCs (HFC-134a and HFC-152a) that are added to halogen-free flammable gases. By far most of the domestically used fluorinated greenhouse gases (HFCs) are imported for filling million of OCF cans that are, on their part, predominantly exported, especially to Eastern Europe. There is, however, also a considerable domestic market for OCF, which is supplied by both domestic manufacturers and – to lesser degree – foreign companies. The EU F-gas Regulation includes restrictions of the use of HFCs in OCF as of July 2008. This Regulation, however, does not prohibit the production for exportation nor the placing on the market of OCF with HFCs in mixtures if the mixture GWP is less than 150. This means that OCF with HFC-152a can be sold in Estonia without any restrictions also in the future.

3.5.3.5.2. Methodological issues

The following data was collected for emission estimation from manufacturing and use of OCF:

- Number of cans (in terms of 750 ml volume) with HFC as blowing agent manufactured in Estonia, average amount of HFC per can, split into HFC-134a and HFC-152a, emissions on filling;
- Number of OCF cans (in terms of 750 ml content) with HFC as blowing agent sold to the Estonian market, HFC split, average amount of HFC propellant per can.

Information sources: The two Estonian companies manufacturing OCF within the country and selling OCF to the Estonian market. The share of foreign OCF companies selling to the Estonian

market was also estimated. The EF_{manu} (1,7%) is based on information from the two domestic manufacturers and was compared to international data. As to the application of OCF, it is assumed that all HFC is emitted from the cans in the year of the OCF use. In contrast to the method of the IPCC Guidelines 1999 and 2006 but in accordance with other submissions under the UNFCCC it is assumed that all use-phase emissions occur in the year of sale (use and disposal occurring promptly after sale). The category “stock 2007” is equated to the HFC content of OFC cans sold to the Estonian market and used in 2007. Hence only emissions from manufacturing and use (= stock) are entered in the CRF table, no emissions from disposal. The 2007 HFC-consumption was in total 805,5 t.

Method according to IPCC Guidelines 2006: Tier 2a with country specific determination of EF.

- Country specific EF_{manu} : 1,7%.
- Country specific EF_{op} : 100%.
- Manufacturing emissions: 5,9 tons HFC-134a; 8,1 tons HFC-152a; together 8756,1 t CO₂ equivalent.
- Stock = use-phase emissions: 17,2 tons HFC-134a; 11,7 tons HFC-152a; together 23 998 t CO₂ equivalent.

The HFC emissions from manufacturing and from stock total to 32,802 t or 32.802 Gg CO₂ equivalent.

3.5.3.5.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts. As the domestic and foreign manufacturers themselves provided all the relevant data, the data uncertainty is estimated low. The uncertainty of the annual HFC consumption and – consequently – use-phase emissions by quantity and HFC type is $\pm 15\%$. The same value applies to the manufacturing emissions.

Time series 1995-2005 were established in 2008.

3.5.3.5.4. Source-specific quality assurance/quality control and verification

The data for this report was collected partly within the framework of the Twinning Project EE2005/IB/EN/01. QC by the data collecting experts.

3.5.3.5.5. Source-specific recalculations

Recalculations were made for the years 1995-2005. No recalculation of preceding data (of the year 2006) was deemed necessary.

3.5.3.5.6. Planned improvements (source-specific)

No requirement.

3.5.4. Fire Extinguishers

In Estonia different types of HFC are used for substituting halons in fire protection (flooding equipment): mostly HFC 227ea (FM-200), the mixture R-866 consisting of HFC-134a, HFC-125 and CO₂, and furthermore HFC-23. This group is responsible for about 0.59% of the Estonian F-gas emissions (0.859 Gg CO₂ equivalent).

3.5.4.1. Source-category description

F-gases are more expensive than environmentally friendlier substances for fire fighting in indoor flooding systems (e.g. nitrogen, argon). The latter are characterized as overpressure gases. Compared to them, the advantage of F-gases is their lower pressure: The pressure of FM 200 (HFC 227ea) in the piping is about one fifth of the pressure of argon. This makes the F-gases suitable for flooding systems of smaller rooms where the higher pressure of e.g. argon could cause damages. F-gas consumption for fire fighting includes also its usage in military objects.

F-gases for fire fighting are imported to Estonia in closed cylinders. Installation is carried out by connecting the cylinder with the piping system. The cylinder has, according to the supplying

companies, no valve outside but only inside so that a mistake upon installation (e.g. opening of the wrong valve) is hardly possible. In case of false alarm or fire the whole charge of the cylinder is blown out. Refilling in situ does normally not take place. Emptied cylinders are replaced by full cylinders.

3.5.4.2. Methodological issues

Data on the amount of the three mentioned HFC-based fluids for fire protection in the 2007 stock was provided directly by six companies dealing with fire protecting systems incl. maintenance and by one supplier of fire fighting agents who submitted the basic data (stock) of eight additional clients. According to experts from these companies no other players were active in this field. The first HFC installation dates back to 2000.

According to IPCC Guidelines 2006 the annual emissions from installed flooding systems are in the range of 2 ± 1 percent of the installed base. As there are no detailed indications on operating emissions from flooding systems in Estonia for a longer period, an EF_{op} of 2% is applied to the bank. Emissions upon filling/refilling (EF_{manu}) are not calculated. According to the long lifetime of flooding systems (15-20 years) and the possibilities of recovery we do not assume end-of-life emissions.

Method Tier 2a according to IPCC guidelines 2006, using IPCC default EF_{op} .

- Operating emission factor EF_{op} : 2%.

In Estonia, the total 2007 quantity of F-gases in installed fire fighting systems amounted to 14.051 t (12.273 t HFC-227ea, 0.467 t HFC-23 and 1.425 t R866, the latter containing 8% CO₂ in mixture with HFC-134a and HFC-125). The emissions from this stock are calculated 2 percent: 9.34 kg HFC-23, 2.85 kg HFC-125, 23.36 kg HFC-134a and 245.46 kg HFC-227ea. The CO₂ equivalent of all 2007 HFC emissions is about 859.5 tons.

3.5.4.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts according to approach 1 of the 2006 IPCC Guidelines.

The data are based on direct information from industry, so that the UN of the data on the different HFC stocks can be estimated comparably low ($\pm 10\%$). The UN of the emission factor is assessed $\pm \sim 10\%$, so that the combined UN of the emissions is estimated $\pm 15\%$.

Time series 1995-2006 were established in 2008.

3.5.4.4. Source-specific quality assurance/quality control and verification

The data for this report was partly collected within the framework of the Twinning Project EE2005/IB/EN/01. QC by the data collecting experts.

3.5.4.5. Source-specific recalculations

As 2007 is the first year of reporting fire extinguishers, recalculations were made through time series.

3.5.4.6. Planned improvements (source-specific)

No source specific improvements are under active consideration at the moment.

3.5.5. Aerosols

This group includes Metered Dose Inhalers (MDI) as well as General and Novelty Aerosols. The sector is responsible for about 2.17% of the Estonian F-gas emissions (3.164 Gg CO₂ equivalent).

3.5.5.1. Metered Dose Inhalers

Under the category of Metered Dose Inhalers (MDI) with HFCs of pharmaceutical grade two aerosol applications are discussed: aerosols for natural medicine and aerosols for the treatment of asthma/COPD (chronic obstructive pulmonary diseases).

3.5.5.1.1. Source-category description

Metered Dose Inhalers for natural drugs containing HFC-134a as propellant of pharmaceutical grade are manufactured in Estonia and are partially exported, however not imported; in contrast, all MDIs for asthma/COPD are imported.

3.5.5.1.2. Methodological issues

The domestic manufacturer provided the data on manufacturing, domestic consumption and export of MDIs for natural drug products including the emissions rate from manufacturing ($EF_{\text{manu}} = 3\%$). Use-phase emissions: The number of MDIs for both natural and anti-asthma drugs sold to the domestic market in 2007 (production + import - export) is the stock of the same year 2007. (A surcharge factor for hospitals and doctors' samples of 5% is applied.) As the consumption of the products follows the purchase immediately, annual stock and the annual emissions are the same size. HFC-134a is completely exhaled after inhalation so that 100% is the appropriate value for the use-phase emission factor.

In 2007 MDIs (asthma/COPD) with HFC-134a as propellant were registered in Estonia from six companies, but only three companies put their products on the market. Detailed information and sales figures on the various pharmaceutical products and on the HFC content per device were provided by the Estonian Medical Board (Ravimiamet) and were controlled by means of information from the respective companies.

Method according to IPCC guidelines 2006: Tier 2a with country specific EF.

- Country specific EF_{manu} : 3%.

- Country specific EF_{op}: 100%.
- Natural MDIs: The 2007 domestic consumption of HFC-134a was 2,39 tons (manufacturing emissions: 71,7 kg), of which 1,34 tons were sold to the domestic market, resulting in use-phase emissions of the same amount (1,34 tons).
- Anti-Asthma MDIs: The 2007 domestic market was 926,8 kg, with the same quantity of emissions.

Overall emissions: 2,343 tons HFC-134a or 3,046 tons CO₂ equivalent (3.046 Gg).

3.5.5.1.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts according to approach 1 of the 2006 IPCC Guidelines.

The data are based on direct information from manufacturers and from trade departments in industry, so that the activity data domestic production and domestic market are deemed highly reliable. As a consequence, the UN of the emissions (manufacturing and use-phase) is estimated $\pm 10\%$.

Time series 1995-2005 were established in 2008.

3.5.5.1.4. Source-specific quality assurance/quality control and verification

The data for this report was partly collected within the framework of the Twinning Project EE2005/IB/EN/01. QC by the data collecting experts.

3.5.5.1.5. Source-specific recalculations

Recalculations were made for the years 1995-2005. No recalculation of preceding data (of the year 2006) was deemed necessary.

3.5.5.1.6. Planned improvements (source-specific)

No requirement.

3.5.5.2. General and Novelty Aerosols**3.5.5.2.1. Source-category description**

HFC-134a is used as propellant in some technical aerosols like solvent and cleaning sprays and in novelty aerosols such as signal horns for sport events or hunting. The signal horns are manufactured in Estonia, solvent and cleaning sprays with HFC-134a are imported.

3.5.5.2.2. Methodological issues

The Estonian manufacturer of signal horns provided data on his HFC-134a consumption for signal horns sold to the Estonian market in 2007; manufacturers from US and Germany submitted the respective data on solvent and cleaning sprays sold to Estonia. The number of cans for all purposes with HFC charge between 11 and 90 g/can was 2630; the HFC-134a charge totalled 89,2 kg (average charge 29,5 g/can).

As in MDIs, the HFC-consumption for general aerosols in 2007 is equated to emission in the same year 2007 (EF_{op} 100%). The very small amount of emissions from manufacturing (3%) in case of the signal horns is calculated separately.

Method according to IPCC guidelines 2006: Tier 2a with country specific EF.

- Country specific EF_{manu} : 3%.
- Country specific EF_{op} : 100%.
- Country specific charge of aerosol cans: 29,5 g

The 2007 domestic consumption of HFC-134a for producing novelty aerosols was 60,3 kg (manufacturing emissions: 1,8 kg). 58,5 kg were sold to the domestic market, resulting in use-

phase emissions of the same amount. The 2007 of HFC-134a stock emissions from general and novelty aerosols is 89,2 kg.

Overall emissions: 91 kg HFC-134a or 118.3 tons CO₂ equivalent (0.118 Gg).

3.5.5.2.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts according to approach 1 of the 2006 IPCC Guidelines.

The data are based on direct information from industry, so that the UN of the activity data on the number of units and on charges can be estimated low ($\pm 10\%$). The same UN value applies to the emissions because the emission factor is 100%.

Time series 1995-2005 were established in 2008.

3.5.5.2.4. Source-specific quality assurance/quality control and verification

The data for this report was collected partly within the framework of the Twinning Project EE2005/IB/EN/01. QC by the data collecting experts.

3.5.5.2.5. Source-specific recalculations

Recalculations were made for the years 1995-2006. The data of the year 2006 were recalculated with regard to manufacturing emissions (3% of production).

3.5.5.2.6. Planned improvements (source-specific)

No requirement.

3.5.6. Electrical Equipment

Electrical equipment for electrical power transmission and distribution is the largest individual SF6 consumption sector in Estonia. The sector's contribution to the Estonian F-gas emissions is about 0.64% (0.937 Gg CO₂-equivalent).

3.5.6.1. Source-category description

SF6 is used as an arc quenching and insulating gas in high-voltage (110-380 kV) and medium-voltage (6-35 kV) switchgear (GIS) and control gear. In Estonia the use of SF6 in this sector started in 1988 (high-voltage) and 1999 (medium-voltage), respectively. The equipment is not manufactured within the country. Medium-voltage GIS (distribution equipment) operate with low over-pressure and little gas quantities of only some kg/system. They are already SF6 charged when imported and are hermetically closed ("sealed for life"). High-voltage GIS (transmission equipment) with a higher operating pressure (up to 7 bar) and bigger gas quantities ("closed for life") have to be replenished in their lifetime. They are imported with a transport filling and are filled up in site (on site erection).

3.5.6.2. Methodological issues

Three Estonian companies of electrical power distribution operate SF6 containing HV-GIS (two companies) and MV-GIS (two companies). The companies provided data on their equipment, on their SF6 consumption in total and on refilling during the last years. The third company, Estonian Railway, operates several own MV-GIS. 95% of the SF6 stock is concentrated at the main power distributor of the country. The refilling data of the HV equipment reported from different power suppliers ranged from 0,1% to 0,7%/year. In case of MV-GIS no losses occurred according to the companies. The main operator of HV-GIS estimated the EFmanu (topping up of imported HV-GIS within the country) 0,1%. The EFop of HV- and MV-GIS used in this report is based on the default emission factors of the IPCC Guidelines 2006 with 0,7% (high voltage) and 0,1% (medium voltage) per year, respectively.

Method according to IPCC guidelines 2006: Tier 3.

- Country specific EF_{manu} (manufacturing emission factor, on site erection): 0,1%.
- EF_{op} (according to IPCC GL): 0,7% (HV), 0,1% (MV).

Manufacturing emissions is 0,595 kg. The respective stock amounts to 5196,4 kg (HV) and 2265,9 kg (MV). Stock emissions: 36,4 kg (HV), 2,2 kg (MV). Total: 38,6 kg.

Total global warming emissions: 936.76 t CO₂ equivalent (0.937 Gg).

3.5.6.3. Uncertainties and time-series consistency

Öko-Recherche experts assessed the emissions uncertainty (UN) pursuant to approach 1 of the 2006 IPCC Guidelines. As the activity data are based on direct information from industry, their UN is estimated low: $\pm 3\%$. The UN of the default emission factors is $\pm 10\%$ (IPCC GL 2006, Tier 3). The combined UN of the emissions is $\pm \sim 10,4\%$.

Time series 1995-2005 were established in 2008.

3.5.6.4. Source-specific quality assurance/quality control and verification

The data for this report was partly collected within the framework of the Twinning Project EE2005/IB/EN/01. QC by the data collecting expert and co-operators.

3.5.6.5. Source-specific recalculations

Recalculations were made for the years 1995-2005. No recalculation of preceding data (of the year 2006) was deemed necessary.

3.5.6.6. Planned improvements (source-specific)

The data of the missing operator shall be collected.

3.5.7. Other

Under this category PFC emissions from sport shoes with gas cushion as well as emissions of SF₆ from radiotherapy devices are reported. This is very small category, which is responsible of about 0.06% Estonian F-gas emissions (0.09 Gg CO₂-equivalent).

3.5.7.1. Other Electrical Equipment

Under “Other Electrical Equipment” Estonia reports emissions of SF₆ from radiotherapy devices. This is very small group, which is responsible of about 0.02% Estonian F-gas emissions (0.029 Gg CO₂ equivalent).

3.5.7.1.1. Source-category description

Two hospitals in Estonia use SF₆ insulated radiotherapy equipment (oncology). The two devices are of different size. Other applications – e.g. SF₆ insulated particle accelerators or gas impregnation of power capacitors – do not occur in Estonia.

3.5.7.1.2. Methodological issues

Data on charge and use-phase losses were directly submitted from the medical operator. The operator calculated the emission rate of the one operating system at 10% a year (in 2006 installed modern system). In case of the smaller and much elder system the EF_{op} was calculated at 30% a year, bases on the operator’s experience from the last four years. The country specific EF_{op} deduced from this information is 12.2%.

Method according to IPCC guidelines 2006: Tier 2a with country specific EF.

- Country specific EF_{op}: 12.2.

The 2007 stock of SF₆ totals 10 kg, the 2007 operating emissions 1.2 kg.
Global warming emissions: 28.7 t CO₂ equivalent (0.0287 Gg).

3.5.7.1.3. Uncertainties and time-series consistency

The data are based on estimation of the operators. The emissions uncertainty is estimated +/- 30%
Time series 1995-2005 were established in 2008.

3.5.7.1.4. Source-specific quality assurance/quality control and verification

The data for this report was partly collected within the framework of the Twinning Project EE2005/IB/EN/01. QC by the data collecting experts.

3.5.7.1.5. Source-specific recalculations

Recalculations were made for the years 1995-2005.

3.5.7.1.6. Planned improvements (source-specific)

No source specific improvements are under active consideration at the moment.

3.5.7.2. Sport Shoe Soles

Under this title PFC emissions from sport shoes with gas cushion are reported. This is very small group, which is responsible of about 0.04% Estonian F-gas emissions (0.061 Gg CO₂ equivalent).

3.5.7.2.1. Source-category description

Sport shoes using soles with SF₆-gas cushions were introduced to the European market in the early 1990's. From 2003 to 2005 SF₆ was replaced by PFC-218 (perfluoropropane). Footwear with SF₆/PFC-cushions has not been manufactured in Estonia but was imported. 100 percent of the F-gases in the soles are emitted at the end-of-life of the shoes. The lifetime is calculated at three years.

3.5.7.2.2. Methodological issues

Data on the Estonian market of sport shoes with SF₆ or PFC gas cushions were provided by the manufacturer. New footwear on the Estonian market has been clear of SF₆ from July 2003 onwards; final disposal emissions occurred in 2006; PFC-stock, PFC quantity for disposal/PFC disposal emissions have been calculated for 2003-2007, and 2006-2008, respectively.

The method follows IPCC guidelines 2006 (Emissions in year t = Sales in year $t-3$).

- EF_{disposal}: 100% (IPCC GL).

The total 2007 quantity of PFC-218 in footwear at decommissioning (end of life emission) amounts to 8.7 kg. The CO₂ equivalent emissions are 60.9 t CO₂ equivalent (0.0609 Gg).

3.5.7.2.3. Uncertainties and time-series consistency

The emissions uncertainty (UN) was assessed by the Öko-Recherche experts according to approach 1 of the 2006 IPCC Guidelines.

The data are based on direct information from industry, so that the UN of the activity data "sales in year 2004" and "emissions in 2007" can be estimated comparably low ($\pm 10\%$).

Time series 1995-2006 were established in 2008.

3.5.7.2.4. Source-specific quality assurance/quality control and verification

The data for this report was collected within the framework of the Twinning Project EE2005/IB/EN/01. QC by the data collecting experts.

3.5.7.2.5. Source-specific recalculations

Recalculations were made for the years 1995-2006.

3.5.7.2.6. *Planned improvements (source-specific)*

No source specific improvements are under active consideration at the moment.

CHAPTER 4. AGRICULTURE (CRF 4)

4.1. Overview of source category description and methodology

Agricultural GHG emissions in Estonia consist of CH₄ emission from enteric fermentation of domestic livestock (for 14 sub-categories of livestock) and CH₄ and N₂O emission from manure management systems, and direct and indirect N₂O emission from agricultural soils. Direct N₂O emission includes emission from synthetic fertilizers, emission from animal waste and sludge applied to agricultural soil; from cropping of N-fixing crops; emission from crop residues and cultivation of organic soils. Indirect N₂O emission includes emissions from atmospheric deposition and leaching and run-off.

The following improvements were carried out in this submission:

- c) the data on population of cattle and swine livestock were updated;
- d) the data on module of manure management system were updated;
- e) GHG emissions from Field Burning of Agricultural Residues were calculated for 1990–2007;
- f) N₂O emissions from N-fixing crops and Crop Residues were recalculated.

Rice is not cultivated in Estonia. Savannas areas do not exist in Estonia (Table 4.1).

Table 4.1. Methods and emissions factors used for estimations of emission from agriculture

	CH ₄		N ₂ O	
	Method Applied	Emission Factor	Method Applied	Emission Factor
I. Enteric Fermentation				
1. Cattle				
a. Cows, bulls and heifers (2 years and over)				
Dairy cattle	T2	IPCC, CS		
Non-Dairy cattle				
...Mature Females	T2	IPCC, CS		
...Mature Males	T2	IPCC, CS		
b. Bovine animals (ages between 1 and 2 years)	T2	IPCC, CS		
c. Calves (less than 1 year old)	T2	IPCC, CS		
2. Swine				
a. Piglets, live weight less than 20 kg	T1, L	IPCC, CS		
b. Young pigs, live weight 20 - <50 kg	T1, L	IPCC, CS		

	CH ₄		N ₂ O	
	Method Applied	Emission Factor	Method Applied	Emission Factor
c. Fattening pigs, live weight				
50 - <80 kg	T1, L	IPCC, CS		
80 - <110 kg	T1, L	IPCC, CS		
110 kg or more	T1, L	IPCC, CS		
d. Breeding pigs, live weight 50 kg and more	T1, L	IPCC, CS		
3. Sheep	T1	IPCC, CS		
4. Goats	T1	IPCC		
5. Horses	T1	IPCC		
6. Poultry	NE			
II. Manure Management				
1. Cattle				
a. Cows, bulls and heifers (2 years and over)				
Dairy cattle	T1	IPCC, CS	T1	IPCC, CS
Non-Dairy Cattle				
Mature Females	T1	IPCC	T1	IPCC, CS
Mature Males	T1	IPCC	T1	IPCC, CS
b. Bovine animals (ages between 1 and 2 years)	T1	IPCC	T1	IPCC, CS
c. Calves (less than 1 year old)	T1	IPCC	T1	IPCC, CS
2. Swine				
a. Piglets, live weight less than 20 kg	T1	IPCC, CS	T1	IPCC, CS
b. Young pigs, live weight 20 - <50 kg	T1	IPCC, CS	T1	IPCC, CS
c. Fattening pigs, live weight				
50 - <80 kg	T1	IPCC, CS	T1	IPCC, CS
80 - <110 kg	T1	IPCC, CS	T1	IPCC, CS
110 kg or more	T1	IPCC, CS	T1	IPCC, CS
d. Breeding pigs, live weight 50 kg and more	T1	IPCC, CS	T1	IPCC, CS
3. Sheep	T1	IPCC	T1	IPCC
4. Goats	T1	IPCC	T1	IPCC
5. Horses	T1	IPCC	T1	IPCC
6. Poultry	T1	IPCC	T1	IPCC
III. Rice Cultivation				
IV. Agricultural soil				
1. Direct Soil Emissions				
a. Synthetic Fertilizers			T1	IPCC
b. Animal Waste Applied to Soils			T1	IPCC
c. N-fixing crops			T1	IPCC
d. Crop Residues			T1	IPCC
e. Cultivation of Histosols			T1	IPCC
2. Animal Production			T1	IPCC
3. Indirect Emissions				
a. Atmospheric Deposition			T1	IPCC
b. Leaching and Run-off			T1	IPCC
V. Prescribed Burning of Savannas				
VI. Field Burning of Agricultural Residues				
	T1	IPCC	T1	IPCC

T1 – Tier 1; T – Tier 2; L – literature; IPCC – IPCC default factors; CS – Country specific

4.1.1. References – sources of information

The estimations were carried out based on approaches presented in the 1996 Revised IPCC Guidelines (IPCC, 1997) and the IPCC Good Practice Guidance (IPCC, 2000).

Activity data were obtained from Estonian National Statistics (Table 4.2), emission factors mostly were taken from the IPCC Guidelines (IPCC, 1997; IPCC, 2000). A list of institutions directly and indirectly involved in the inventory process is presented in Table 4.2.

Table 4.2. List of institutions (datasets) involved in the emission inventory for the agricultural sector

References	Link	Abbreviation	Data
Tallinn University of Technology	www.ttu.ee	TUT	- activity data gathering; - estimation of emissions; - reporting (the CRF tables, the NIR).
Statistics Estonia – Agricultural Statistics	www.stat.ee	ESO	- collection and reporting of data on livestock population, quantities of crop produced and amounts of fertilizers applied on fields.
Estonian Animal Recording Centre	www.jkkeskus.ee	EARC	- collection and reporting of data on milk production, fat content in milk, and percentage of cows that give birth.
Estonian Environmental Information Centre	www.keskkonnainfo.ee	EEIC	- providing with CORINE land cover map. - collection and reporting of data on amounts of sludge used for improvement of environment (on agricultural fields)

4.1.2. Quantitative overview

The total GHG emission from the agriculture sector was 1,333.09Gg in Estonia in 2007. It was 6.0%⁵ of the total GHG emission in Estonia (Figure 4.1). CO₂-equiv emission from Enteric Fermentation of livestock and Direct CO₂-equiv emission from agricultural soils contributed to the main share to the total emissions from the agricultural sector.

⁵ GHG emissions related to LULUCF sector is not included.

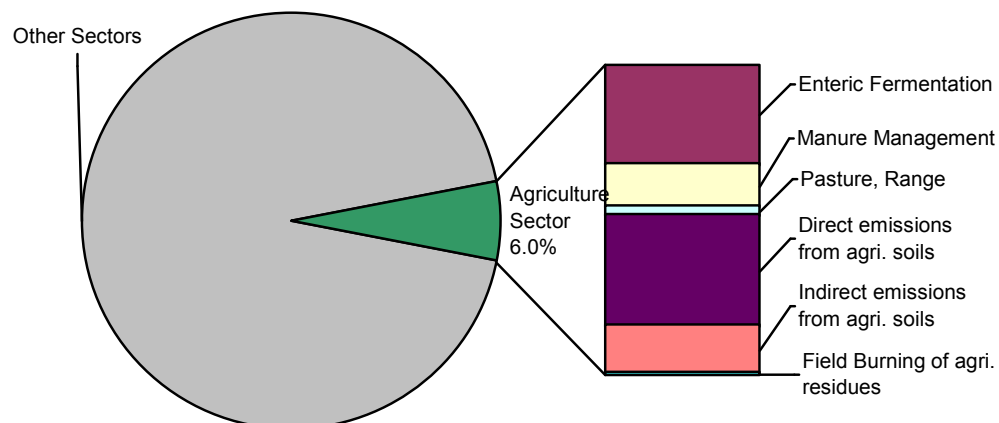


Figure 4.1. Emissions from agriculture compared to total GHG emissions in 2007, Gg

CO₂equiv emission from the agricultural sector has declined 2.3-fold compared with the base year, mostly due to decreasing livestock population and to quantities of synthetic fertilizers and manure applied on agricultural fields (Figure 4.1, Figure 4.2).

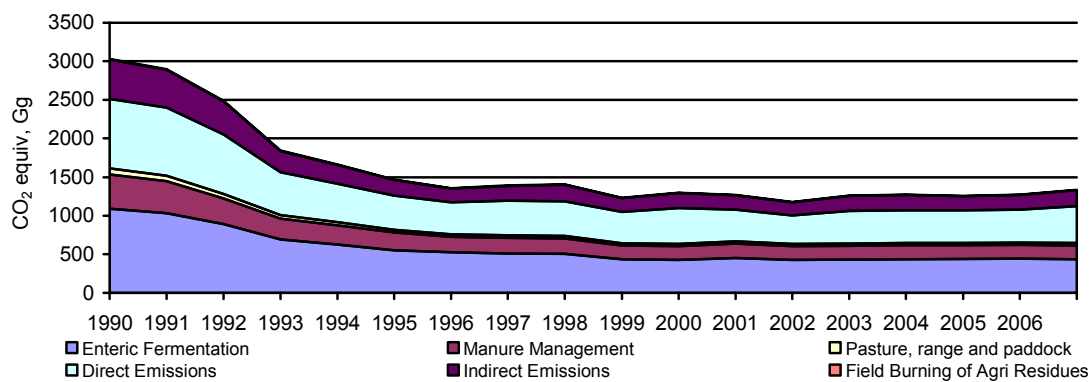


Figure 4.2. Trend in agricultural emissions by source categories in 1990–2007, Gg

Table 4.3. Estonia's agricultural greenhouse gases emissions by sources in 1990–2007, Gg

Year	Enteric Fermentation	Manure Management		Agricultural soils		Field Burning of Agricultural Residues		Total GHG emissions		Total CO ₂ equiv emissions
	CH ₄	CH ₄	N ₂ O ⁶	Direct N ₂ O	Indirect N ₂ O	CH ₄	N ₂ O	CH ₄	N ₂ O	CO ₂ equiv
1990	51.92	6.85	1.21	2.91	1.66	0.25	0.004	59.11	5.78	3,032.7
1991	49.09	6.37	1.13	2.85	1.59	0.24	0.004	55.80	5.57	2,899.7
1992	42.34	4.95	0.93	2.49	1.39	0.17	0.003	47.53	4.81	2,488.8
1993	32.98	3.95	0.74	1.80	0.88	0.21	0.003	37.18	3.43	1,843.6
1994	29.68	3.94	0.68	1.60	0.80	0.14	0.002	33.67	3.09	1,664.0
1995	26.27	3.63	0.62	1.42	0.66	0.14	0.002	29.97	2.70	1,467.8
1996	25.05	3.04	0.54	1.33	0.58	0.17	0.003	28.18	2.46	1,355.7
1997	24.77	3.08	0.55	1.43	0.63	0.18	0.003	27.61	2.62	1,391.6
1998	24.05	3.09	0.54	1.45	0.69	0.15	0.002	27.21	2.69	1,403.9
1999	20.70	2.74	0.48	1.32	0.58	0.11	0.002	23.48	2.38	1,232.0
2000	20.39	2.75	0.48	1.51	0.62	0.18	0.003	23.26	2.61	1,298.0
2001	21.49	2.94	0.50	1.33	0.60	0.14	0.002	24.51	2.43	1,267.5
2002	20.29	2.83	0.48	1.20	0.54	0.13	0.002	23.18	2.22	1,175.9
2003	20.55	2.84	0.48	1.36	0.64	0.13	0.002	23.45	2.47	1,258.7
2004	20.76	2.83	0.49	1.37	0.65	0.14	0.002	23.67	2.50	1,273.5
2005	20.95	2.83	0.49	1.35	0.58	0.18	0.002	23.90	2.43	1,255.3
2006	21.05	2.81	0.49	1.37	0.62	0.15	0.002	23.95	2.49	1,274.4
2007	20.70	2.91	0.50	1.53	0.66	0.21	0.003	23.76	2.69	1,333.1

4.1.3. Key categories

Agricultural key categories in 2007 estimated in accordance with IPCC Tier 1 method are follows:

	Category	LULUCF sector is not included	LULUCF sector is included
4.A.	Enteric Fermentation: Cattle (CH ₄)	L, T	L
4.B.	Manure Management (N ₂ O)	L, T	
4.D.1.1.	Synthetic Fertilizers	L, T	L
4.D.1.2.	Animal Manure Applied to Soils	L	
4.D.1.5	Cultivation of Histosols	L, T	L, T
4.D.3.2.	Nitrogen Leaching and Run-off	L, T	L

⁶ N₂O emissions emitted during livestock pasturing is included into the total.

4.1.4. *Uncertainty assessment*

The combined uncertainties associated with Agriculture sector as percent from the total national emission in 2007 as follows⁷:

4.A.	Enteric Fermentation (CH ₄)	0.9896%
4.B.	Manure Management (N ₂ O)	0.0724%
4.B	Manure Management (N ₂ O)	0.5624%
4.D.1	Direct Soil Emission from Agricultural Soils (N ₂ O)	1.9874%
4.D.3	Indirect Emission from Agricultural Soils (N ₂ O)	3.3823%
4.F	Field Burning of Agricultural Residues (CH ₄ , N ₂ O)	0.0105%
	Agriculture sector total	6.9941%

4.2. Enteric fermentation and manure management

4.2.1. Source category description

Emissions of CH₄ and N₂O from livestock are reported under this category.

4.2.2. Livestock activity data

Livestock population decreased in comparison with the base year: the total number of swine decreased 2.3 fold, horses – 1.6 fold and poultry – 4.4 fold. The number of dairy cattle decreased 2.7 fold: from 280.7 thousand heads to 103 thousand heads, the number of non-dairy cattle decreased from 477 thousand heads in 1990 to 137.9 thousand heads in 2007. The number of sheep decreased 1.9 fold and the number of goats increased from 0.9 thousand heads to 4 thousand heads from 1990 to 2007 (Figure 4.3, Figure 4.4).

⁷ Uncertainty calculation for the Estonian GHG inventory **excluding** LULUCF sector

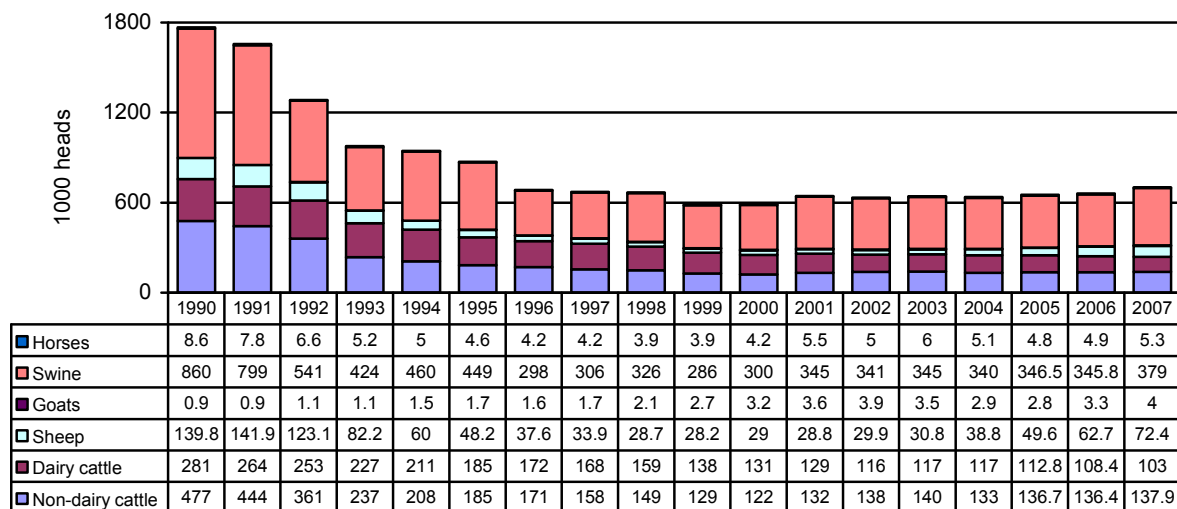


Figure 4.3. Population of livestock in Estonia from 1990–2007, 1000 heads

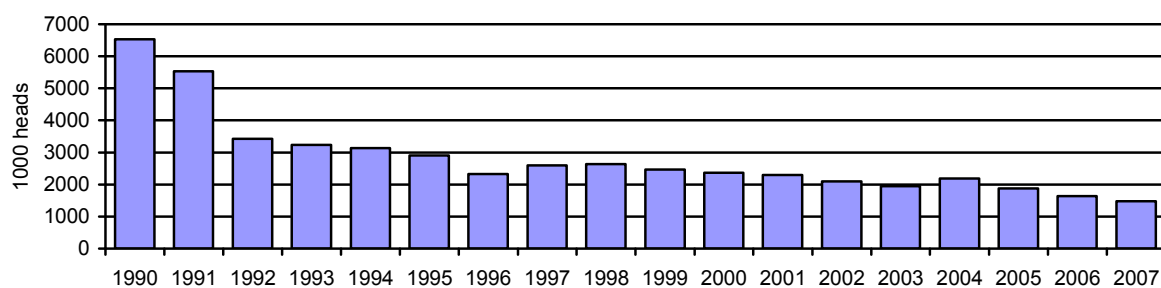


Figure 4.4. Population of poultry in Estonia from 1990 to 2007, 1000 heads

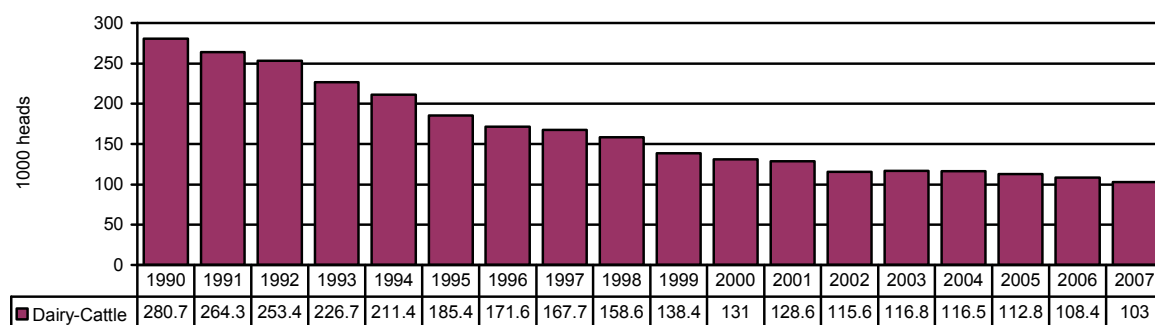


Figure 4.5. Population of dairy cattle in Estonia in 1990–2007, 1000 heads

The number of mature non-dairy cattle population was collected and reported by ESO according to two methodologies employed: for 1990–1998, livestock population data were reported for two sub-categories (bovine animals and mature males) and for 1999–2007, the population of three

sub-categories of non-dairy mature cattle was reported by ESO (bovine animals, mature males and females). In order to guarantee the consistency in the activity data used, the data of 1990–1998 were updated basing on assumptions, the results are illustrated in Figure 4.6 (Annex 5_I).

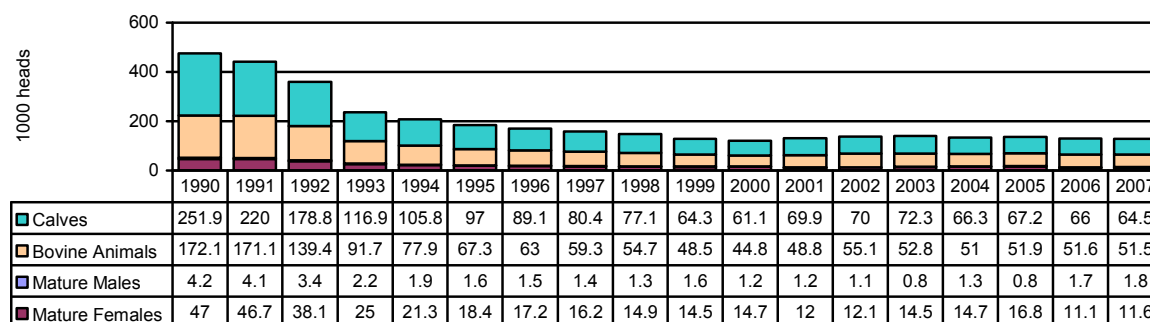
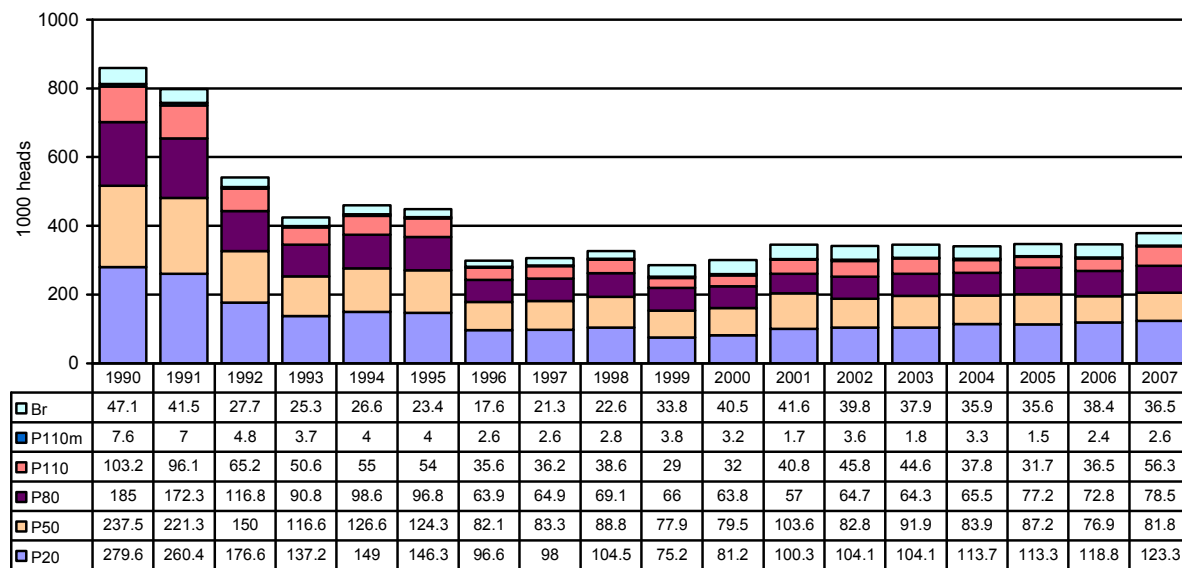


Figure 4.6. Population of non-dairy cattle in Estonia in 1990–2007, 1000 heads⁸

The activity data on swine population in 1990–1998 were updated. The number of swine population for 1990–1998 was break downed/reported for three sub-categories of swine (breeding sows, fattening pigs and young swine) and for 1999–2007 for six sub-categories of swine (piglets, with live weight less than 20 kg; young pigs, with live weight 20–<50kg; pigs, with live weight 50–<80kg, 80–<110kg and 110 kg and more; and breeding sows). Based on assumptions, the activity data on swine population in 1990–1998 were recalculated for six sub-categories instead of three reported (Annex 5_I).

⁸ DC – Dairy Cattle;
 MF – Bulls (1 year and over);
 MM – Heifers (1 year and over);
 B – Bovine animals (aged between 1 and 2 years);
 C – Calves (under 1 year old);

Figure 4.7. Population of pigs in Estonia in 1990–2007, 1000 heads⁹

The activity data used in the estimations in the 2009 submission differ from those reported in FAO statistic dataset due to different methods of data reporting (Table 4.4). The ESO data have been used in the estimates of the 2009 submission.

Table 4.4. The number of livestock population in Estonia in 1992–2007, in accordance with ESO and FAO datasets, 1000 heads

Year	Cattle		Pigs		Sheep		Goats		Horses		Poultry	
	ESO	FAO	ESO	FAO	ESO	FAO	ESO	FAO	ESO	FAO	ESO	FAO
1992	614.0	708.3	541	798.6	123.1	141.9	1.1		6.6	7.8	3,418.1	5,538
1993	464.0	614.6	424	541.1	82.2	124.2	1.1		5.2	6.6	3,236.1	3,418
1994	419.0	463.2	460	424.3	60	83.3	1.5		5.0	5.2	3,129.7	3,226
1995	370.0	419.5	449	459.8	48.2	61.5	1.7		4.6	5.0	2,911.3	3,130
1996	343.0	370.4	298	448.8	37.6	49.8	1.6		4.2	4.6	2,324.9	2,911
1997	326.0	343.0	306	298.4	33.9	39.2	1.7		4.2	4.2	2,602	2,325
1998	308.0	325.6	326	306.3	28.7	33.9	2.1	1.7	3.9	4.2	2,635.7	2,602
1999	267.0	307.5	286	326.4	28.2	28.7	2.7	2.1	3.9	3.9	2,461.8	2,636
2000	253.0	267.3	300	285.7	29	28.2	3.2	2.7	4.2	3.9	2,366.4	2,414
2001	261.0	252.8	345	300.2	28.8	29	3.6	3.2	5.5	4.2	2,294.9	2,318
2002	254.0	260.5	341	345.0	29.9	28.8	3.9	3.6	5.0	5.5	2,096.3	2,249

⁹ P20 - Piglets, live weight less than 20 kg;
P50 - Young pigs, live weight 20–<50 kg;
P80 – Pigs, live weight 50–<80 kg;
P110 – Pigs, live weight 80–<110 kg;
P100m – Pigs, live weight 110 kg or more;
Br - Breeding sows;

Year	Cattle		Pigs		Sheep		Goats		Horses		Poultry	
	ESO	FAO	ESO	FAO	ESO	FAO	ESO	FAO	ESO	FAO	ESO	FAO
2003	257.0	253.9	345	340.8	30.8	29.9	3.5	3.9	6.0	5.3	1,945.2	2,070
2004	250.0	257.2	340	344.6	38.8	30.8	2.9	3.5	5.1	5.8	2,183	1,929
2005	249.5	249.8	346.5	340.1	49.6	38.1	2.8	2.9	4.8	5.1	1,878.7	2,161
2006	244.8	249.5	345.8	346.5	62.7	49.6	3.3	2.8	4.9	4.8	1,638.7	1,854
2007	240.9	244.8	379	345.8	72.4	62.7	4	3.3	5.3	4.9	1,477.6	1,638

4.2.3. CH₄ emissions from Enteric Fermentation

4.2.3.1. Source category description

Methane is emitted as a by-product of the livestock digestive process, in which microbes resident in the animal's digestive system ferment the feed consumed by the animal. This fermentation process is also known as enteric fermentation. The CH₄ is then eructated or exhaled by the animal. Within livestock, ruminant livestock (cattle, buffalo, sheep, and goats) are the primary source of emissions (Gibbs *et al.*, 2000). Pigs are non-ruminant animals and convert a smaller proportion of feed intake into methane than ruminants.

CO₂-equiv emission from enteric fermentation of livestock made up 33% from the total CO₂-equiv emission of the agricultural sector in Estonia in 2007 (Table 4.5).

CH₄ emission of 2007 is 60% lower than the emission of the base year due especially to decreasing number of livestock (Figure 4.8, Figures 4.3-4.7).

Table 4.5. CH₄ emissions from Enteric Fermentation by animal type in 1990–2007 in Estonia, Gg

Year	Cattle	Pigs	Sheep	Goats	Horses	Poultry	Total	Total CO ₂ equiv
1990	49.96	0.68	1.12	0.005	0.15	NE	51.92	1,090.4
1991	47.18	0.63	1.14	0.005	0.14	NE	49.09	1,031.0
1992	40.80	0.43	0.98	0.006	0.12	NE	42.34	889.1
1993	31.88	0.34	0.66	0.006	0.09	NE	32.98	692.5
1994	28.74	0.37	0.48	0.008	0.09	NE	29.68	623.3
1995	25.44	0.36	0.39	0.009	0.08	NE	26.27	551.8
1996	24.43	0.24	0.30	0.008	0.08	NE	25.05	526.0
1997	24.17	0.24	0.27	0.009	0.08	NE	24.77	520.2
1998	23.48	0.26	0.23	0.011	0.07	NE	24.05	505.1

Year	Cattle	Pigs	Sheep	Goats	Horses	Poultry	Total	Total CO ₂ equiv
1999	20.15	0.24	0.23	0.014	0.07	NE	20.70	434.8
2000	19.82	0.25	0.23	0.016	0.08	NE	20.39	428.2
2001	20.86	0.28	0.23	0.018	0.10	NE	21.49	451.3
2002	19.65	0.28	0.24	0.020	0.10	NE	20.29	426.0
2003	19.90	0.28	0.25	0.018	0.10	NE	20.55	431.5
2004	20.08	0.27	0.31	0.015	0.09	NE	20.76	436.1
2005	20.18	0.28	0.40	0.014	0.09	NE	20.95	440.0
2006	20.16	0.28	0.50	0.017	0.09	NE	21.05	442.0
2007	19.69	0.31	0.58	0.020	0.10	NE	20.70	434.7
%, 2007	95.1	1.5	2.8	0.1	0.5			

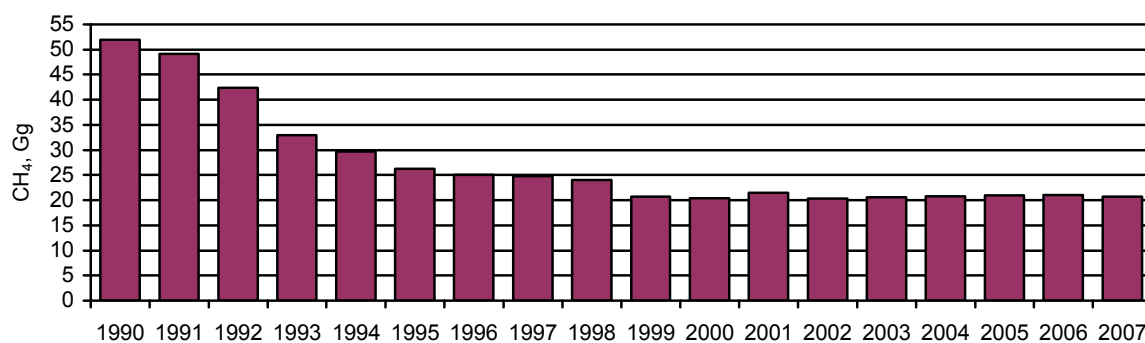


Figure 4.8. CH₄ emissions from Estonia's livestock enteric fermentation in 1990–2007, Gg

4.2.3.2. Cattle

4.2.3.2.1. Methodology, data availability, data sources and emission factors

The *Tier 2* method (IPCC, 1997) was used to estimate CH₄ emission from enteric fermentation of the main cattle livestock sub-categories (presented by ESO). A disaggregation on county level of Estonia was applied (Table 4.6).

Table 4.6. Symbols used in the algorithm for cattle

County	Cattle classes
i1- Harju county	j1- Dairy Cattle
i2- Hiiu county	j2- Mature Females
i3- Ida-Viru county	j3- Mature Males
i4- Jõgeva county	j4- Bovine cattle
i5- Järva county	j5- Calves (less than 1 year old)
i6- Lääne county	
i7- Lääne-Viru county	
i8- Põlva county	
i9- Pärnu county	
i10- Rapla county	

County	Cattle classes
i11- Saare county	
i12- Tartu county	
i13- Valga county	
i14- Viljandi county	
i15- Võru county	

Net energy for maintenance – Net energy required by the animal to keep the animals in energy equilibrium

$$NE_{mji} \text{ (MJ/day)} = C_{fji} \times (\text{weight_in_kg}_{ij})^{0.75} \quad (4.1)^{10}$$

NE_{mji} - Net energy for maintenance by j category of cattle in i county, MJ/head/day;

Weight – Live weight of j category of cattle in i county, kg;

C_f – Coefficient for calculating NE_m (Table 4.7);

Table 4.7. C_f coefficient¹¹

Animal Category	C_f
Cattle (non-lactating)	0.322
Cattle (lactating)	0.335

Net energy for activity for animals

$$NE_{aji} = C_a \times NE_{mji} \text{ _for_cattle} \quad (4.2)^{12}$$

NE_{aji} - Net energy intake by j category of cattle in i county, MJ/head/day;

C_a - Coefficient corresponding to animal's feeding situation;

NE_m – Net energy required for maintenance by j category of cattle in i county (4.1);

¹⁰ IPCC 2000, Agriculture, Equation 4.1, pp 4.13.

¹¹ IPCC 2000, Agriculture, Table 4-4 – Coefficient for calculating NE_m , pp. 4.15

¹² IPCC 2000, Agriculture, Equation 4.2a, pp. 4.12.

Table 4.8. Activity coefficients corresponding to animal's feeding situation¹³

Situation	Definition	C _a
Stall	Animals are confined to a small area with the result that they expend very little or no energy to acquire feed.	0
Pasture	Animals are confined in areas with sufficient means to forage, requiring a modest energy expense to acquire feed.	0.17

Net energy for growing – net energy needed for growth live weight gain

$$NE_{gji} \text{ (MJ/day)} = 4.18 \times \left\{ (0.035 W_{ji}^{0.75} \times WG_{ji}^{1.119}) + WG_{ji} \right\} \quad (4.3)^{14}$$

NE_{gji} – Net energy for growing by *j* category of cattle in *i* county, MJ/head/day;

W – Weight, kg;

WG – Weight gain by *j* category of cattle in *i* county, kg per day;

Net energy for lactation – energy for lactation

$$NE_{li} \text{ (MJ/day)} = \text{kg_of_milk/day}_i \times (1.47 + 0.40 \times \text{Fat}_i) \quad (4.4)^{15}$$

NE_{li} – Net energy for lactation by dairy cattle in *i* county, MJ/head/day;

Fat – Fat content of milk in *i* county, %;

Net energy for pregnancy

$$NE_{\text{pregnancy}} \text{ (MJ/281 – day_period)} = 28 \times \text{calf_birth_weight_in_kg} \quad (4.5)^{16}$$

$$\text{Calf_birth_weight_kg} = 0.266 \times (\text{cow_weight_in_kg})^{0.79} \quad (4.6)$$

¹³ IPCC 2000, Table 4.5 – Activity coefficients corresponding to animal's feeding situation, pp. 4.15

¹⁴ IPCC 1996, Agriculture, Reference Manual, Equation 3, pp. 4.18.

¹⁵ IPCC 2000, Agriculture, Equation 4.5a, pp. 4.17.

¹⁶ IPCC 1996, Agriculture, Reference Manual, Equation 6, pp. 4.19.

Ratio of net energy available in a diet for maintenance to digestible energy consumed

$$NE/DE_{ji} = 1.123 - (4.092 \times 10^{-3} \times DE_{ji} \%) + (1.126 \times 10^{-5} \times (DE_{ji} \%)^2) - 25.4/DE_{ji} \% \quad (4.7)^{17}$$

NE_{ma}/DE_{ji} – Ratio of net energy available in a diet for maintenance to digestible energy consumed for j category of cattle in i county;

DE_{ji} – Digestible energy expressed as a percentage of gross energy for j category of cattle in i county;

Ratio of net energy available for growth in a diet to digestible energy consumed

$$NE_g/DE_{ji} = 1.164 - (5.160 \times 10^{-3} \times DE_{ji} \%) + (1.308 \times 10^{-5} \times (DE_{ji} \%)^2) - 37.4/DE_{ji} \% \quad (4.8)^{18}$$

NE_{gaji} – Ratio of net energy available for growth in a diet to digestible energy consumed for j category of cattle in i county;

¹⁷ IPCC 2000, Agriculture, Equation 4.9, pp. 4.19.

¹⁸ IPCC, 1997, Agriculture, Reference Manual, Equation 10, pp. 4.19.

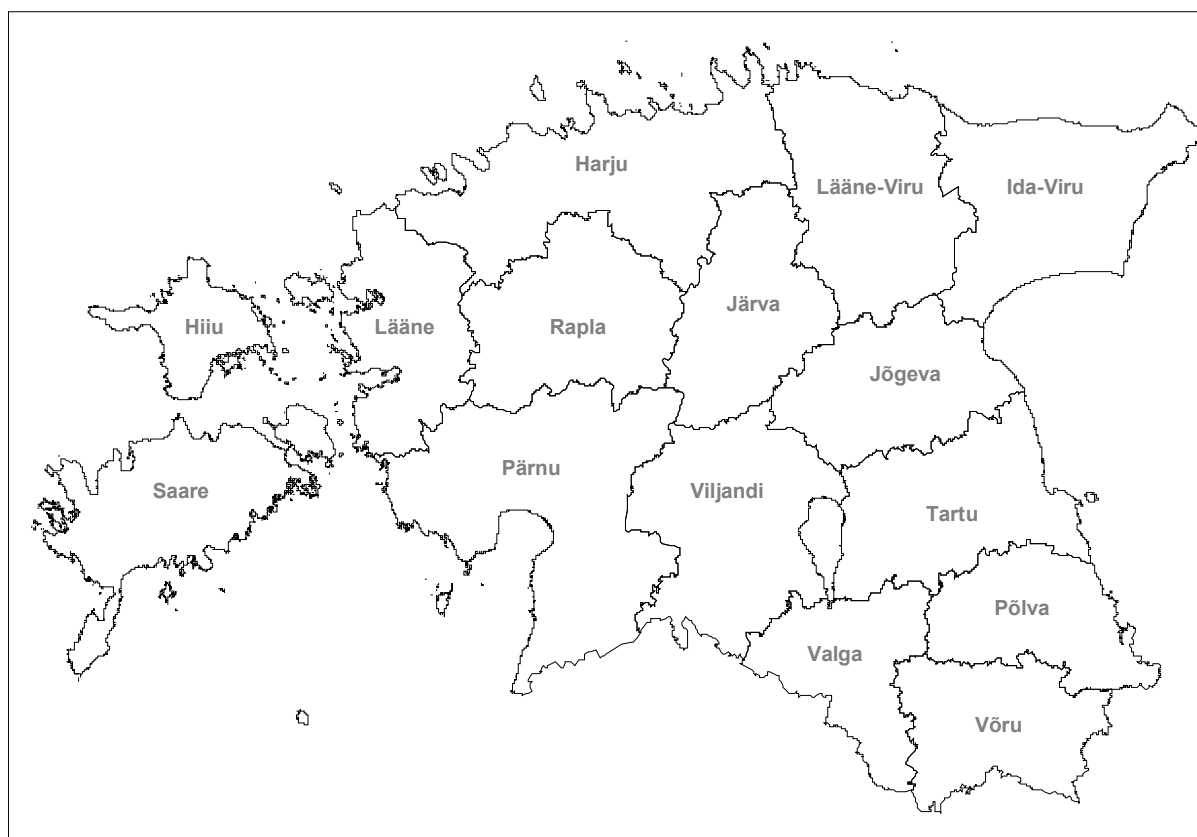


Figure 4.9. Administrative boundaries of Estonia's counties ([Estonian Land Board](#))

Gross energy for cattle

$$GE = \frac{(NE_{m_{ji}} + NE_{feed_{ji}} + NE_{l_{ji}} + NE_{work_{ji}} + NE_{pregnancy_{ji}}) \times \left(\frac{100}{DE_{ji} \%} \right)}{(NE/DE)_{ji} + (NE_{g_{ji}} / \{NE_g/DE\}_{ji})} \quad (4.9)^{19}$$

GE – Gross energy by j category of cattle in i county, MJ/head/day;

NE_m – Net energy required by the animal for maintenance by j category of cattle in i county, MJ/head/day;

NE_a or N_{feed} – Net energy for animal activity by j category of cattle in i county, MJ/day

NE_l – Net energy for lactation by dairy cattle in i county, MJ/head/day;

¹⁹ IPCC, 1997, Reference Manual, Equation 16, pp. 4.21.

NE_w – Net energy for work by j category of cattle in i county²⁰, MJ/head/day;

NE_p or $NE_{\text{pregnancy}}$ – Net energy required for pregnancy by dairy cattle in i county, MJ/head/day;

NE_g – Net energy needed for growth by j category of cattle in i county, MJ/head/day;

DE – Digestible energy as percentage of gross energy of j category of cattle in i county, %;

Methane emission factor from livestock category

$$E = [GE \times Y_m \times (365 \text{ days/yr})] / [55.65 \text{ MJ} / \text{CH}_4 \text{ kg}] \quad (4.10)^{21}$$

E – Methane emission from enteric fermentation of j category of cattle in i county, kg CH_4 /year;

GE – Gross Energy Intake by j category of cattle in i county, MJ/head/day;

Y_m – Methane conversion rate, which is the factor of gross energy in feed converted to methane;

The main sources of data used in the algorithm to estimate the methane emission factor from enteric fermentation by sub-categories of cattle:

Weight, kg – data on weight of cattle were obtained from the IPCC reported tables²².

Feeding situation – data were obtained from databases (tables) reported by the IPCC¹⁴

Milk production per day, kg/day – a source of data is ESO (Table 4.9, Table 4.10). The data in Table 4.10 illustrates the trend of milk yield per cow in Estonia and fat content of milk in 1990–2007.

Fat content of milk, % - the data were taken from [EARC](#) (Table 4.9, Table 4.10) (Annex 5_II).

Percentage of cows that give birth in a year, % – the data were employed from [EARC](#) (Table 4.9, Table 4.10) (Annex 5_II).

Feed digestibility, % - data were used from databases (tables) presented by IPCC¹⁴ (Annex 5_III)

²⁰ Net energy for work was not calculated

²¹ IPCC, 2000, Agriculture, Equation 4.14, pp. 4.26.

²² IPCC, 1997, Agriculture, Reference Manual, Table A-1- Data for estimating enteric fermentation emission factors for dairy cattle. pp. 4.31

Table 4.9. Average milk yield per cow, fat content and percentage of cows that gave birth in 2007

County	Average milk yield per cow, kg/day	Fat content ²³ , %	Percentage of cows that gave birth in 2007, %
Estonian average	17.76	4.15	88.4
Harju county	16.49	4.18	78.3
Hiiu county	12.84	4.28	73.0
Ida-Viru county	14.90	4.08	82.1
Jõgeva county	18.66	4.20	98.9
Järva county	19.30	4.11	94.2
Lääne county	15.10	4.28	99.1
Lääne-Viru county	18.69	4.03	91.5
Põlva county	20.11	4.11	87.3
Pärnu county	17.55	4.19	89.1
Rapla county	17.33	4.06	81.6
Saare county	15.39	4.23	85.4
Tartu county	19.46	4.13	92.1
Valga county	16.08	4.22	87.2
Viljandi county	16.25	4.26	88.4
Võru county	17.21	4.29	78.1

Table 4.10. Average milk yield [kg/head/yr] per cow and fat content of milk [%] in 1990–2007

Year	Fat content of milk, %	Milk yield per cow, kg/head/yr	Percentage of cows that gave birth, %
1990 ²⁴	4.14	10.87	80.0
1991	4.14	10.87	80.0
1992	4.07	9.67	80.0
1993	4.10	9.10	80.0
1994	4.12	9.47	80.0
1995	4.20	9.83	80.0
1996	4.34	10.44	95.8
1997	4.32	12.28	94.9
1998	4.26	12.21	97.1
1999	4.23	11.43	81.3
2000	4.29	12.77	76.9
2001	4.31	14.55	76.3
2002	4.29	14.08	82.8
2003	4.31	14.33	81.3
2004	4.27	15.33	81.7
2005	4.21	16.13	84.0
2006	4.17	17.22	92.2
2007	4.15	17.76	88.4

²³ www.jkkeskus.ee/pages/sta/2005/ka2005.htm

²⁴ The values of 1991

Table 4.11. CH₄ emission factor from enteric fermentation of cattle in 2007, kg CH₄/head/year

County	Emission factors for Enteric Fermentation, kg CH ₄ /head/yr				
	Dairy Cattle	Non-Dairy Cattle			
		Mature Males	Mature Females	Bovine animals	Calves
Harju county	121.2	67.7	59.0	62.7	34.4
Hiiu county	106.6	67.7	59.0	62.7	34.4
Ida-Viru county	114.0	67.7	59.0	62.7	34.4
Jõgeva county	131.2	67.7	59.0	62.7	34.4
Järva county	132.7	67.7	59.0	62.7	34.4
Lääne county	117.1	67.7	59.0	62.7	34.4
Lääne-Viru county	129.3	67.7	59.0	62.7	34.4
Põlva county	135.7	67.7	59.0	62.7	34.4
Pärnu county	126.1	67.7	59.0	62.7	34.4
Rapla county	123.7	67.7	59.0	62.7	34.4
Saare county	117.3	67.7	59.0	62.7	34.4
Tartu county	133.5	67.7	59.0	62.7	34.4
Valga county	120.2	67.7	59.0	62.7	34.4
Viljandi county	121.3	67.7	59.0	62.7	34.4
Võru county	125.1	67.7	59.0	62.7	34.4

The average enteric fermentation emission factor of dairy cattle is continuing to grow since 1995 due mostly to increasing milk production by cow and fat content of milk (Figure 4.10).

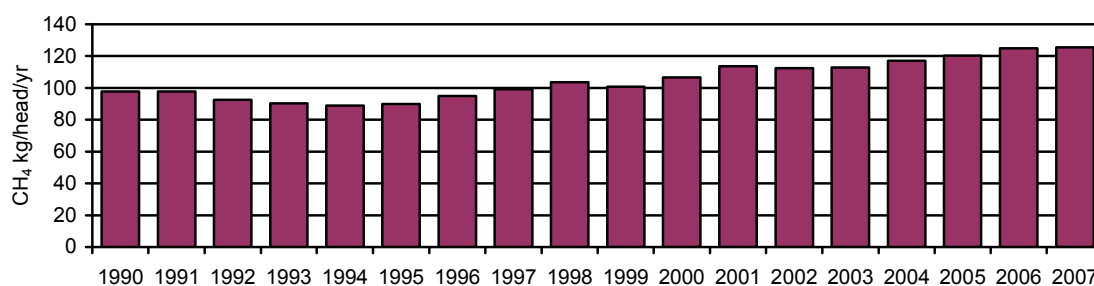


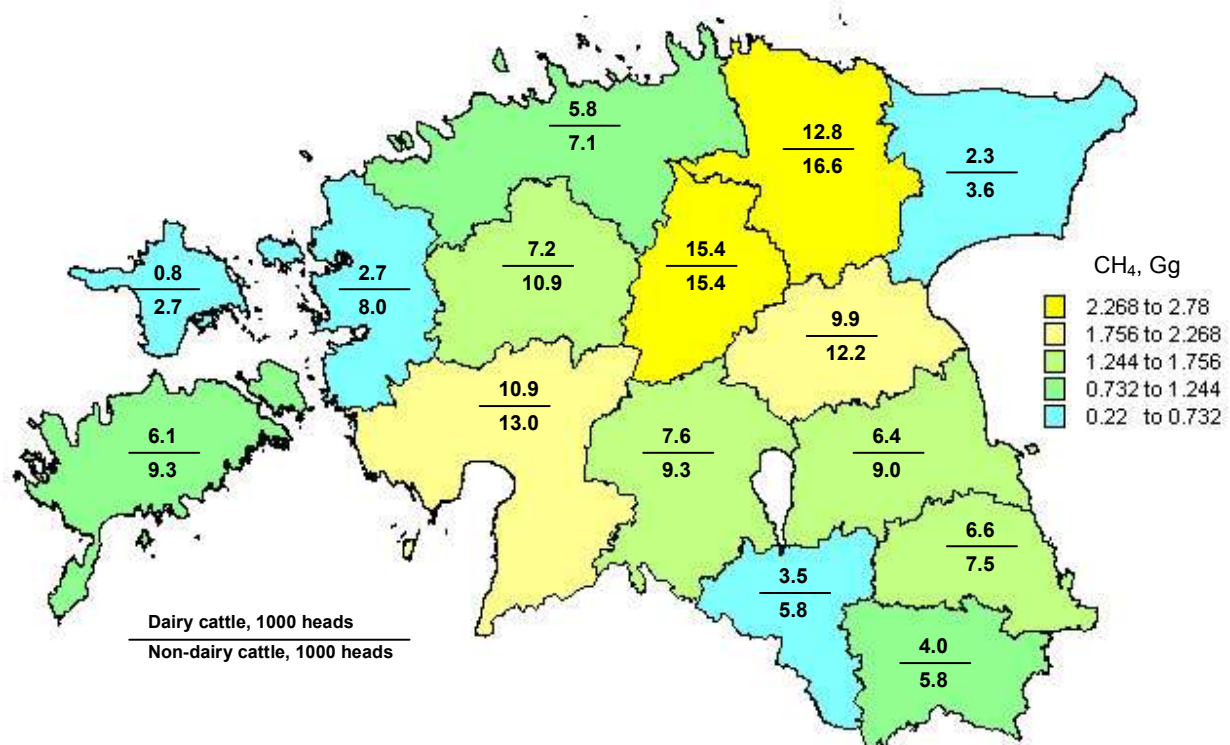
Figure 4.10. Average enteric fermentation emission factor of dairy cattle in 1990–2007, CH₄ kg/head/yr

4.2.3.2.2. Quantitative overview – CH₄ emission from enteric fermentation of cattle in 2007

The total CH₄ emission from enteric fermentation of cattle was 19.69Gg in 2007. Dairy cattle livestock was a main contributor to the total CH₄ emission from cattle enteric fermentation in Estonia in 2007 (Table 4.12). The breakdown of CH₄ emission from cattle enteric fermentation by counties of Estonia is presented in Figure 4.11.

Table 4.12. CH₄ emissions from Enteric Fermentation of cattle in 1990–2007 in Estonia⁶, Gg

Year	Cattle				
	DC	MF	MM	B	C
1990	27.46	2.77	0.28	10.78	8.67
1991	25.85	2.76	0.28	10.72	7.57
1992	23.44	2.25	0.23	8.73	6.16
1993	20.48	1.48	0.15	5.75	4.02
1994	18.83	1.26	0.13	4.88	3.64
1995	16.69	1.08	0.11	4.22	3.34
1996	16.29	1.01	0.10	3.95	3.07
1997	16.64	0.96	0.10	3.71	2.77
1998	16.42	0.88	0.09	3.43	2.65
1999	13.94	0.86	0.11	3.04	2.21
2000	13.96	0.87	0.08	2.81	2.10
2001	14.61	0.71	0.08	3.06	2.41
2002	13.00	0.71	0.07	3.45	2.41
2003	13.19	0.86	0.05	3.31	2.49
2004	13.64	0.87	0.09	3.20	2.28
2005	13.57	0.99	0.05	3.25	2.31
2006	13.53	1.01	0.12	3.23	2.27
2007	12.94	1.19	0.12	3.23	2.22
%, 2007	65.7	6.0	0.6	16.4	11.3

**Figure 4.11. Population of cattle and CH₄ emissions from cattle enteric fermentation by counties of Estonia in 2007, 1000 heads, Gg (see also Figure 4.9)**

4.2.3.3. Pigs

4.2.3.3.1. Methodology, data availability, data sources and emission factors

The *Tier 1* (IPCC, 1997) was used for the estimation of CH₄ emission from enteric fermentation of pigs, the estimation was carried out for the main sub-categories of pigs reported by the ESO (Table 4.13).

Table 4.13. Symbols used in the algorithm for swine

County	Swine classes
i1- Harju county	j1- Piglets, live weight less than 20 kg
i2- Hiiu county	j2- Young pigs, live weight 20–<50 kg
i3- Ida-Viru county	j3- Pigs, with live weight 50–<80 kg
i4- Jõgeva county	j4- Pigs, with live weight 80–<110 kg
i5- Järva county	j5- Pigs, with live weight 110 kg or more
i6- Lääne county	j6- Breeding pigs, live weight 50 kg or more
i7- Lääne-Viru county	
i8- Põlva county	
i9- Pärnu county	
i10- Rapla county	
i11- Saare county	
i12- Tartu county	
i13- Valga county	
i14- Viljandi county	
i15- Võru county	

Gross energy intake by swine

$$E_{ji} = 2.0 \times w_{ji}^{0.63} \quad (4.11)^{25}$$

GE – Gross energy intake by *j* category of swine in *i* county, MJ/head/day;

w – Live weight of *j* category in *i* county, kg;

Methane emission factor from livestock category

$$E = [GE \times Y_m \times (365 \text{ days/yr})] / [55.65 \text{ MJ} / \text{CH}_4 \text{ kg}] \quad (4.12)^{26}$$

²⁵ Oll *et al.*, 1991; Turnpenny *et al.*, 2001.

²⁶ IPCC, 2000. Agriculture. Equation 4.14, pp. 4.26.

E – Methane emission from enteric fermentation, kg CH₄ / year;

GE – Gross energy intake, MJ/head/day;

Y_m – Methane conversion rate, which is the factor of gross energy in feed converted to methane;

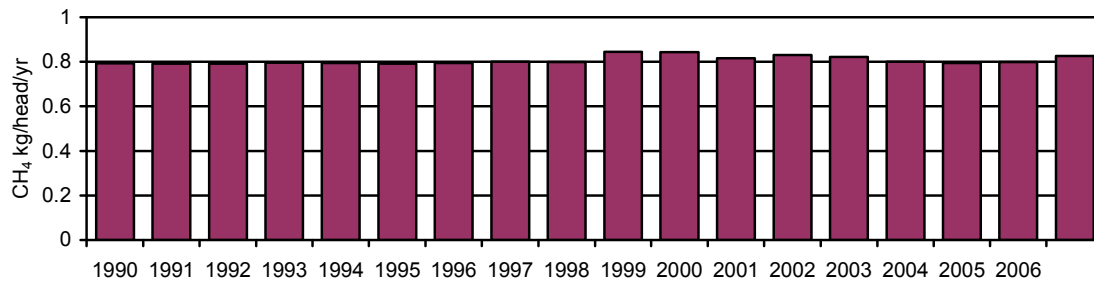


Figure 4.12. Average swine enteric fermentation emission factor, CH₄ kg/head/year.

4.2.3.3.2. Quantitative overview – CH₄ emission from enteric fermentation of pigs in 2007

The total CH₄ emission from swine enteric fermentation was 0.31Gg in 2007. The emission has decreased by 54% since the base year due to decreasing population of pigs (Table 4.14, Figure 4.13).

Table 4.14 CH₄ emissions from Enteric Fermentation of pigs in 1990–2007 in Estonia⁷, Gg

Year	Swine					
	P20	P50	P80	P110	P100m	Br
1990	0.0939	0.1756	0.2020	0.1431	0.0115	0.0563
1991	0.0874	0.1636	0.1881	0.1332	0.0107	0.0496
1992	0.0593	0.1109	0.1276	0.0904	0.0073	0.0331
1993	0.0461	0.0862	0.0991	0.0702	0.0056	0.0302
1994	0.0500	0.0936	0.1076	0.0762	0.0061	0.0318
1995	0.0491	0.0919	0.1057	0.0749	0.0060	0.0280
1996	0.0324	0.0607	0.0698	0.0494	0.0040	0.0210
1997	0.0329	0.0616	0.0708	0.0502	0.0040	0.0254
1998	0.0351	0.0656	0.0755	0.0535	0.0043	0.0270
1999	0.0252	0.0576	0.0721	0.0402	0.0058	0.0404
2000	0.0273	0.0588	0.0697	0.0444	0.0049	0.0484
2001	0.0337	0.0766	0.0622	0.0566	0.0026	0.0497
2002	0.0350	0.0612	0.0706	0.0635	0.0055	0.0476
2003	0.0350	0.0679	0.0702	0.0618	0.0027	0.0453
2004	0.0382	0.0620	0.0715	0.0524	0.0050	0.0429
2005	0.0380	0.0645	0.0843	0.0440	0.0023	0.0425
2006	0.0399	0.0568	0.0795	0.0506	0.0037	0.0459
2007	0.0414	0.0605	0.0857	0.0781	0.0040	0.0436
%, 2007	13.2	19.3	27.4	24.9	1.3	13.9

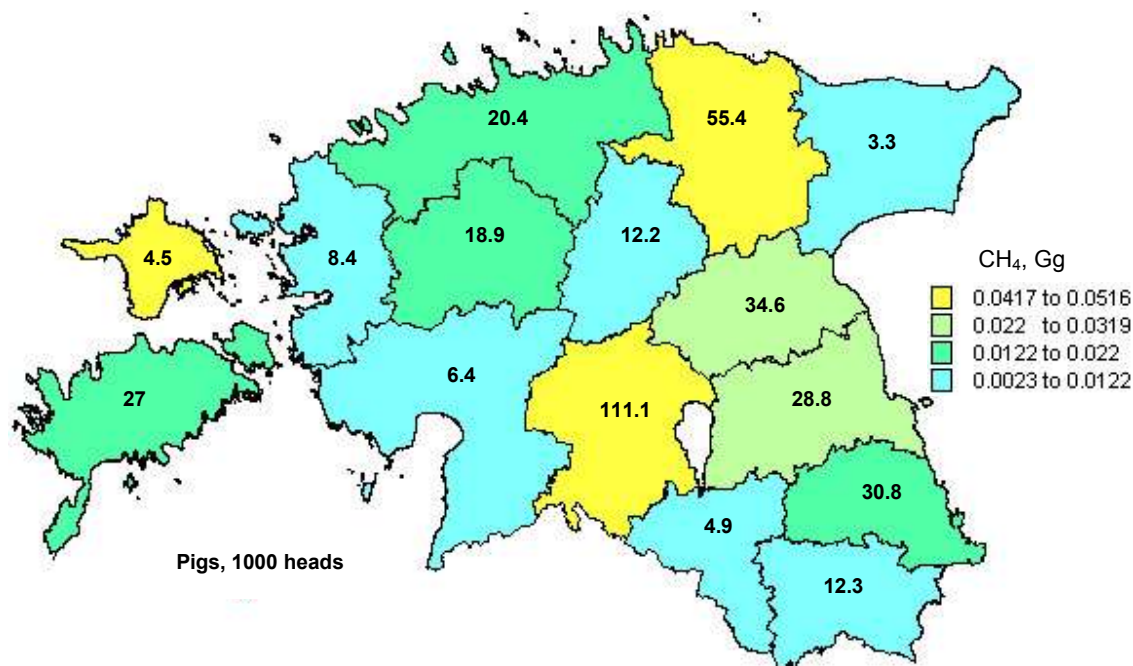


Figure 4.13. Population of pigs and CH₄ emissions from pig enteric fermentation by counties of Estonia in 2007, 1000 heads, Gg²⁷

4.2.3.4. Other livestock

4.2.3.4.1. Methodology, data availability, data sources and emission factors

The algorithm based on the *Tier 1* (IPCC, 1997) and is presented below by the formula (4.13).

$$\text{CH}_4 \text{ Emissions} = \text{EF}_{ji} \times \text{population}_{ji} / (10^6 \text{ kg/Gg}) \quad (4.13)^{28}$$

CH₄ Emissions_{ji} – Methane emission from enteric fermentation from *j* category of animals in *i* county, Gg CH₄/year;

EF_{ji} – Methane emission factor for *j* category of animals in *i* county, CH₄ kg/head/year;

Population_{ji} – The number of *j* category of animals in *i* county, head;

²⁷ The number of pig population of Hiiu and Viljandi counties was calculated.

²⁸ IPCC, 2000. Agriculture. Equation 4.12, pp. 4.25.

The IPCC (1997) reports the average methane emission factor for some livestock types both for developing and for developed countries. The emissions factors (for developed countries) were used in the process of the estimation of CH₄ emission from sheep, goats and horses (Table 4.15).

Table 4.15. Enteric fermentation methane emission factors, kg CH₄/head/year²⁹

Enteric Fermentation	Emission Factor, kg CH ₄ /head/yr
Sheep	8
Goats	5
Horses	18
Poultry	Not estimated

4.2.3.4.2. Quantitative overview – CH₄ emission from enteric fermentation of other livestock in 2007

The total CH₄ emission from enteric fermentation of other livestock was 0.69Gg in 2007. The emission of CH₄ declined by 46% by 2007 in comparison with the base year due to decreasing number of other livestock population (Table 4.16).

Table 4.16. CH₄ emissions from Enteric Fermentation of other livestock in 1990–2007 in Estonia, Gg

Year	Other Livestock		
	Sheep	Goats	Horses
1990	1.118	0.005	0.155
1991	1.135	0.005	0.140
1992	0.985	0.006	0.119
1993	0.658	0.006	0.094
1994	0.480	0.008	0.090
1995	0.386	0.009	0.083
1996	0.301	0.008	0.076
1997	0.271	0.009	0.076
1998	0.230	0.011	0.070
1999	0.226	0.014	0.070
2000	0.232	0.016	0.076
2001	0.230	0.018	0.099
2002	0.239	0.020	0.095
2003	0.246	0.018	0.104
2004	0.310	0.015	0.092

²⁹ IPCC, 1997. Agriculture. Reference Manual. Table 4-3 Enteric Fermentation Emission Factors (default values for developed countries) pp. 4.10

Year	Other Livestock		
	Sheep	Goats	Horses
2005	0.397	0.014	0.086
2006	0.502	0.017	0.088
2007	0.579	0.020	0.095

4.2.3.5. Uncertainties and time-series consistency

The estimations of CH₄ emission from enteric fermentation of cattle are carried out based on the *Tier 2* approach based on Estonian activity data and default factors taken from the IPCC Guidelines (1997, 2000). The *Tier 1* method is used to estimate CH₄ emissions from other livestock: swine, goats, horses and sheep.

Uncertainties in activity data are not calculated in Estonia. The data were obtained from (Rypdal K., *et al.*, 2001), where the uncertainties in activity data (livestock population) are presented for a few countries: Austria ($\pm 10\%$), Norway ($\pm 5\text{--}10\%$), the Netherlands ($\leq \pm 5\%$), USA ($\pm 2\%$). The experiences of Austria were taken in order to calculate uncertainties in emissions from enteric fermentation of livestock (Table 4.17). The uncertainty in CH₄ emission factors for livestock categories (sheep, goats, horses) is reported to be $\pm 20\%$ (IPCC, 1997).

In spite of the fact that the *Tier 2* method is used in the calculation of emissions from cattle, all parameters were used as IPCC defaults, excluding milk production per cow and milk fat content. The uncertainty rate was taken as $\pm 50\%$ (Table 4.17) (IPCC, 2000).

The estimations of CH₄ emissions from enteric fermentation of swine were estimated based on sub-categories of pigs. Almost all IPCC default parameters were used in the estimates (excl. weight). According to these, the uncertainties of the estimations are taken as $\pm 50\%$ (Table 4.17) (IPCC, 2000).

Table 4.17. Estimated values of uncertainties used in agriculture sector (enteric fermentation)

Input	Uncertainties	References
<i>Activity data</i>		
Estonia's Livestock Population (cattle, swine, sheep, goats, horses, poultry)	± 10%	Rypdal K., et al., 2001
<i>Emission factors</i>		
Enteric Fermentation (CH ₄) (cattle, swine)	± 50%	IPCC, 2000. Agriculture. pp. 4.27
Enteric Fermentation (CH ₄) (sheep, goats, horses)	± 20%	Table 4-3 of the 1996 IPCC Guidelines, pp. 4.10

The combined uncertainties related to 'enteric fermentation' sub-sector (CRF 4.A) as percent from the total national emission in 2007 are follows³⁰:

4.A.	Dairy Cattle	0.6284%
4.A.	Non-Dairy Cattle	0.3282%
4.A.	Sheep	0.0149%
4.A.	Goats	0.0005%
4.A.	Horses	0.0024%
4.A.	Swine	0.0152%

4.2.3.6. Source-specific recalculations

Several updates of the activity data were carried out in the 2009 submission: the structures of cattle and swine population by sub-categories were changed for 1990–1998; the data on milk production per cow, fat content of milk and the percentage of cows that gave birth were updated.

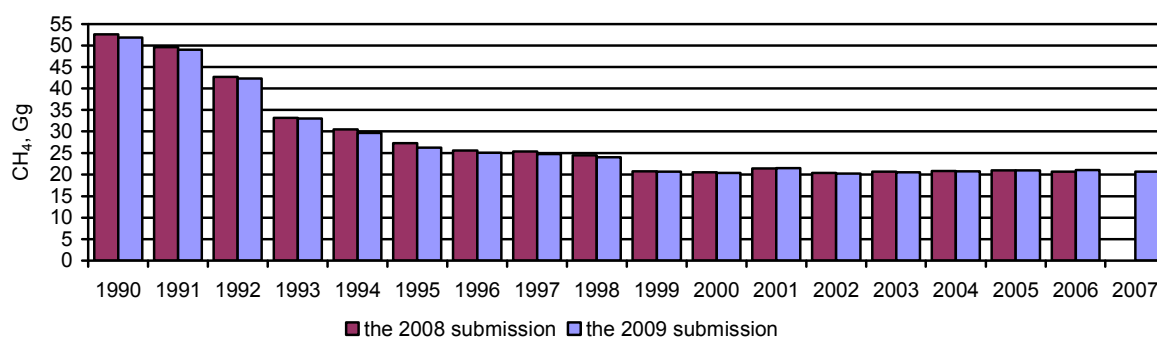


Figure 4.14. CH₄ emissions from enteric fermentation of Estonia's livestock in 1990–2007, Gg

³⁰ Uncertainty calculation for the Estonian GHG inventory **excluding** LULUC (following IPCC Tier 1)

Table 4.18. Reported and recalculated CH₄ emissions from enteric fermentation in 1990–2007, Gg

	Reported emissions of CH ₄ in the 2008 submission	Recalculated emissions of CH ₄ (the 2009 submission)
1990	52.59	51.92
1991	49.61	49.09
1992	42.69	42.34
1993	33.25	32.98
1994	30.57	29.68
1995	27.29	26.27
1996	25.63	25.05
1997	25.37	24.43
1998	24.47	24.05
1999	20.81	20.70
2000	20.52	20.39
2001	21.43	21.49
2002	20.38	20.29
2003	20.68	20.55
2004	20.86	20.76
2005	20.96	20.95
2006	20.69	21.05
2007		20.70

4.2.3.7. Source-specific planned improvements

The data (activity data, emission factors) are kept under consideration and will be improved necessarily.

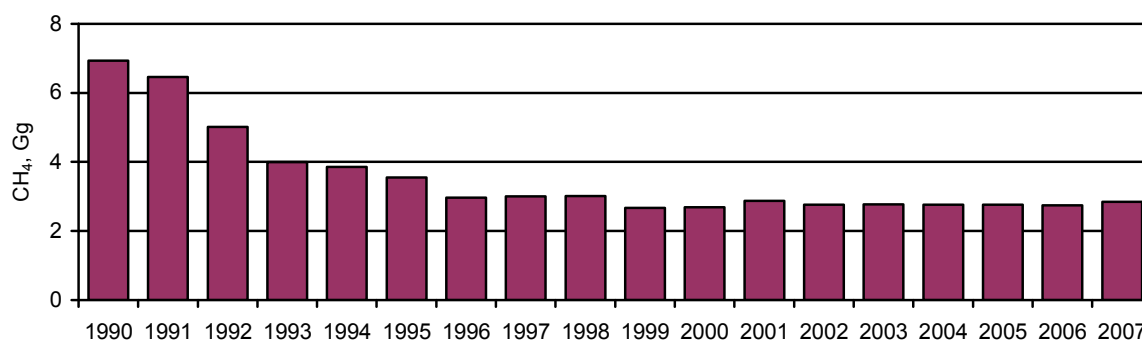
4.2.4. CH₄ emissions from Manure Management**4.2.4.1. Source category description**

Methane is produced from the decomposition of the organic matter remaining in the manure under anaerobic conditions (IPCC, 2000). The quantities of CH₄ emission from manure management directly depend on the manure management system and temperature.

Methane emission (recalculated to CO₂equiv) from manure management comprised 4.5% from the total agricultural emission in Estonia.

Table 4.19. CH₄ emissions from manure management in 1990–2007 in Estonia, Gg

Year	Cattle	Swine	Sheep	Goats	Horses	Poultry	Total	Total CO ₂ equiv
1990	3.70	2.68	0.0266	0.0001	0.012	0.510	6.94	145.6
1991	3.50	2.49	0.0270	0.0001	0.011	0.432	6.46	135.7
1992	3.04	1.68	0.0234	0.0001	0.009	0.267	5.02	105.5
1993	2.39	1.33	0.0156	0.0001	0.007	0.252	3.99	83.8
1994	2.16	1.44	0.0114	0.0002	0.007	0.244	3.86	81.0
1995	1.91	1.40	0.0092	0.0002	0.006	0.227	3.55	74.5
1996	1.83	0.93	0.0071	0.0002	0.006	0.181	2.96	62.2
1997	1.82	0.96	0.0064	0.0002	0.006	0.203	3.00	63.0
1998	1.77	1.03	0.0055	0.0003	0.005	0.206	3.01	63.2
1999	1.52	0.95	0.0054	0.0003	0.005	0.192	2.67	56.1
2000	1.49	1.00	0.0055	0.0004	0.006	0.185	2.69	56.4
2001	1.57	1.11	0.0055	0.0004	0.008	0.179	2.87	60.3
2002	1.48	1.11	0.0057	0.0005	0.007	0.164	2.77	58.1
2003	1.49	1.11	0.0059	0.0004	0.008	0.152	2.77	58.2
2004	1.51	1.07	0.0074	0.0003	0.007	0.170	2.77	58.1
2005	1.52	1.08	0.0094	0.0003	0.007	0.147	2.76	58.0
2006	1.52	1.09	0.0119	0.0004	0.007	0.128	2.75	57.7
2007	1.48	1.23	0.0138	0.0005	0.007	0.115	2.85	59.8
%, 2007	52.0	43.2	0.5	0.0	0.2	4.0		

Figure 4.15. CH₄ emission from Estonia's livestock manure management in 1990–2007, Gg

4.2.4.2. Cattle

4.2.4.2.1. Methodology, data availability, data sources and emission factors

CH₄ production from manure of dairy cattle, non-dairy cattle was estimated based on the algorithm presented in the IPCC (2000) using specific country data and IPCC default factors.

CH₄ emission from manure management

$$\text{CH}_4\text{Emissions}_{ji} = \text{Emission_Factor}_{ji} \times \text{Population}_{ji} / (10^6 \text{ kg/Gg}) \quad (4.14)^{31}$$

CH₄ Emissions_{ji} – Methane emission from manure management of *j* category of cattle in *i* county, Gg CH₄/yr;

Emission Factor_{ji} – Methane emission factor for *j* category of cattle in *i* county, kgCH₄/head/yr;

Population_{ji} – The number of head in *j* category of cattle in *i* county, heads;

Emission factor from manure management

$$\text{EF}_{ji} = \text{VS}_{ji} \times 365\text{_days/yr} \times \text{B}_{oji} \times 0.67 \text{ kg/m}^3 \times \sum_{nK} \text{MCF}_{nk} \times \text{MS\%}_{jik} \quad (4.15)^{32}$$

EF_{ji} - Annual methane emission factor for *j* category of cattle in *i* county, kg;

VS_{ji} - Daily VS excreted for for *j* category of cattle in *i* county, kg;

Bo_{ji} – Maximum CH₄ producing capacity for manure produced by *j* category of cattle in *i* county, kg of VS (Table 4.20);

MCF_{ik} - CH₄ conversion factors for each manure management system *n* by climate region *k* (Table 4.21);

MS_{ijk} - Fraction of animal species/category *j*'s manure handled using manure system *n* in *i* country in climate region *k* (Table 4.21);

Volatile Solid excretion rates

$$\text{VS}_{ji} \text{ (kg dm/day)} = \frac{\text{GE}_{ii}}{18.45} \times \left(1 - \frac{\text{DE}_{ji} \%}{100\%}\right) \times \left(1 - \frac{\text{ASH}\%}{100\%}\right) \quad (4.16)^{33}$$

³¹ IPCC 2000. Agriculture. Equation 4.15, pp. 4.30.

³² IPCC 2000. Agriculture. Equation 4.17, pp. 4.34.

³³ IPCC 2000. Agriculture. Equation 4.16, pp. 4.30.

VS_{ji} – Volatile solid excretion per day on a dry-matter weight basis of *j* category of cattle in *i* county, kg DM/day;

GE_{ji} – Daily gross energy intake per head of *j* category of cattle in *i* county, MJ/day;

1 dm kg – 18.45 MJ;

DE_{ji} – Digestible energy of the feed for *j* category of cattle in *i* county, % (Table 4.20);

ASH – Ash content of the manure as a percentage, % (8%);

Table 4.20. Parameters used in the estimates³⁴

	Feeding	Digestibility of Feed, %	CH ₄ Conversion	Bo (m ³ CH ₄ /kg VS)
Cows, bulls and heifers (2 years and over)				
...Dairy	Stall Fed	60	6%	0.24
...Non-Dairy Cattle:				
.....Mature Females	Pasture/Range	60	6.5%	0.17
.....Mature Males	Pasture/Range	60	6.5%	0.17
Bovine animals (aged between 1 and 2 years)	Pasture/Range	60	6%	0.17
Calves (less than 1 year old)	Pasture/Range	65	6%	0.17

Table 4.21. Manure management system usage (%), Eastern Europe manure management system) and methane conversion factor (MCFs)³⁵

	Lagoon	Liquid/Slurry Solid	Solid Storage	Dry lot	Pasture/Range	Daily Spread	Digester	Burned for Fuel	Other
	Manure Management System Usage (%) ³⁶								
Dairy Cattle	0	19	68	0	13	1	0	0	0
Non-Dairy Cattle	0	28	0	0	26	0	0	0	46
	Methane Conversion Factors (MCFs) ³⁷								
	90%	10%	1%	1%	1%	0.1%	10.0%	7.5%	1%

Basing on the algorithm presented in this chapter, CH₄ emission factor was estimated as follows (Table 4.22)

³⁴ Table A-1 and Table A-2 of the 1996 Revised IPCC Guidelines. Agriculture. Reference Manual. pp. 4.31

³⁵ Table B-3 (Eastern Europe) of the 1996 Revised IPCC Guidelines. Agriculture. Reference Manual. pp. 4.43

³⁶ For Dairy Cattle – IPCC 1996. Agriculture. Reference Manual. Table B-3 – Manure Management Emission Derivation for Dairy Cattle. pp. 4.43

For Non-Dairy Cattle – IPCC 1996. Agriculture. Reference Manual. B-4 – Manure Management Emission Derivation for Non-Dairy Cattle. pp. 4.44

³⁷ IPCC 2000. Agriculture. Table 4-10 – MCF Values for Manure Management System (for cool climate). pp 4.37

Table 4.22. Manure management emission factors for cattle, kg CH₄/head/year

	Dairy Cattle	Mature Non-Dairy Cattle	Calves
1990	7.60	4.13	2.23
1991	7.60	4.13	2.23
1992	7.18	4.13	2.23
1993	7.02	4.13	2.23
1994	7.34	4.52	2.23
1995	7.42	4.52	2.23
1996	7.83	4.52	2.23
1997	8.18	4.52	2.23
1998	8.54	4.52	2.23
1999	8.30	4.51	2.23
2000	8.78	4.50	2.23
2001	9.36	4.53	2.23
2002	9.27	4.54	2.23
2003	9.31	4.52	2.23
2004	9.65	4.51	2.23
2005	9.92	4.50	2.23
2006	10.29	4.50	2.23
2007	10.35	4.48	2.23

4.2.4.2.2. Quantitative overview – CH₄ emission from cattle manure management in 2007

The total CH₄ emission from cattle manure management was 1.48Gg in Estonia in 2007, the emission declined by 60% by 2007 in comparison with the base year (Table 4.23).

Table 4.23. CH₄ emissions from cattle manure management activities in 1990–2007 in Estonia⁶, Gg

Year	Cattle				
	DC	MF	MM	B	C
1990	2.133	0.168	0.018	0.736	0.563
1991	2.008	0.167	0.018	0.732	0.492
1992	1.821	0.136	0.014	0.596	0.399
1993	1.591	0.089	0.009	0.392	0.261
1994	1.552	0.086	0.009	0.362	0.236
1995	1.376	0.074	0.008	0.313	0.217
1996	1.343	0.069	0.007	0.293	0.199
1997	1.371	0.065	0.007	0.276	0.180
1998	1.354	0.060	0.006	0.254	0.172
1999	1.149	0.059	0.007	0.225	0.144
2000	1.150	0.059	0.006	0.208	0.137
2001	1.204	0.048	0.006	0.227	0.156
2002	1.071	0.049	0.005	0.256	0.156
2003	1.087	0.059	0.004	0.245	0.162
2004	1.125	0.059	0.006	0.237	0.148

2005	1.118	0.068	0.004	0.241	0.150
2006	1.116	0.069	0.008	0.240	0.147
2007	1.066	0.081	0.008	0.239	0.144
%, 2007	69.3	5.3	0.5	15.5	9.4

4.2.4.3. Pigs

4.2.4.3.1. Methodology, data availability, data sources and emission factors

Methane production from the manure of swine by sub-categories was estimated employing the algorithm described in Chapter 4.2.4.2.1.

Methane conversion factor and the system of manure management usage (%) for cattle manure storage are presented in Table 4.24. The factors (DE, B_o) used in the estimates were obtained from IPCC tables on default factors (Table 4.25). Estimated emission factors are reported in Table 4.26.

Table 4.24. Manure Management System Usage (%), Eastern European manure management system) and Methane Conversion Factor (MCFs)

	Lagoon	Liquid/ Slurry Solid	Solid Storage	Dry lot	Pit < 1 month	Pit > 1 month	Daily Spread	Digester	Other
	Manure Management System Usage (%) ³⁸								
Swine	8	0	39	14	19	19	0	0	1
	Methane Conversion Factors (MCFs) ³⁹								
Swine	90%	39%	1%	1%	5%	10%	0.1%	10%	1%

Table 4.25. Parameter used in the estimates

	Feed Digestibility (DE) %	Feed Intake kg/day	VS kg/h/d	B _o (m ³ CH ₄ /kg VS)	Methane Conversion Factor (%)
Piglets, live weight less than 20 kg	75%	0.5	0.113	0.45	0.6%
Young pigs, live weight 20–<50 kg	75%	1.0	0.249	0.45	0.6%
Fattening pigs ...live weight 50–<80 kg	75%	1.5	0.368	0.45	0.6%

³⁸ For Dairy Cattle – IPCC 1996. Agriculture. Reference Manual. Table B-3 – Manure Management Emission Derivation for Dairy Cattle. pp. 4.43

For Non-Dairy Cattle – IPCC 1996. Agriculture. Reference Manual. B-4 – Manure Management Emission Derivation for Non-Dairy Cattle. pp. 4.44

³⁹ IPCC 2000. Agriculture. Table 4-10 – MCF Values for Manure Management System (for cool climate). pp 4.37

...live weight 80–<110 kg	75%	1.9	0.468	0.45	0.6%
...live weight 110 kg or more	75%	2.1	0.513	0.45	0.6%
Breeding pigs, live weight 50 kg or more	75%	1.6	0.403	0.45	0.6%

Table 4.26. Methane emission factors from swine manure management systems, kg CH₄/head/year

Category of Swine	Emission factor, kg CH ₄ /head/yr
Estonian average	3.25
Piglets, live weight less than 20 kg	1.32
Young pigs, live weight 20–<50 kg	2.91
Fattening pigs	
...live weight 50–<80 kg	4.29
...live weight 80–<110 kg	4.45
...live weight 110 kg or more	5.98
Breeding pigs, live weight 50 kg or more	4.70

Averaged reported in the CRF factors on CH₄ emission from pig manure management system are reported in Figure 4.16.

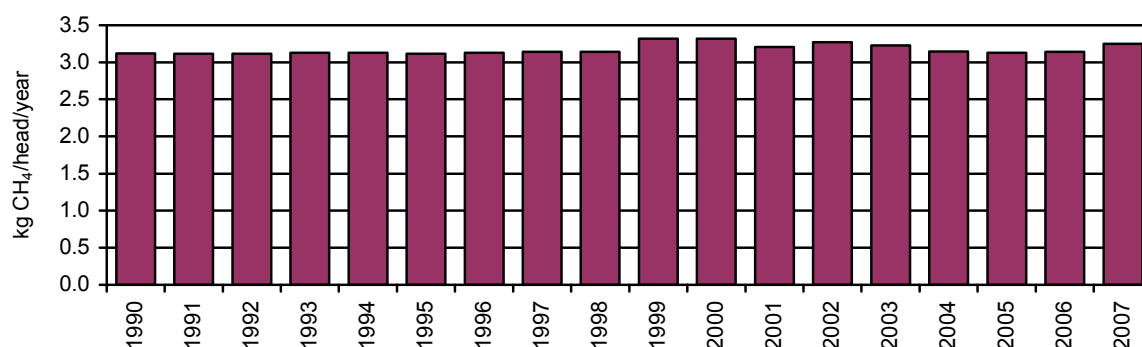


Figure 4.16. Averaged CH₄ emission factor for pig manure management system in 1990–2007, kgCH₄/head/year.

4.2.4.3.2. Quantitative overview – CH₄ emission from pig manure management in 2007

The total CH₄ emission from swine manure management was 1.23Gg in Estonia in 2007. The emission decreased by 54% by 2007 in comparison with the base year due to decreasing number of swine population (Table 4.27).

Table 4.27. CH₄ emissions from swine manure management activities in 1990–2007 in Estonia⁷, Gg

Year	Swine					
	P20	P50/YS	P80	P110	P100m	Br
1990	0.369	0.691	0.794	0.563	0.045	0.221
1991	0.344	0.643	0.740	0.524	0.042	0.195
1992	0.233	0.436	0.502	0.355	0.029	0.130
1993	0.181	0.339	0.390	0.276	0.022	0.119
1994	0.197	0.368	0.423	0.300	0.024	0.125
1995	0.193	0.361	0.416	0.294	0.024	0.110
1996	0.128	0.239	0.274	0.194	0.016	0.083
1997	0.129	0.242	0.278	0.197	0.016	0.100
1998	0.138	0.258	0.297	0.210	0.017	0.106
1999	0.099	0.226	0.283	0.158	0.023	0.159
2000	0.107	0.231	0.274	0.174	0.019	0.190
2001	0.132	0.301	0.245	0.222	0.010	0.195
2002	0.137	0.241	0.278	0.250	0.022	0.187
2003	0.137	0.267	0.276	0.243	0.011	0.178
2004	0.150	0.244	0.281	0.206	0.020	0.169
2005	0.150	0.253	0.331	0.173	0.009	0.167
2006	0.157	0.224	0.313	0.199	0.014	0.180
2007	0.163	0.238	0.337	0.307	0.016	0.171
%, 2007	13.2	19.3	27.4	24.9	1.3	13.9

4.2.4.4. Other livestock

4.2.4.4.1. Methodology, data availability, data sources and emission factors

CH₄ emission from manure management for other livestock was calculated in accordance with formula (4.14) using activity data on the population of livestock and IPCC factors (IPCC 1997).

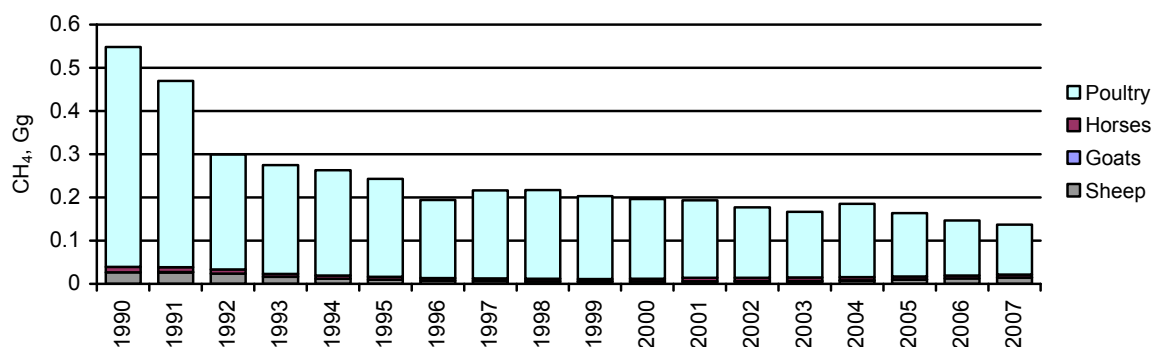
Methane emission factors for categories of livestock were taken from the IPCC Guidelines (1997) (Table 4.28)

Table 4.28. Methane emission factors for other livestock from manure management, kg CH₄/head/year⁴⁰

Category of livestock	Emission Factor, kg CH ₄ /head/yr
Sheep	0.19
Goats	0.12
Horses	1.4
Poultry	0.078

4.2.4.4.2. Quantitative overview – CH₄ emission from other livestock manure management in 2007

The total CH₄ emission from other livestock manure management system was 0.14Gg in Estonia in 2007 (Figure 4.17). The emission declined by 75% by 2007 in comparison with the base year due to decreasing number of other livestock population.

Figure 4.17. CH₄ emission from other livestock manure management in 1990–2007, Gg

4.2.4.5. Source-specific recalculations

Several recalculations were carried out in the 2009 submission: the population structure of cattle and swine was changed for 1990–1998; the module of Western Europe manure management system was changed with the module of Eastern Europe manure management system for 2003–2006 in order to guarantee consistency. The results of the recalculations made are reported in Table 4.29–Table 4.31 and in Figure 4.18–Figure 4.20.

⁴⁰ IPCC 1997. Agriculture. Reference Manual. Table 4-5 manure management emission factors (developed countries, cool climate region). pp. 4-12

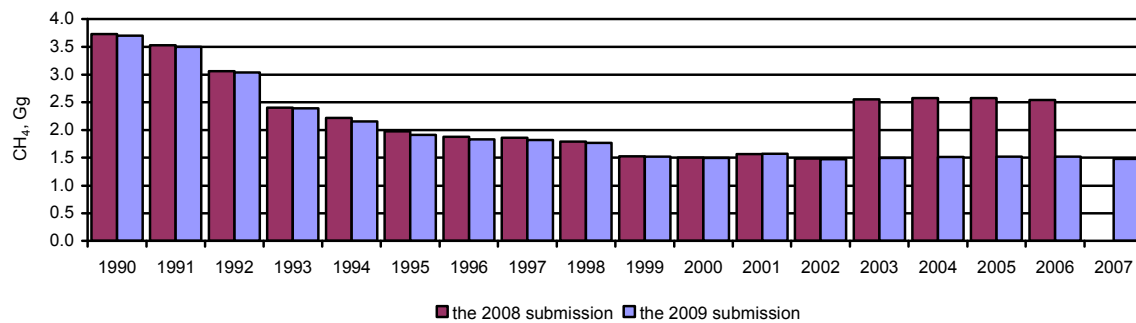


Figure 4.18. Reported and recalculated CH₄ emissions from cattle manure management in 1990–2007, Gg

Table 4.29. Reported and recalculated CH₄ emissions from cattle manure management in 1990–2007, Gg

	Reported emissions of CH ₄ in the 2008 submission	Recalculated emissions of CH ₄ (the 2009 submission)
1990	3.733	3.704
1991	3.531	3.502
1992	3.060	3.037
1993	2.405	2.390
1994	2.216	2.156
1995	1.977	1.908
1996	1.875	1.834
1997	1.861	1.819
1998	1.795	1.769
1999	1.525	1.518
2000	1.503	1.494
2001	1.567	1.572
2002	1.483	1.476
2003	2.552	1.494
2004	2.578	1.510
2005	2.577	1.517
2006	2.546	1.515
2007		1.478

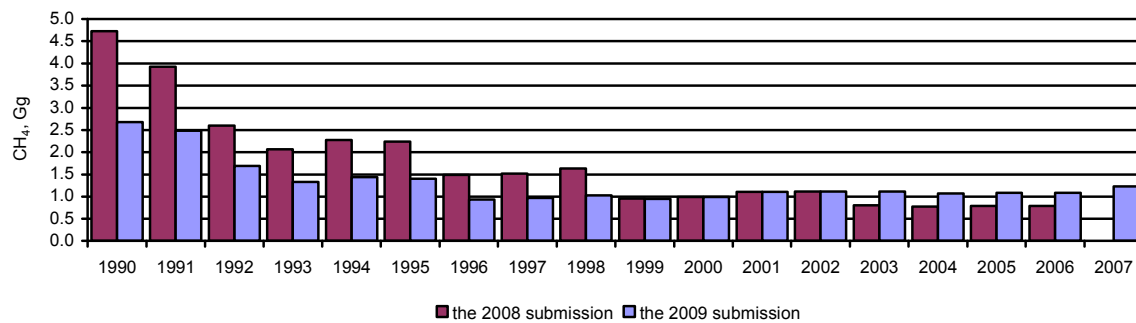


Figure 4.19. Reported and recalculated CH₄ emissions from swine manure management in 1990–2007, Gg

Table 4.30. Reported and recalculated CH₄ emissions from swine manure management in 1990–2007, Gg

	Reported emissions of CH ₄ in the 2008 submission	Recalculated emissions of CH ₄ (the 2009 submission)
1990	4.727	2.683
1991	3.929	2.488
1992	2.595	1.685
1993	2.064	1.327
1994	2.274	1.437
1995	2.242	1.398
1996	1.489	0.933
1997	1.519	0.963
1998	1.632	1.026
1999	0.949	0.949
2000	0.996	0.996
2001	1.106	1.106
2002	1.114	1.114
2003	0.808	1.113
2004	0.777	1.070
2005	0.788	1.084
2006	0.789	1.087
2007		1.232

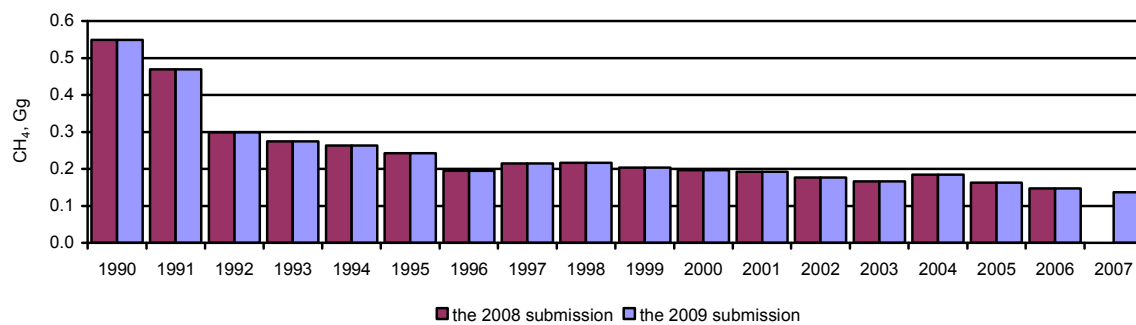


Figure 4.20. Reported and recalculated CH₄ emissions from other livestock manure management in 1990–2007, Gg

Table 4.31. Reported and recalculated CH₄ emissions from other livestock manure management in 1990–2007, Gg

	Reported emissions of CH ₄ in the 2008 submission	Recalculated emissions of CH ₄ (the 2009 submission)
1990	0.548	0.549
1991	0.470	0.470
1992	0.299	0.299
1993	0.275	0.275
1994	0.263	0.263
1995	0.243	0.243
1996	0.195	0.195
1997	0.215	0.215
1998	0.217	0.217
1999	0.203	0.203
2000	0.196	0.196
2001	0.193	0.193
2002	0.177	0.177
2003	0.166	0.166
2004	0.185	0.185
2005	0.163	0.163
2006	0.147	0.147
2007		0.137

4.2.5. N₂O emissions from Manure Management

4.2.5.1. Source category description

Production of N₂O during storage and treatment of animal wastes can occur via combined nitrification-denitrification of nitrogen contained in the wastes (Jun *et al.*, 2003).

N₂O emissions from manure management made up 9.0% from the total agricultural emission in Estonia in 2007. N₂O emission from animal manure stored of the base year is 2.5 fold higher than 2007 emission (Table 4.32, Figure 4.21).

Table 4.32. N₂O emissions from manure management in 1990–2007 in Estonia, Gg⁴¹

Year	Cattle	Pigs	Sheep	Goats	Horses	Poultry	Total	Total CO ₂ equiv
1990	0.784	0.254	0.070	0.001	0.006	0.090	1.206	373.77
1991	0.743	0.236	0.071	0.001	0.006	0.077	1.133	351.09
1992	0.651	0.160	0.062	0.001	0.005	0.047	0.926	286.92
1993	0.527	0.125	0.041	0.001	0.004	0.045	0.742	230.17
1994	0.470	0.136	0.030	0.001	0.004	0.043	0.684	212.00
1995	0.416	0.132	0.024	0.001	0.003	0.040	0.618	191.48
1996	0.401	0.088	0.019	0.001	0.003	0.032	0.545	168.91
1997	0.401	0.091	0.017	0.001	0.003	0.036	0.549	170.30
1998	0.392	0.097	0.014	0.002	0.003	0.036	0.544	168.51
1999	0.337	0.088	0.014	0.002	0.003	0.034	0.478	148.15
2000	0.333	0.092	0.015	0.002	0.003	0.033	0.478	148.08
2001	0.348	0.102	0.014	0.003	0.004	0.032	0.503	155.87
2002	0.323	0.103	0.015	0.003	0.004	0.029	0.477	147.91
2003	0.327	0.103	0.015	0.003	0.004	0.027	0.479	148.49
2004	0.333	0.099	0.020	0.002	0.004	0.030	0.488	151.13
2005	0.333	0.100	0.025	0.002	0.003	0.026	0.490	151.99
2006	0.333	0.101	0.032	0.002	0.004	0.023	0.494	153.02
2007	0.323	0.116	0.036	0.003	0.004	0.020	0.502	155.75
%, N ₂ O	64.3	23.1	7.2	0.6	0.8	4.0	100	

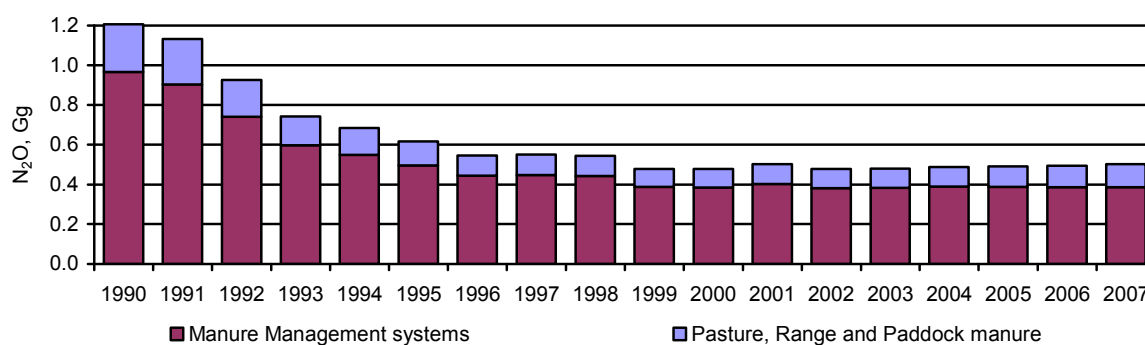


Figure 4.21. N₂O emissions from Estonia's manure management in 1990–2007, Gg

⁴¹ N₂O emission from pasture, range and paddock is included.

4.2.5.2. Cattle

4.2.5.2.1. Methodology, data availability, data sources and emission factors

The key methodology used for the estimation of N₂O emission from manure management was *Tier 1* method (IPCC, 1997).

$$(N_2O - N)_{(mm)} = \sum_{(S)} \{ [\sum_{(T)} N_{(T)} \bullet Nex_{(T)} \bullet MS_{(T,S)}] \bullet EF_{3(S)} \} \quad (4.17)^{42}$$

$(N_2O - N)_{(mm)}$ – N₂O-N emissions from manure management in the country, kg N₂O-N/year;

$N_{(T)}$ – Number of head of livestock species j in the country;

$Nex_{(T)}$ – Annual average N excretion per head of livestock species j in the country, kg N/head/year;

$MS_{(T,S)}$ – Fraction of total annual excretion for each livestock species T that is managed in manure management system S in the country;

$EF_{3(S)}$ – N₂O emission factor for manure management system S in the country, kg N₂O-N/kg N in manure management system S ;

S – Manure management system;

T – Species of livestock;

Conversion of $(N_2O - N)_{(mm)}$ emissions to $N_2O_{(mm)}$ emissions for reporting purposes is performed by using the following equation:

$$N_2O_{(mm)} = (N_2O - N)_{(mm)} \bullet 44/28 \quad (4.18)$$

The data on population of livestock by categories were obtained from database of the ESO (Annex 5_I). The percentage of manure production per animal waste management systems (Table 4.34) and emission factors for N₂O from manure management (Table 4.34) were used from the reports of IPCC (1997).

⁴² IPCC 2000. Agriculture. Equation 4.18. pp. 4.42

Nitrogen excretion factor was estimated using the algorithm presented in Chapter 4.2.5.2.1. An example of the estimation of the factor for dairy and non-dairy cattle for 1990 is presented in Box 1. The average N excretion factors reported in the CRF is presented in Table 4.33.

Table 4.33. Average N excretion factors used in the estimates, kg N/head/year

Year	Dairy Cattle	Mature Non-dairy cattle	Young cattle
1990	74.74	46.19	17.24
1991	74.74	46.19	17.24
1992	70.68	46.19	17.24
1993	69.04	46.19	17.24
1994	66.73	46.19	17.24
1995	67.56	46.19	17.24
1996	71.16	46.19	17.24
1997	74.29	46.19	17.24
1998	77.57	46.19	17.24
1999	75.84	46.46	17.24
2000	80.28	46.53	17.24
2001	85.19	46.90	17.24
2002	84.41	47.51	17.24
2003	84.69	47.57	17.24
2004	87.88	48.07	17.24
2005	90.21	49.41	17.24
2006	93.53	50.27	17.24
2007	94.19	51.79	17.24

Table 4.34. Percentage of Manure Production per Animal Waste Management Systems, %⁴³ and default Emission Factors for N₂O from Manure Management⁴⁴

Type of Animal	Anaerobic Lagoon	Liquid System	Daily Spread	Solid Storage and Dry lot	Pasture Range and Paddock	Other System
Non-Dairy Cattle	0%	19%	1%	67%	37%	0%
Dairy Cattle	8%	39%	0%	52%	0%	1%
EF ₃ (kg N ₂ O-N/kg Nitrogen excreted)	0.001	0.001	0.0	0.02	0.02 ⁴⁵	0.001 ⁴⁶

⁴³ IPCC, 1997. Agriculture. Reference Manual. Table 4-7 –Default values for percentage of manure N production in different animal waste management systems in different world regions (Default values for Eastern Europe were used). pp 4-11

⁴⁴ IPCC, 2000. Agriculture. Table 4.12 – Default emission factors for N₂O from manure management. pp 4.43

⁴⁵ The factors were used in the ‘Animal waste applied to soils and excreted on pasture’ chapter

⁴⁶ Cattle and Swine Deep Litter from IPCC 2000. Agriculture. Table 4.13 – Default emission factors for N₂O from manure management system not specified in the IPCC. pp 4.44

Box 1

Table B1.1. Estimating of Nitrogen Excretion factor of dairy cattle

		Reference
Weight, kg	550	IPCC, 1997. Table A-1, pp. 4.31
Feeding Situation	Stall Fed	IPCC, 1997. Table A-1, pp. 4.31
Milk, kg/day	10.9	ESO
Pregnant, %	80%	IPCC, 1997. Table A-1, pp. 4.31
Digestibility of Feed, %	60%	IPCC, 1997. Table A-1, pp. 4.31
Energy Intake (MJ/day)	248.6	
Feed Intake, kg/day	13.5	
Manure, kg/hd/ d DM	5.4	
Manure, kg/hd/yr DM	1,967	
Moisture Content, %	15%	
Manure, tonnes/hd/yr	13.1	Applying Nutrient Management Estimated using the algorithm presented in Chapter 4.2.3.2.1
	$M, \text{kg} / \text{hd} / \text{yr} = \frac{\text{Manure} \times (100\% - 15\%)}{15\%} + \text{Manure, kgDM} / \text{hd}$	Equation 1
N content in manure, kg/t	5.7	Kaasik A., <i>at al.</i> , 2002
Nitrogen Excretion per head, kg/head/yr	74.7	Equation 2
	$N_factor, \text{kg} / \text{hd} / \text{yr} = Ncontent, \text{kg} / \text{t} \times \text{Manure, t} / \text{hd} / \text{yr}$	

Table B1.2. Estimating of Nitrogen Excretion factor of non-dairy cattle

	Mature Females	Mature Males	Replacement / Growing	Young/ Calves	Reference
Weight, kg	500	600	400	230	IPCC, 1997. Table B-1, pp 4.39
Weight Gain, kg/day	0		0.75	0.5	Põllukultuuride väetamine
Feeding Situation	Pasture Range	Pasture Range	Pasture Range	Pasture Range	
Digestibility of Feed, %	60%	60%	60%	60%	
Energy Intake (MJ/day)	138.4	158.7	159.2	87.5	
Feed Intake, kg/day	7.5	8.6	8.6	4.7	
Manure, kg/hd/ d DM	3.0	3.4	3.5	1.7	
Moisture Content, %	13%	13%	13%	13%	
Manure, tonnes/hd/yr	8.4	9.7	9.7	4.7	Applying Nutrient Management Estimated using the algorithm presented in Chapter 4.2.3.2.1
	$M, \text{kg} / \text{hd} / \text{yr} = \frac{\text{Manure} \times (100\% - 13\%)}{13\%} + \text{Manure, kgDM} / \text{hd}$				Equation 1
N content in manure, kg/t	4.9	4.9	4.9	3.7	Kaasik A., <i>at al.</i> , 2002
Nitrogen Excretion per head, kg/head/yr	41.3	47.3	47.5	17.2	Equation 2
	$N_factor, \text{kg} / \text{hd} / \text{yr} = Ncontent, \text{kg} / \text{t} \times \text{Manure, t} / \text{hd} / \text{yr}$				

4.2.5.2.2. Quantitative overview – N₂O emission from cattle manure management in 2007

The total N₂O emission from cattle manure management was 0.323 Gg in Estonia in 2007. The emission declined 2.5 fold by 2007 compared to the base year.

Table 4.35. Table N₂O emissions from cattle manure management⁶, Gg

Year	Cattle				
	DC	MF	MM	B	C
1990	0.534	0.033	0.003	0.140	0.074
1991	0.503	0.033	0.003	0.139	0.065
1992	0.456	0.027	0.003	0.113	0.053
1993	0.398	0.018	0.002	0.074	0.034
1994	0.359	0.015	0.002	0.063	0.031
1995	0.319	0.013	0.001	0.055	0.029
1996	0.311	0.012	0.001	0.051	0.026
1997	0.317	0.011	0.001	0.048	0.024
1998	0.313	0.011	0.001	0.044	0.023
1999	0.267	0.010	0.001	0.039	0.019
2000	0.268	0.010	0.001	0.036	0.018
2001	0.279	0.008	0.001	0.040	0.021
2002	0.248	0.009	0.001	0.045	0.021
2003	0.252	0.010	0.001	0.043	0.021
2004	0.260	0.010	0.001	0.041	0.020
2005	0.259	0.012	0.001	0.042	0.020
2006	0.258	0.012	0.001	0.042	0.019
2007	0.247	0.014	0.001	0.042	0.019
%, 2007	76.5	4.3	0.3	13.0	5.9

4.2.5.3. Pigs

4.2.5.3.1. Methodology, data availability, data sources and emission factors

The activity data were obtained from national statistics, a method used in the estimation was employed from the IPCC Guidelines. Nitrogen excretion factor was estimated using the algorithm presented in Box 2, the factor was calculated for each swine sub-category.

Box 2

Table B2.1. Estimating of N excretion factor for each pig sub-category

	Mass (average), kg	Feed Digestibility %	Energy Intake MJ/day	Feed Intake kg/day	Manure, kg/h/d DM	Manure, kg/hd/yr DM	Manure, t/hd/yr	N content	Nitrogen Excretion per head (estimated)	IPCC Default kg N /hd/yr
Piglets, live weight less than 20 kg	10	75%	9	0.5	0.114	42	0.474	10.9	5.2	
Young pigs, live weight 20–<50 kg	35	75%	19	1.0	0.252	92	1.044	10.9	11.4	
Fattening pigs										
...live weight 50–<80 kg	65	75%	28	1.5	0.372	136	1.543	12.5	19.3	
...live weight 80–<110 kg	95	75%	35	1.9	0.472	172	1.959	12.5	24.5	
...live weight 110 kg or more	110	75%	39	2.1	0.518	189	2.149	12.5	26.9	
Breeding pigs, live weight 50 kg or more	75	75%	30	1.6	0.407	149	1.688	8.8	14.9	
										20

Swine manure dry matter – 8.8% ([Dustan A., 2002](#))

Table 4.36. Percentage of Manure Production per Animal Waste Management Systems, %⁴⁷ and default Emission Factors for N₂O from Manure Management⁴⁸

Type of Animal	Anaerobic Lagoon	Liquid System	Daily Spread	Solid Storage and Dry lot	Pasture Range and Paddock	Other System
Swine	0%	29%	0%	23%	27%	44%
EF ₃ (kg N ₂ O-N/kg Nitrogen excreted)	0.001	0.001	0.0	0.02	0.02 ⁴⁹	0.02 ⁵⁰

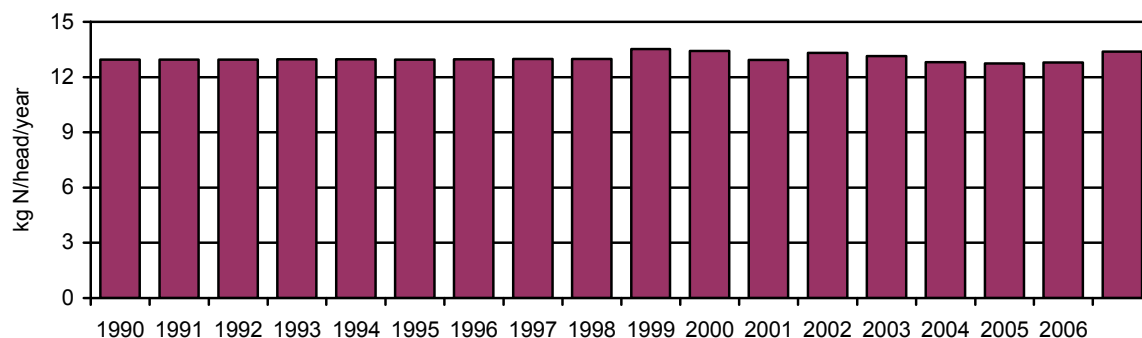


Figure 4.22. Averaged Nitrogen excretion factor reported in the CRF for 1990–2007, kg N/head/year

4.2.5.3.2. Quantitative overview – N₂O emission from swine manure management in 2007

The total N₂O emission from swine manure management was 0.116 Gg in Estonia in 2007. The emission decreased by 2.2 fold by 2007 compared to the base year.

Table 4.37. N₂O emissions from swine manure management in 1990–2007 in Estonia⁵¹, Gg

Year	Swine					
	P20	P50	P80	P110	P100m	Br
1990	0.033	0.062	0.081	0.058	0.005	0.016
1991	0.031	0.057	0.076	0.054	0.004	0.014
1992	0.021	0.039	0.051	0.036	0.003	0.009
1993	0.016	0.030	0.040	0.028	0.002	0.009
1994	0.018	0.033	0.043	0.031	0.002	0.009

⁴⁷ IPCC 1997. Agriculture. Reference Manual. Table 4-7 –Default values for percentage of manure N production in different animal waste management systems in different world regions (Default values for Eastern Europe were used). pp 4-11

⁴⁸ IPCC, 2000. Agriculture. Table 4.12 – Default emission factors for N₂O from manure management. pp 4.43

⁴⁹ The factors were used in the ‘Animal waste applied to soils and excreted on pasture’ chapter

⁵⁰ Cattle and Swine Deep Litter from IPCC 2000. Agriculture. Table 4.13 – Default emission factors for N₂O from manure management system not specified in the IPCC. pp 4.44

⁵¹ Emissions from Pasture, range and paddock are reported

Year	Swine					
	P20	P50	P80	P110	P100m	Br
1995	0.017	0.032	0.043	0.030	0.002	0.008
1996	0.011	0.021	0.028	0.020	0.002	0.006
1997	0.012	0.022	0.028	0.020	0.002	0.007
1998	0.012	0.023	0.030	0.022	0.002	0.008
1999	0.009	0.020	0.029	0.016	0.002	0.011
2000	0.010	0.021	0.028	0.018	0.002	0.014
2001	0.012	0.027	0.025	0.023	0.001	0.014
2002	0.012	0.021	0.028	0.026	0.002	0.013
2003	0.012	0.024	0.028	0.025	0.001	0.013
2004	0.013	0.022	0.029	0.021	0.002	0.012
2005	0.013	0.023	0.034	0.018	0.001	0.012
2006	0.014	0.020	0.032	0.020	0.001	0.013
2007	0.015	0.021	0.034	0.031	0.002	0.012
%, 2007	13.0	18.3	29.6	27.0	1.7	10.4

4.2.5.4. Other livestock

4.2.5.4.1. Methodology, data availability, data sources and emission factors

The activity data on other livestock population were taken from national statistics, a module of manure management system, emission factors (Table 4.39) and nitrogen excretion factors (Table 4.38) were obtained from the Revised 1996 IPCC Guidelines ([IPCC, 1997](#)).

Table 4.38. Nitrogen excretion factors per head of animal

Animal category	Nitrogen Excretion factor, kg N/head/year
Poultry	0.6
Sheep	20
Other animal	25

Table 4.39. Percentage of Manure Production per Animal Waste Management Systems, %⁵² and Default Emission Factors for N₂O from Manure Management⁵³

Type of Animal	Anaerobic Lagoon	Liquid System	Daily Spread	Solid Storage and Dry lot	Pasture Range and Paddock	Other System
Poultry	0	28	0	1	1	71
Sheep	0	0	0	0	73	27
Other animals	0	0	0	0	92	8
EF ₃ (kg N ₂ O-N/kg Nitrogen excreted)	0.001	0.001	0.0	0.02	0.02 ⁵⁴	0.02 ⁵⁵

4.2.5.4.2. Quantitative overview – N₂O emission from other livestock manure management in 2007

The total Estonian N₂O emission from other livestock manure management was 0.064 Gg in 2007.

4.2.5.5. Quantitative overview - Manure management systems

The main share in the total N₂O emission from livestock manure management occurred from solid storage manure management system in 1990–2007 in Estonia (Table 4.40, Figure 4.23).

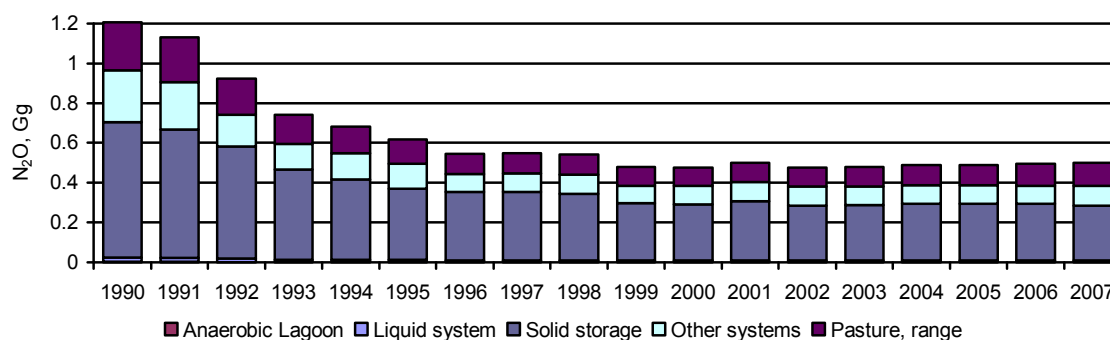


Figure 4.23. N₂O emissions from Estonia's manure management systems in 1990–2007, Gg

⁵² IPCC, 1997. Agriculture. Reference Manual. Table 4-7 – Default values for percentage of manure N production in different animal waste management systems in different world regions (Default values for Eastern Europe were used). pp 4-11

⁵³ IPCC, 2000. Agriculture. Table 4.12 – Default emission factors for N₂O from manure management. pp 4.43

⁵⁴ The factors were used in the 'Animal waste applied to soils and excreted on pasture' chapter

⁵⁵ Cattle and Swine Deep Litter from IPCC 2000. Agriculture. Table 4.13 – Default emission factors for N₂O from manure management system not specified in the IPCC. pp 4.44

Table 4.40. N₂O emissions from Estonia's manure management systems in 1990–2007, Gg

Year	Anaerobic Lagoon	Liquid System	Solid Storage	Other system
1990	0.0018	0.0220	0.6812	0.2609
1991	0.0018	0.0207	0.6454	0.2367
1992	0.0014	0.0165	0.5640	0.1596
1993	0.0009	0.0126	0.4523	0.1306
1994	0.0008	0.0117	0.4032	0.1326
1995	0.0007	0.0107	0.3570	0.1260
1996	0.0007	0.0093	0.3439	0.0899
1997	0.0006	0.0092	0.3430	0.0946
1998	0.0006	0.0091	0.3344	0.0979
1999	0.0005	0.0080	0.2878	0.0903
2000	0.0005	0.0080	0.2843	0.0914
2001	0.0005	0.0084	0.2973	0.0964
2002	0.0006	0.0082	0.2770	0.0950
2003	0.0006	0.0082	0.2800	0.0929
2004	0.0005	0.0082	0.2848	0.0948
2005	0.0005	0.0082	0.2854	0.0930
2006	0.0006	0.0082	0.2850	0.0917
2007	0.0006	0.0083	0.2774	0.0999
%, 2007	0.2	2.1	71.8	25.9

4.2.5.6. Uncertainties and time-series consistency

CH₄ emission from manure management is calculated based on activity data and emission factors.

Uncertainties in estimates of CH₄ emissions from sheep, goats, horses and poultry manure management are reported in (IPCC, 1997), and the value of uncertainties is ±20% (Table 4.41). This factor has been used in the estimates.

Emission factors for cattle and swine are calculated using IPCC default parameters (Volatile Solids, CH₄ producing capacity, Methane Conversion Factors, manure management system).

IPCC default uncertainty was used in the estimates (±25%) (Table 4.41), the factor was developed based on the experience of other countries. Rypdal documented that an uncertainty in CH₄ emission from manure management is ±25% in Norway, ±25% in the Netherlands, ±30% in UK and ±36% in USA (Rypdal K., *et al.*, 2001) and ±30% in Finland (Monni S., *et al.*, 2003).

N₂O emission from livestock manure management is calculated based on activity data (livestock population), nitrogen excretion factors (N_{ex}, kg/head/yr) and N emission factor related to manure management system.

An uncertainty of N_{ex} (by categories of livestock) is presented in IPCC Guidelines (IPCC, 1997), where the value is the same for all categories of livestock – ±25% (Table 4.41).

IPCC reports nitrogen emission factors for all systems of manure management used in Estonia's estimates of N₂O emissions from animal manure. Uncertainties of the factors are estimated at -50%...+100% (Table 4.41).

Table 4.41. Estimated values of uncertainties used in agriculture sector (manure management)

Input	Uncertainties	References
<i>Activity data</i>		
Estonia's Livestock Population (cattle, swine, sheep, goats, horses, poultry)	± 10%	Rypdal K., <i>et al.</i> , 2001
<i>Emission factors</i>		
Manure Management (CH ₄) (cattle, swine)	± 25%	Rypdal K., <i>et al.</i> , 2001
Manure Management (CH ₄) (sheep, goats, horses)	± 20%	Table 4-5 of the 1996 IPCC Guidelines, pp. 4.12
Manure Management (N ₂ O)		
...Nitrogen excretion factor (N _{ex})	± 25%	IPCC, 2000. Agriculture. pp. 4.46
...Anaerobic Lagoon	-50%...+100%	IPCC, 2000. Agriculture. pp. 4.43
...Liquid system	-50%...+100%	IPCC, 2000. Agriculture. pp. 4.43
...Solid storage	-50%...+100%	IPCC, 2000. Agriculture. pp. 4.43
...Pasture/range and paddock	-50%...+100%	IPCC, 2000. Agriculture. pp. 4.43
...Other Systems (cattle and swine deep litter, poultry manure with bedding)	-50%...+100%	IPCC, 2000. Agriculture. pp. 4.43

The combined uncertainties related to 'manure management' sub-sector (CRF 4.B) as percent from the total national emission in 2007 are follows⁵⁶:

4.B.	Dairy Cattle (CH ₄)	0.0258%
4.B.	Non-Dairy Cattle (CH ₄)	0.0121%
4.B.	Sheep (CH ₄)	0.0003%
4.B.	Goats (CH ₄)	0.0000%
4.B.	Horses (CH ₄)	0.0002%
4.B.	Swine (CH ₄)	0.0316%
4.B.	Poultry (CH ₄)	0.0025%

⁵⁶ Uncertainty calculation for the Estonian GHG inventory **excluding** LULUC (following IPCC Tier 1)

4.B.	Anaerobic Lagoon (N ₂ O)	0.0008%
4.B.	Liquid system (N ₂ O)	0.0121%
4.B.	Solid storage and dry lot (N ₂ O)	0.4040%
4.B.	Other AWMS (N ₂ O)	0.1454%

4.2.5.7. Source-specific recalculations

There are several recalculations carried out in the 2009 submission: 1) the activity data on cattle and swine population structure by sub-categories were updated for 1990–1998; 2) the activity data on milk production per cow, fat content and the percentage of cows that gave birth were updated; 3) the module of Eastern Europe manure management system was applied for 2003–2006 was implemented, in the 2008 submission the module of Western Europe manure management system was employed in the estimates (Figure 4.24–Figure 4.27, Table 4.42–Table 4.45).

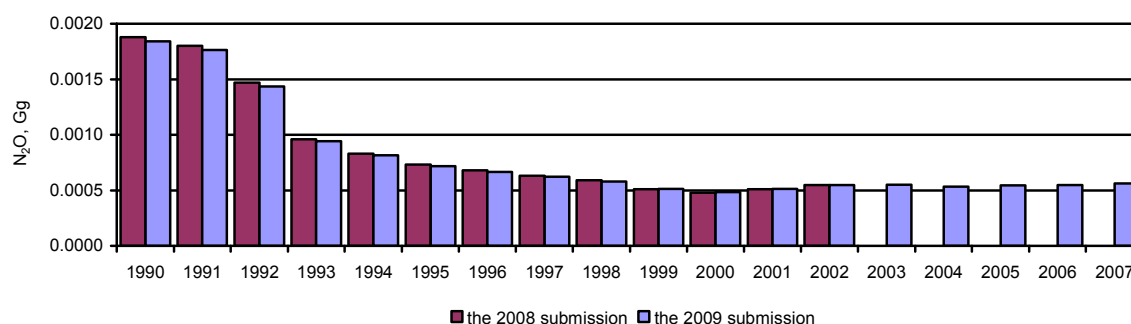
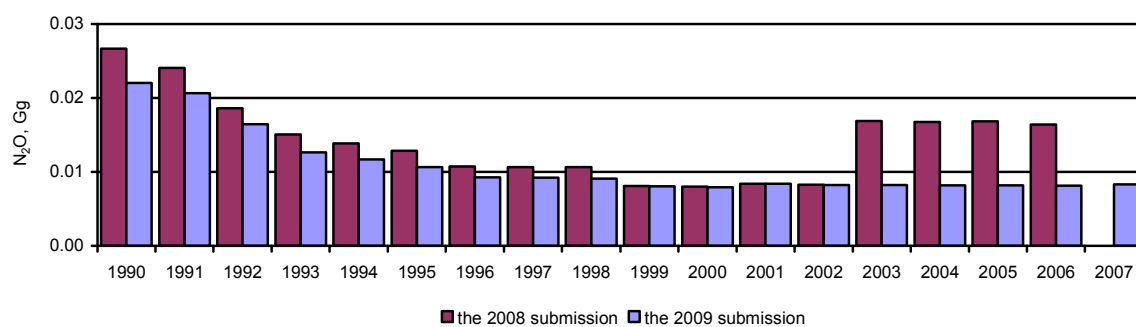


Figure 4.24. N₂O emissions from Anaerobic Lagoon manure management systems in 1990–2007, Gg

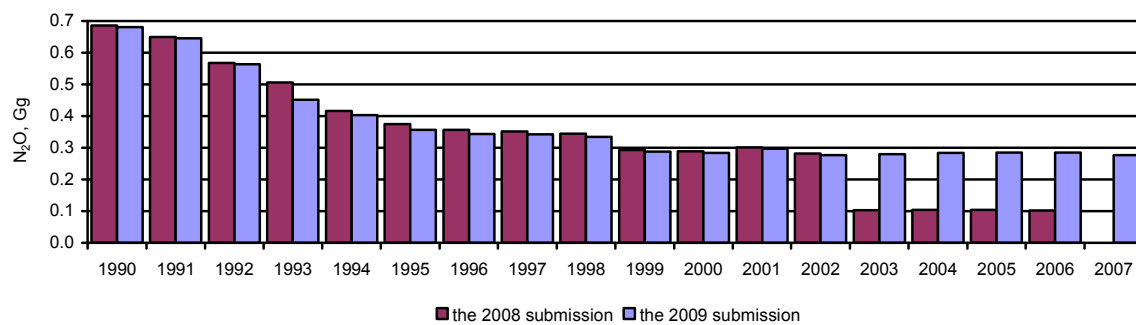
Table 4.42. N₂O emissions from Anaerobic Lagoon manure management in 1990–2007, Gg

Year	Reported emissions of N ₂ O in 1990–2006 (the 2008 submission)	Recalculated emissions of N ₂ O (the 2009 submission)
1990	0.0019	0.0018
1991	0.0018	0.0018
1992	0.0015	0.0014
1993	0.0010	0.0009
1994	0.0008	0.0008
1995	0.0007	0.0007
1996	0.0007	0.0007
1997	0.0006	0.0006
1998	0.0006	0.0006

Year	Reported emissions of N ₂ O in 1990–2006 (the 2008 submission)	Recalculated emissions of N ₂ O (the 2009 submission)
1999	0.0005	0.0005
2000	0.0005	0.0005
2001	0.0005	0.0005
2002	0.0006	0.0006
2003	NO	0.0006
2004	NO	0.0005
2005	NO	0.0005
2006	NO	0.0006
2007		0.0006

Figure 4.25. N₂O emissions from Liquid manure management systems in 1990–2007, Gg**Table 4.43. N₂O emissions from Liquid manure management in 1990–2007, Gg**

Year	Reported emissions of N ₂ O in 1990–2006 (the 2008 submission)	Recalculated emissions of N ₂ O (the 2009 submission)
1990	0.0267	0.0220
1991	0.0241	0.0207
1992	0.0186	0.0165
1993	0.0151	0.0126
1994	0.0139	0.0117
1995	0.0128	0.0107
1996	0.0107	0.0093
1997	0.0107	0.0092
1998	0.0107	0.0091
1999	0.0081	0.0080
2000	0.0080	0.0080
2001	0.0084	0.0084
2002	0.0083	0.0082
2003	0.0169	0.0082
2004	0.0168	0.0082
2005	0.0168	0.0082
2006	0.0164	0.0082
2007		0.0083

Figure 4.26. N₂O emissions from Solid Storage manure management systems in 1990–2007, Gg**Table 4.44. N₂O emissions from Solid Storage manure management in 1990–2007, Gg**

Year	Reported emissions of N ₂ O in 1990–2006 (the 2008 submission)	Recalculated emissions of N ₂ O (the 2009 submission)
1990	0.686	0.681
1991	0.650	0.645
1992	0.568	0.564
1993	0.506	0.452
1994	0.417	0.403
1995	0.376	0.357
1996	0.357	0.344
1997	0.352	0.343
1998	0.345	0.334
1999	0.293	0.288
2000	0.289	0.284
2001	0.301	0.297
2002	0.282	0.277
2003	0.103	0.280
2004	0.104	0.285
2005	0.104	0.285
2006	0.102	0.285
2007		0.277

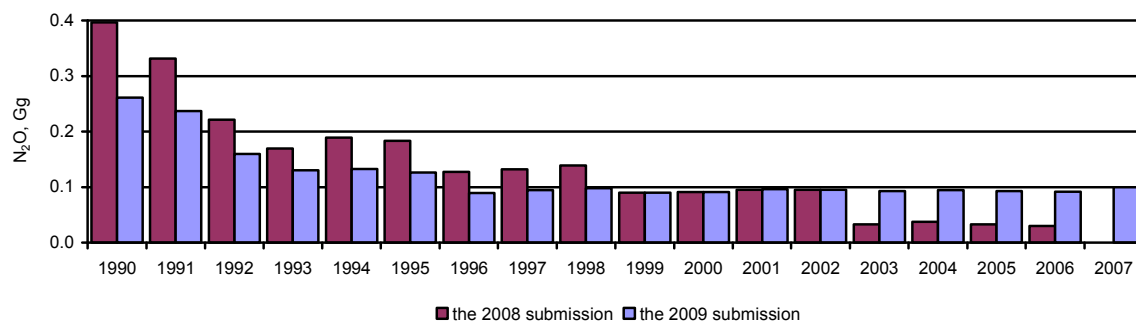
Figure 4.27. N₂O emissions from Other manure management systems in 1990–2007, Gg

Table 4.45. N₂O emissions from Other manure management in 1990–2007, Gg

Year	Reported emissions of N ₂ O in 1990–2006 (the 2008 submission)	Recalculated emissions of N ₂ O (the 2009 submission)
1990	0.397	0.261
1991	0.332	0.237
1992	0.221	0.160
1993	0.170	0.131
1994	0.189	0.133
1995	0.183	0.126
1996	0.127	0.090
1997	0.132	0.095
1998	0.139	0.098
1999	0.090	0.090
2000	0.091	0.091
2001	0.095	0.096
2002	0.095	0.095
2003	0.033	0.093
2004	0.038	0.095
2005	0.033	0.093
2006	0.030	0.092
2007		0.100

4.2.5.8. Source-specific planned improvements

A country-specific module on manure management system is being under development, the result will be employed in the next submissions.

4.2.6. N₂O emission from Pasture, Range and Paddock (CRF 4.D.2)**4.2.6.1. Methodology, data availability, data sources and emission factors**

The method reported in Chapter 4.2.5.2.1 was used in order to estimate N₂O emission from animal pasture, range and paddock.

4.2.6.2. Quantitative overview – N₂O emission from pasture, range and paddock in 2007

The N₂O emission from pasture, range and paddock manure management was 0.12 Gg in 2007 in Estonia (Figure 4.23). The emission declined by 2 fold by 2007 in comparison with the base year.

4.3. Direct emissions from agricultural soils

N₂O oxide is produced naturally in soils through the microbial processes of nitrification and denitrification. A number of agricultural activities add nitrogen to soils, increasing the amount of nitrogen (N) available for nitrification and the amount of N₂O emitted (IPCC, 2000).

The following agricultural activities exert influence on N flows in agricultural soils:

- Synthesis fertilizers;
- Animal excreta nitrogen used as fertilizer;
- Biological nitrogen fixation;
- Crop residue;
- Cultivation of high organic content soils;
- Sludge application on agricultural soils;

4.3.1. Source category description

The total direct N₂O emission from agricultural soils was 1.53Gg in Estonia in 2007 (Figure 4.28).

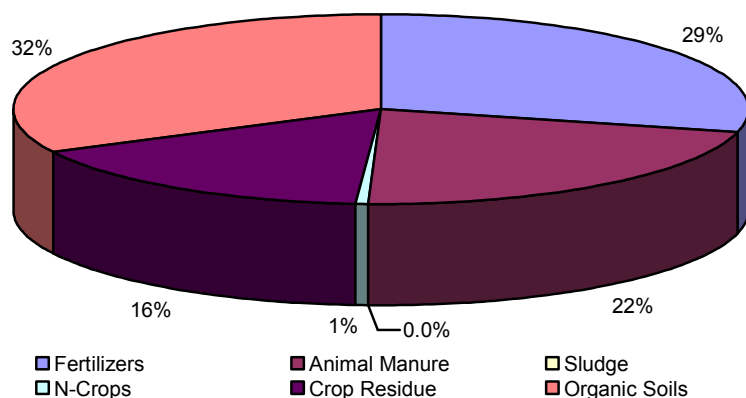


Figure 4.28. Direct N₂O emissions from agricultural soils in Estonia in 2007, Gg

Table 4.46. Direct N₂O emissions from agricultural soils in Estonia in 1990–2007, Gg

Year	Synthetic fertilizers	Animal manure	Sludge applied	N-fixing crops	Crop residue	Organic soils	Total	Total CO ₂ equiv
1990	1.141	0.815	0.0040	0.0003	0.41	0.537	2.910	902.13
1991	1.111	0.765	0.0047	0.0003	0.40	0.570	2.849	883.21
1992	1.032	0.622	0.0006	0.0005	0.28	0.559	2.494	773.26
1993	0.529	0.491	0.0079	0.0009	0.28	0.491	1.798	557.32
1994	0.461	0.453	0.0080	0.0009	0.25	0.428	1.605	497.54
1995	0.334	0.409	0.0119	0.0053	0.26	0.407	1.424	441.50
1996	0.293	0.361	0.0136	0.0117	0.27	0.388	1.334	413.53
1997	0.362	0.362	0.0096	0.0144	0.26	0.429	1.433	444.31
1998	0.441	0.358	0.0144	0.0070	0.15	0.474	1.447	448.49
1999	0.352	0.315	0.0154	0.0026	0.18	0.459	1.319	409.04
2000	0.396	0.313	0.0246	0.0056	0.26	0.512	1.508	467.33
2001	0.347	0.330	0.0168	0.0055	0.20	0.428	1.327	411.41
2002	0.295	0.316	0.0155	0.0043	0.17	0.403	1.201	372.29
2003	0.416	0.317	0.0210	0.0043	0.17	0.429	1.356	420.31
2004	0.439	0.321	0.0006	0.0028	0.18	0.429	1.370	424.70
2005	0.355	0.323	0.0009	0.0049	0.22	0.450	1.354	419.81
2006	0.400	0.324	0.0019	0.0047	0.18	0.465	1.374	426.08
2007	0.442	0.330	0.0007	0.0081	0.25	0.498	1.530	474.28

4.3.2. Activity data employed

The activity data on synthetic fertilizers applied on agricultural fields, crop production in Estonia were taken from the datasets of the ESO. The data on amounts of sludge used on arable lands were used from the EEIC. The data on areas of histosols cultivated in Estonia were estimated merging two map-datasets: CORINE cover map (scale 1:100 000) and Estonian soil map (scale 1:10 000).

4.3.3. N₂O emission from Synthetic Fertilizer nitrogen applied to soils (CRF 4.D.1.1)

The emission of N₂O is estimated from annual synthetic nitrogen applied to soils.

4.3.3.1. Methodology, data availability, data sources and emission factors

The algorithm reported in IPCC (2000) was used for the estimation of nitrogen input into agricultural soils adjusted for volatilization.

$$F_{SN} = N_{FERT} \times (1 - \text{Frac}_{GASF}) \quad (4.19)^{57}$$

F_{SN} – Calculation of synthetic fertilizer use, N_2O Gg;

N_{FERT} - Total use of synthetic fertilizer in country, kg N/year;

Frac_{GASF} – Fraction of total synthetic fertilizer nitrogen that is emitted as $NO_x + NH_3$, kg N/kg N;

N_2O emission into the atmosphere from using of synthetic nitrogen was calculated based on the formula (4.20).

$$N_2O_{\text{direct}} - N = F_{SN} \bullet EF \bullet 44/28_1 \quad (4.20)$$

Table 4.47. IPCC default factors used in the estimation

Factors	Value
EF_1 for F_{SN}	1.25% ⁵⁸
Frac_{GASF}	0.1 kg NH_3 -N + NO_x -N/kg of synthetic fertilizer nitrogen applied ⁵⁹

4.3.3.2. Quantitative overview – N_2O emission from synthetic fertilizers applied to soils in 2007

The total N_2O emission from synthetic fertilizers applied onto agricultural soils was 0.442 Gg in Estonia in 2007 (Figure 4.29). The emission declined 2.6 fold by 2007 in comparison with the base year.

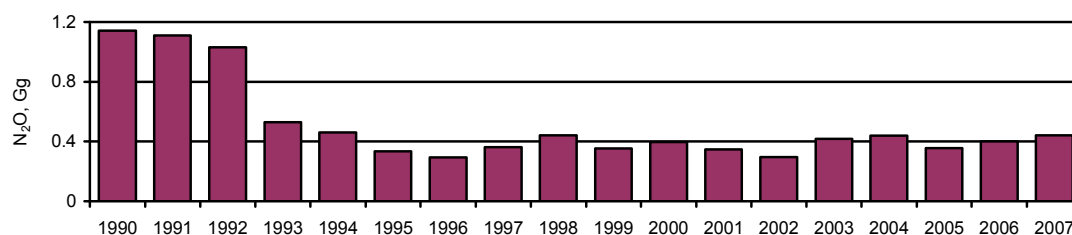


Figure 4.29. N_2O emissions from synthetic fertilizers applied to agricultural soils in 1990–2007 in Estonia, Gg

⁵⁷ IPCC, 1997. Agriculture. Workbook. Equation 1, pp. 4.33.

⁵⁸ IPCC, 2000. Agriculture. Table 4-17. Updated default emission factors to estimate direct N_2O emissions from agricultural soils, pp. 4.60

⁵⁹ IPCC, 1997. Agriculture. Reference Manual. Table 4-17 Summary of default values for parameters, 1996, pp. 4.35

4.3.4. N₂O emission from Animal Manure applied to soils and excreted on pasture (CRF 4.D.1.2)

N₂O emits from agricultural soil through manure application to fields as organic fertilizer and animal pastures by grazing animals.

4.3.4.1. Methodology, data availability, data sources and emission factors

N₂O emission into the atmosphere from animal waste applied to agricultural fields as organic fertilizer was estimated according to the algorithm suggested by IPCC (1997).

$$N_2O_{\text{direct}} - N = F_{\text{AW}} \bullet EF_1 \quad (4.21)$$

$$F_{\text{AW}} = (Nex \bullet (1 - \text{Frac}_{\text{FUEL}} + \text{Frac}_{\text{GRAZ}} + \text{Frac}_{\text{GASM}})) \quad (4.22)^{60}$$

$$Nex = \sum [N_{(T)} \times Nex_{(T)}] \quad (4.23)$$

$$Nex_{(\text{AWMS})} = \sum [N_{(T)} \times Nex_{(T)} \times \text{AWMS}_{(T)}] \quad (4.24)$$

F_{AW} – Manure nitrogen used as fertilizer in country, corrected for NH₃ and NO_x emissions and excluding manure produced during grazing, kg N/yr;

$\text{AWMS}_{(T)}$ – Fraction of $Nex_{(T)}$ that is produced in the different distinguished animal waste management systems in country;

$\text{Frac}_{\text{FUEL}}$ – Fraction of livestock nitrogen excretion contained in excrements burned for fuel, kg N/kg N totally excreted;

$\text{Frac}_{\text{GRAZ}}$ – Fraction of livestock nitrogen excreted and deposited onto soil during grazing, kg N/kg N excreted;

$\text{Frac}_{\text{GASM}}$ – Fraction of total nitrogen excretion that is emitted as NO_x or NH₃, kg N/kg N;

$N_{(T)}$ – Number of animals per type of animal in country;

Nex – Total nitrogen excretion by animals in country, kg N/yr;

⁶⁰ IPCC 1996. Agriculture. Workbook. Equations 2-4, pp 4.33.

$N_{ex(T)}$ – Nitrogen excretion per Type of animal in country, kg/yr;

$N_{ex(AWMS)}$ – Nitrogen excretion per Animal Waste Management System, kg/yr;

Nitrogen excretion generated per type of animals and per animals waste management system was estimated in ‘N₂O emissions from manure management’ chapter.

IPCC default factors were used to estimate nitrogen input to agricultural soils (Table 4.48).

Table 4.48. IPCC default factors used in the estimation of N₂O emission from animal waste applied to soils

Factor	Value
Frac _{FUEL}	0.0 kg N/kg nitrogen excreted ⁶¹
Frac _{GRAZ}	see Tables Tables 4.21, 4.24 (Pasture, Range and Paddock)
Frac _{GASM}	0.2 kg NH ₃ -N + NO _x -N/kg of nitrogen excreted by livestock ⁴⁵

4.3.4.2. Quantitative overview – N₂O emission from Animal Manure applied to soils and excreted on pasture in 2007

The total N₂O emission from animal manure applied on agricultural soils was 0.330Gg in Estonia in 2007 (Figure 4.30).

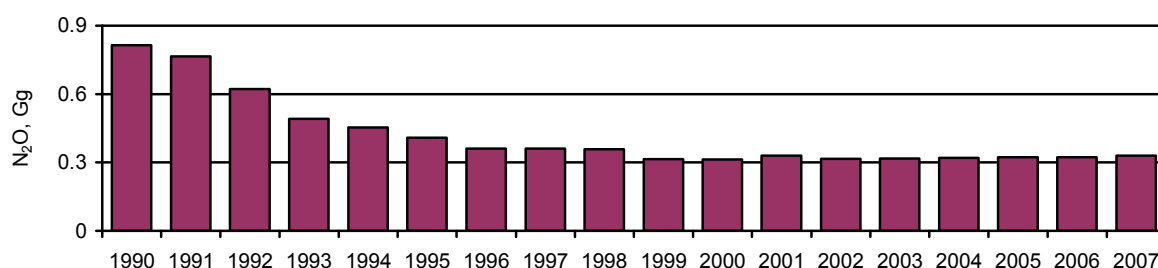


Figure 4.30. N₂O emissions from animal manure applied to agricultural soils in 1990–2007 in Estonia, Gg

⁶¹ IPCC, 1997. Agriculture. Workbook. Table 4-17 – Summary of default values for parameters. pp 4.35

4.3.4.3. Source-specific recalculations

There is one recalculation in the estimation of N₂O emissions from animal manure applied to soils in the 2009 submission. The recalculation was carried out due to the changes in the activity data.

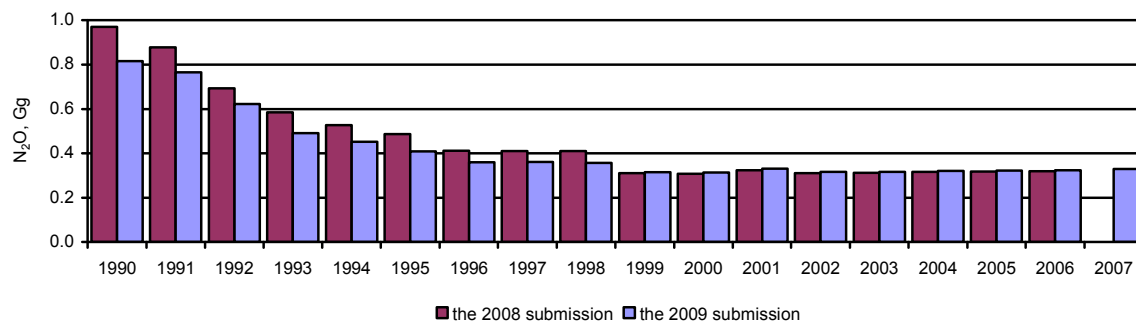


Figure 4.31. N₂O emissions from animal manure applied onto agricultural land in 1990–2007, Gg

Table 4.49. N₂O emission from animal manure applied onto agricultural land in Estonia in 1990–2007, Gg

Year	Reported emissions of N ₂ O in 1990–2006 (the 2008 submission)	Recalculated emissions of N ₂ O (the 2009 submission)
1990	0.970	0.815
1991	0.878	0.765
1992	0.694	0.622
1993	0.586	0.491
1994	0.526	0.453
1995	0.487	0.409
1996	0.412	0.361
1997	0.411	0.362
1998	0.411	0.358
1999	0.311	0.315
2000	0.308	0.313
2001	0.323	0.330
2002	0.311	0.316
2003	0.313	0.317
2004	0.317	0.321
2005	0.318	0.323
2006	0.320	0.324
2007		0.330

4.3.5. Nitrogen input in N-fixing crops (CRF 4.D.1.3)

The amount of nitrogen fixed by N-fixing crops cultivated annually (IPCC, 2000).

4.3.5.1. Methodology, data availability, data sources and emission factors

The *Tier 1* method (IPCC, 1997) was used to estimate emissions from N fixing crops and pastures.

$$F_{BN} = 2 \times \text{Crop}_{BF} \times \text{Frac}_{NCRBF} \quad (4.25)^{62}$$

Crop_{BF} – Production of pulses + soybeans in country, kg dry biomass/yr;

Frac_{NCRBF} – Fraction of nitrogen in N-fixing crop, kg N/kg of dry biomass;

Factor 2, which converts the crop production to total crop biomass, was changed by the factor from presented in the work by Jonas M., *et al.*, 2001 (Table 4.50).

The activity data on the production of N-fixing crops in Estonia were obtained from the ESO (Table 4.50). IPCC default factor was in the estimation (Table 4.50). The factor for conversion of the crop production from Fresh Matter (FM) to Dry Matter (DM) was obtained from Jonas M., *et al.*, 2001.

Annual N_2O emission from N-fixing crops was calculated using the formula (4.26) (the *Tier 1*, IPCC 1997)

$$N_2O_{\text{direct}} = F_{BN} \bullet EF_1 \bullet 44 / 28 \quad (4.26)$$

EF_1 – IPCC default factor for N-fixing crops (Table 4.50);

⁶² IPCC 1996. Agriculture. Workbook. Equation 5, pp. 4.35.

Table 4.50. Factors used in the algorithm of the estimation

Factor	Value
Frac _{NCRBF} ⁶³	0.03 kg N/kg of Dry Matter
Conversion factor from FM to DM ⁶⁴	0.87 t DM / t FM
Grain-to-Straw ratio for Legumes ⁴⁸	1.525
EF ₁ for F _{BN}	1.25%

4.3.5.2. Quantitative overview – N₂O emission from growing of N-fixing crops in 2007

The total production of legumes in Estonia was 9,515 tonnes in 2007 (Table 4.51) that equals 411,188 kg N.

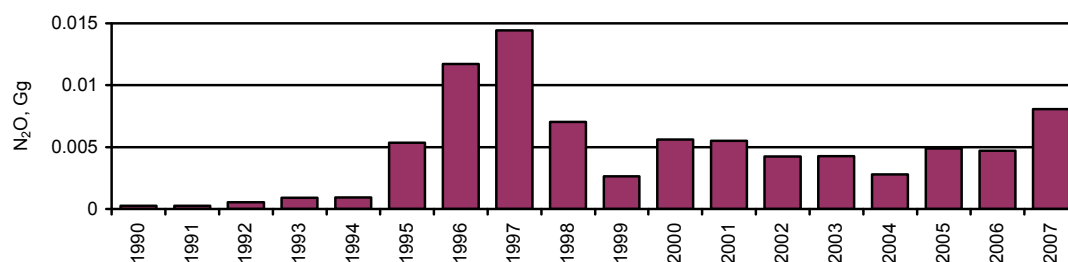
Table 4.51. Production of Legumes in Estonia in 2007 (ESO)

	Harvest, tonnes	Total production, t DM	N ₂ O emission, Gg
Harju county	346	498	0.0003
Hiiu county	29	42	0.0000
Ida-Viru county	132	190	0.0001
Jõgeva county	86	124	0.0001
Järva county	531	765	0.0005
Lääne county	232	334	0.0002
Lääne-Viru county	1704	2,455	0.0014
Põlva county	773	1,114	0.0007
Pärnu county	1708	2,460	0.0014
Rapla county	233	336	0.0002
Saare county	434	625	0.0004
Tartu county	1038	1,495	0.0009
Valga county	531	765	0.0005
Viljandi county	1304	1,878	0.0011
Võru county	434	625	0.0004
Whole country	9515	13,706	0.0081

The total N₂O emission from growing of N-fixing crops was 0.008Gg in Estonia in 2007 (Figure 4.32). The contribution of the emission to the total direct emission from agricultural crops is negligible.

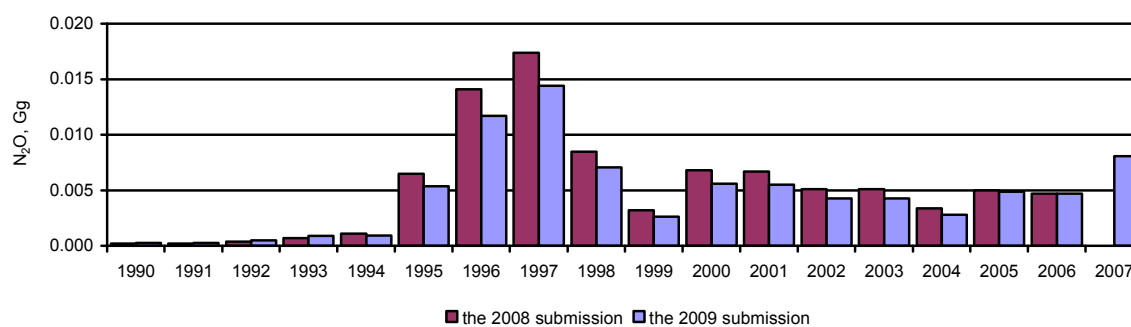
⁶³ IPCC 1996. Agriculture. Workbook. Table 4.17 – Summary of default values for parameters. pp 4.35

⁶⁴ Jonas *et al.*, 2001

Figure 4.32. N₂O emissions from growing of N-fixing crops in 1990–2007 in Estonia, Gg

4.3.5.3. Source-specific recalculations

There is one recalculation carried out in the 2009 submission: grain-to-root factor employed in the estimates was updated.

Figure 4.33. N₂O emissions from growing of N-fixing crops in 1990–2007 in Estonia, Gg**Table 4.52. N₂O emission from growing of N-fixing crops in Estonia in 1990–2007, Gg**

Year	Reported emissions of N ₂ O in 1990–2006 (the 2008 submission)	Recalculated emissions of N ₂ O (the 2009 submission)
1990	0.0002	0.0003
1991	0.0002	0.0003
1992	0.0004	0.0005
1993	0.0007	0.0009
1994	0.0011	0.0009
1995	0.0065	0.0053
1996	0.0141	0.0117
1997	0.0174	0.0144
1998	0.0085	0.0070
1999	0.0032	0.0026
2000	0.0068	0.0056
2001	0.0067	0.0055

Year	Reported emissions of N ₂ O in 1990–2006 (the 2008 submission)	Recalculated emissions of N ₂ O (the 2009 submission)
2002	0.0051	0.0043
2003	0.0051	0.0043
2004	0.0034	0.0028
2005	0.0050	0.0049
2006	0.0047	0.0047
2007		0.0081

4.3.6. N₂O emission from nitrogen input from crop-residue (CRF 4.D.1.4)

The amount of nitrogen returned to soils annually through the incorporation of crop residues.

4.3.6.1. Methodology, data availability, data sources and emission factors

The default IPCC *Tier 1* method was used for the estimation emissions from crop residues returned to the soil.

$$F_{CF} = 2 \times [\text{Crop}_0 \times \text{Frac}_{NCR0} + \text{Crop}_{BF} \times \text{Frac}_{NCRBF}] \times (1 - \text{Frac}_R) \times (1 - \text{Frac}_{BURN}) \quad (4.27)^{65}$$

Crop_{BF} - Production of pulses + soybeans in country, kg dry biomass/yr;

Crop₀ – Production of non-N-fixing crops in country, kg dry biomass/yr;

Frac_{NCRBF} – Fraction of nitrogen in N-fixing crops, kg N/kg of dry biomass;

Frac_{NCR0} – Fraction of nitrogen in non-N-fixing crops, kg N/kg of dry biomass;

Frac_R – Fraction of crop residue that is removed from the field as crop, kg N/kg crop-N;

Frac_{BURN} – Fraction of crop residue that is burned rather than left on field;

2 – The factor converts the crop production to total crop biomass. The factor was suggested by IPCC methodology, however the factors from (Jonas M., *et al*, 2001) were used instead of this factors in the estimation;

⁶⁵ IPCC 1996. Agriculture. Workbook. Equation 6. pp. 4.36

Annual N₂O emission from crop residues was calculated using the formula (4.28) (the *Tier 1* method, IPCC 1997).

$$N_2O_{\text{direct}} = F_{\text{CR}} \bullet EF_1 \bullet 44 / 28 \quad (4.28)$$

Table 4.53. Factors used in the algorithm of the estimation of N₂O emissions from crop residues⁶⁶

Factor	Unit
Frac _{NCRBF}	0.03 kg N/kg of Dry Matter
Frac _{NCR0}	0.015 kg N/kg of Dry Matter
Frac _R	0.45 kg N/kg crop-N
Frac _{BURN}	0.10, kg N/kg crop-N (for developed countries)
EF ₁ for F _{CF}	1.25% ⁶⁷

4.3.6.2. Quantitative overview – N₂O emission from crop-residues in 2007

In 2007, the production of cereals was 879 thousand tonnes, industrial crops – 127 thousand tonnes, potatoes – 192 thousand tonnes and legumes and fodder roots – 9.5 and 3.4 thousand tonnes respectively. The crop production in Dry Matter is reported in Table 4.54.

The total N₂O emission from crop residues left on agricultural land was 0.25 Gg in 2007 (Figure 4.35).

Table 4.54. Crop harvest in Estonia in 2007, DM tonnes (with residues)

	Cereals	Legumes	Potatoes	Fodder roots	Industrial crops
Whole country	1,364,746	13,706	230,105	4,135	99,314
Harju county	73,788	498	25,109	216	6,373
Hiiu county	6,399	42	5,369	53	479
Ida-Viru county	28,907	190	9,239	394	2,357
Jõgeva county	136,781	124	17,967	829	9,187
Järva county	108,420	765	8,859	7	9,367
Lääne county	36,420	334	8,849	239	3,635
Lääne-Viru county	213,211	2,455	12,954	0	15,245
Põlva county	91,871	1,114	17,885	330	6,085
Pärnu county	74,865	2,460	20,019	404	5,880
Rapla county	62,585	336	17,412	72	6,139

⁶⁶ IPCC 1996. Agriculture. Workbook. Table 4-17 – Summary of default values for parameters. pp 4.35

⁶⁷ IPCC 2000. Agriculture. Table 4-17 – Updated default emission factors to estimate direct N₂O emissions from agricultural soils. pp 4.60

	Cereals	Legumes	Potatoes	Fodder roots	Industrial crops
Saare county	25,942	625	9,365	469	1,299
Tartu county	206,230	1,495	26,107	263	11,203
Valga county	77,852	765	7,588	157	4,378
Viljandi county	156,993	1,878	22,726	398	14,680
Võru county	64,481	625	20,657	304	3,009

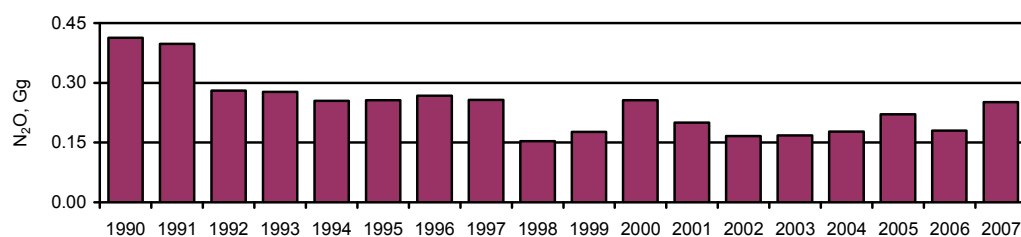


Figure 4.34. N₂O emissions from crop residues left on agricultural fields in 1990–2007 in Estonia, Gg

4.3.6.3. Source-specific recalculations

There are two recalculations carried out in the 2009 submission: 1) the activity data on crop production were updated; 2) conversion factors from fresh matter to dry matter were updated.

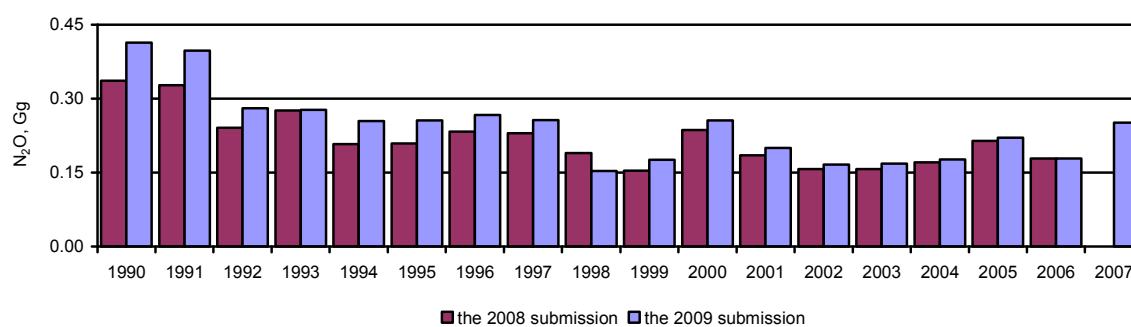


Figure 4.35. N₂O emissions from crop residues left on agricultural fields in 1990–2007 in Estonia, Gg

Table 4.55. N₂O emission from crop residues left on agricultural fields in 1990–2007, Gg

Year	Reported emissions of N ₂ O in 1990–2006 (the 2008 submission)	Recalculated emissions of N ₂ O (the 2009 submission)
1990	0.336	0.414
1991	0.327	0.398
1992	0.241	0.281
1993	0.276	0.277
1994	0.208	0.254
1995	0.209	0.256
1996	0.233	0.267
1997	0.230	0.257
1998	0.190	0.153
1999	0.154	0.177
2000	0.236	0.256
2001	0.185	0.200
2002	0.158	0.166
2003	0.157	0.168
2004	0.171	0.177
2005	0.215	0.221
2006	0.179	0.179
2007		0.252

4.3.7. N₂O emission from Organic Soils Cultivation (CRF 4.D.1.5)

Large N₂O emissions occur as a result of cultivation of organic soils due to enhanced mineralization of old, N-rich organic matter. The rate of N-mineralization is determined by N-quality of Histosols, management practice and climatic conditions (IPCC, 1997).

4.3.7.1. Methodology, data availability, data sources and emission factors

The *Tier 1* method was applied in order to estimate N₂O emission from organic soils cultivation (IPCC, 1997).

$$N_2O_{\text{direct}} = F_{OS} \bullet EF_2 \bullet 44 / 28 \quad (4.29)$$

F_{OS} – area of cultivated organic soils, ha;

EF_2 – emission factor for organic soil mineralization due to cultivation, kg N₂O-N ha/yr (Table 4.56);

Table 4.56. Factors used in the algorithm of the estimation of N₂O emissions from cultivated organic soils⁶⁸

Factor	Unit
EF ₂	8 kg N/kg of Dry Matter

4.3.7.2. Quantitative overview – N₂O emission from organic soils cultivated in 2007

The N₂O emission from cultivation of organic soils was 0.50 Gg in 2007 in Estonia. The estimation was carried out basing on the data received from combination (the interpolation method was employed) of data from CORINE map and the data on arable land from ESO.

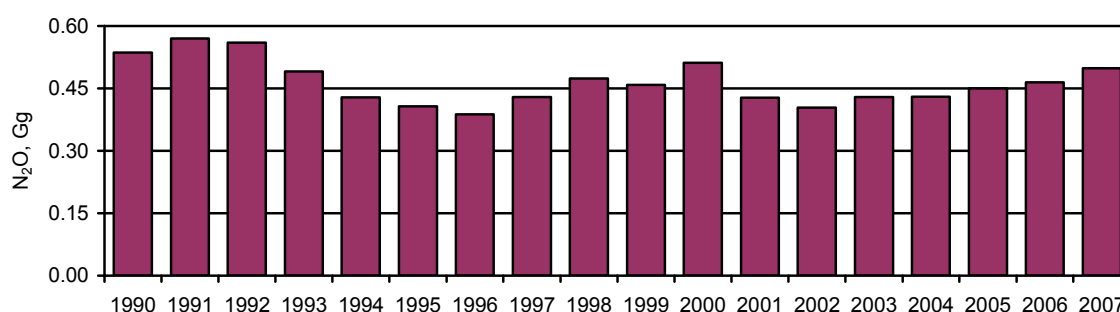


Figure 4.36. N₂O emission from cultivation of organic soils in Estonia in 1990–2007, Gg

4.3.7.5. Uncertainties and time-series consistency

4.3.7.5.1. Synthetic Fertilizers used (CRF 4.D.1.1)

The estimation of N₂O emissions from synthetic fertilizers used are carried out based on activity data and emission factors.

Investigations made into the estimates of uncertainties related to activity data (synthetic fertilizers applied on agricultural soils) are presented in (Rypdal K., *et al.*, 2001). The authors report uncertainties at ±5% in Austria, at ±5% in Norway, at ±10-50% in the Netherlands, at ±2% in the USA and at ±10% in Finland (Monni S., *et al.*, 2003). No similar research has been done in Estonia, therefore the uncertainty of Finland was used in the estimates (Table 4.57).

⁶⁸ IPCC 2000. Agriculture. Table 4.17 – Updated default factors to estimate direct N₂O emissions from agricultural soils, pp 4.60

Nitrogen emission factors have been used as IPCC default in the estimates of N₂O emissions. The IPCC gives an uncertainty of the factor of $\pm 80\%$, the factor is 0.0125 with a range of 0.0025–0.0255 (IPCC, 1997).

4.3.7.5.2. Animal Manure Applied to Soils (CRF 4.D.1.2)

The estimation of N₂O emission from animal manure applied to soils is carried out based on activity data (amounts of nitrogen produced by livestock) and emission factors.

Uncertainties of N generated were described in the ‘Manure Management’ chapter above.

Nitrogen emission factor was taken as IPCC default. An uncertainty of the factors is given in the IPCC Guidelines (1996) at $\pm 80\%$ (Table 4.57) (IPCC, 1997).

4.3.7.5.3. N-fixing Crops and Crop Residues (CRF 4.D.1.3 and CRF 4.D.1.4)

The estimation of N₂O emission from N-fixing crops and crop residue is carried out based on activity data (crop production) and emission factors (N emission factor, crop residue ratios, nitrogen content in crops and fraction of residues left on fields).

Data on uncertainty of crop production (N-fixing and non-nitrogen fixing crops) in Estonia are not available, therefore the uncertainty of activity data was not estimated.

The uncertainty of N content in N-fixing crops and non-nitrogen crops and the fraction of crop residue left on fields have not been estimated in the submission of 2007 due to lack of data.

IPCC default nitrogen emission factor has been used in the estimates. IPCC gives an uncertainty of the factor at $\pm 80\%$ (Table 4.57) as the value of the factor is 0.0125 with a range of 0.0025–0.0255 (IPCC, 1997).

Table 4.57. Estimated values of uncertainties used in agriculture sector

Input	Uncertainties	References
<i>Activity data</i>		
Estonia's Livestock Population (cattle, swine, sheep, goats, horses, poultry)	± 10%	Rypdal K., <i>et al.</i> , 2001
Synthetic Fertilizers (applied to agricultural soils)	± 10%	Rypdal K., <i>et al.</i> , 2001
<i>Emission factors</i>		
Emission factor (synthetic fertilizers, animal manure, n-fixing crops and crop residues)	± 80%	Table 4-18 of the 1996 IPCC Guidelines, pp. 4.89
Fraction of synthetic N fertilizers that volatilizes as NH ₃ and NO _x	± 30%	Monni S., <i>et al.</i> , 2003
Fraction of animal manure N that volatilizes as NH ₃ and NO _x	± 40%	Monni S., <i>et al.</i> , 2003

The combined uncertainties related to 'Direct emissions from agricultural soils' sub-sector (CRF 4.D) as percent from the total national emission in 2007 are follows⁶⁹:

4.D.1.1	Synthetic Fertilizers (N ₂ O)	0.5316%
4.D.1.2	Animal Manure Applied to Soils (N ₂ O)	0.4332%
4.D.1.3	N-fixing Crops (N ₂ O)	0.0091%
4.D.1.4	Crop Residue (N ₂ O)	0.2832%
4.D.1.5	Cultivation of Histosols (N ₂ O)	0.5603%
4.D.1.6	Sludge applied on agricultural fields (N ₂ O)	0.0008%
4.D.2	Pasture, Range and Paddock Manure (N ₂ O)	0.1693%

4.4. Indirect emissions from agricultural soils

Nitrous oxide is produced naturally in soils and aquatic systems through the microbial processes of nitrification and denitrification. A number of agricultural and other anthropogenic activities add nitrogen (N) to soils and aquatic systems, increasing the amount of N available for nitrification and denitrification, and ultimately the amount of N₂O emitted (IPCC, 2000).

The IPCC provides methods to estimate N₂O emissions from (the formula 4.30):

- Leaching and runoff of N that is applied to, or deposited on, soils;
- Disposal of sewage N;
- Formation of N₂O in the atmosphere from NH₃ emissions originating from anthropogenic activities;

⁶⁹ Uncertainty calculation for the Estonian GHG inventory **excluding** LULUC (following IPCC Tier 1)

- Disposal of processing effluents from food processing and other operations;

4.4.1. Source category description

The total indirect N₂O emission from agricultural soils was 0.66 Gg in 2007 (Table 4.58). The emission declined by 2.5 fold by 2007 due to decreasing number of livestock population and synthetic and sludge application onto agricultural land.

Table 4.58. Indirect N₂O emissions from agricultural soils in Estonia in 1990–2007, Gg

Year	Atmospheric Deposition	Leaching and Run-off	Total	Total CO ₂ equiv
1990	0.269	1.390	1.659	514.21
1991	0.256	1.332	1.588	492.40
1992	0.219	1.166	1.386	429.52
1993	0.149	0.736	0.885	274.30
1994	0.135	0.661	0.796	246.62
1995	0.115	0.546	0.660	204.72
1996	0.101	0.482	0.583	180.65
1997	0.107	0.526	0.633	196.36
1998	0.114	0.579	0.692	214.64
1999	0.097	0.487	0.584	181.04
2000	0.102	0.521	0.623	193.18
2001	0.100	0.496	0.596	184.87
2002	0.092	0.450	0.543	168.29
2003	0.103	0.532	0.636	197.01
2004	0.105	0.540	0.645	199.96
2005	0.098	0.485	0.583	180.81
2006	0.102	0.517	0.619	191.84
2007	0.107	0.549	0.656	203.22

4.4.2. Atmospheric deposition of NO_x and NH₄ (CRF 4.D.3.1)

Atmospheric deposition of nitrogen compounds such as nitrogen oxides (NO_x) and ammonium (NH₄) fertilizes soils and surface waters, which results in enhanced biogenic N₂O formation (IPCC, 2000).

4.4.2.1. Methodology, data availability, data sources and emission factors

The default IPCC *Tier 1* method was used to estimate emissions from the atmospheric deposition.

$$N_2O_{(G)} - N = [(N_{FERT} \bullet Frac_{GASF}) + (\sum_T (N_{(T)} \bullet Nex_{(T)}) \bullet Frac_{GASM})] \bullet EF_4 \quad (4.30)^{70}$$

$N_2O_{(G)} - N$ – N_2O produced from atmospheric deposition of N, kg N/yr;

N_{FERT} – Total amount of synthetic nitrogen fertilizer applied to soils, kg N/yr;

$\sum_T (N_{(T)} \bullet Nex_{(T)})$ – total amount of animal manure nitrogen excreted in a country, kg N/yr;

$Frac_{GASF}$ – Fraction of synthetic N fertilizer that volatilises as NH_3 and NO_x , kg NH_3 -N and NO_x -N/kg of N input;

$Frac_{GASM}$ – Fraction of animal manure N that volatilises as NH_3 and NO_x , kg NH_3 -N and NO_x -N/kg of N excreted;

EF_4 – Emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces kg N_2O -N/kg NH_3 -N and NO_x -N emitted;

Table 4.59. Factors used in the algorithm of the estimation of atmospheric deposition

Factor	Value
$Frac_{GASF}$	0.1 kg NH_3 -N + NO_x -N/kg of synthetic fertilizer nitrogen applied ⁷¹
$Frac_{GASM}$	0.2 kg NH_3 -N + NO_x -N/kg of nitrogen excreted by livestock ⁷²
EF_4	0.01 kg N_2O -N per kg NH_3 -N and NO_x -N emitted

⁷⁰ IPCC, 2000. Agriculture. Equation 4.31, pp 4.68.

⁷¹ IPCC, 1997. Agriculture. Workbook. Table 4-17 Summary of default values for parameters. pp. 4.35

⁷² IPCC, 1997. Agriculture. Workbook. Table 4-17 Summary of default values for parameters. pp. 4.35

4.4.2.2. Quantitative overview – Atmospheric deposition of NO_x and NH_4 in 2007

The N_2O emission from atmospheric deposition was 0.107 Gg in 2007 in Estonia (Figure 4.37).

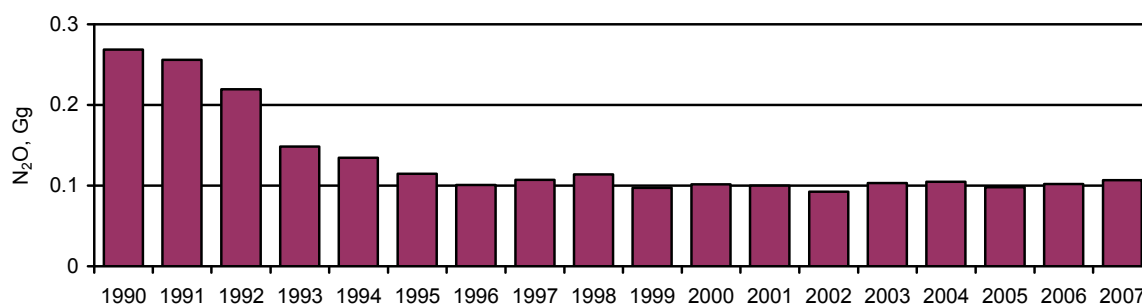


Figure 4.37. Atmospheric deposition of NO_x and NH_4 in 1990–2007, Gg

4.4.2.3. Source-specific recalculations

There is one recalculation in the ‘Atmospheric deposition of NO_x and NH_4 ’ category of the 2009 submission: the activity data in livestock population structure were updated.

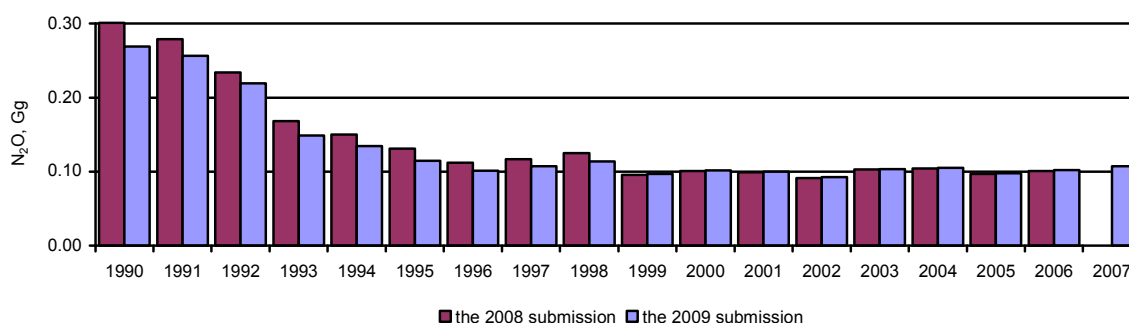


Figure 4.38. N_2O emissions from atmospheric deposition in 1990–2007 in Estonia, Gg

Table 4.60. N_2O emissions from atmospheric deposition in Estonia in 1990–2007, Gg

Year	Reported emissions of N_2O in 1990–2006 (the 2008 submission)	Recalculated emissions of N_2O (the 2009 submission)
1990	0.301	0.269
1991	0.279	0.256
1992	0.234	0.219
1993	0.168	0.149

Year	Reported emissions of N ₂ O in 1990–2006 (the 2008 submission)	Recalculated emissions of N ₂ O (the 2009 submission)
1994	0.150	0.135
1995	0.131	0.115
1996	0.112	0.101
1997	0.117	0.107
1998	0.125	0.114
1999	0.096	0.097
2000	0.101	0.102
2001	0.099	0.100
2002	0.091	0.092
2003	0.103	0.103
2004	0.104	0.105
2005	0.097	0.098
2006	0.101	0.102
2007		0.107

4.4.3. Leaching/Run-off of applied or deposited nitrogen (CRF 4.D.3.2)

A large proportion of nitrogen is lost from agricultural soils through leaching and runoff. This nitrogen enters the groundwater, riparian areas and wetlands, rivers, and eventually the ocean, where it enhances biogenic production of N₂O ([IPCC, 2000](#)).

4.4.3.1. Methodology, data availability, data sources and emission factors

The default IPCC *Tier 1* method was is used to estimate emissions from the atmospheric deposition.

$$N_2O_{(L)} - N = [N_{\text{FERT}} + \sum_T (N_{(T)} \bullet Nex_{(T)})] \bullet \text{Frac}_{\text{LEACH}} \bullet EF_5 \quad (4.31)^{73}$$

N_{FERT} – Total amount of synthetic nitrogen fertilizer applied to soils, kg N/yr;

$\sum_T (N_{(T)} \bullet Nex_{(T)})$ – Total amount of animal manure nitrogen excreted in a country, kg N/yr;

$\text{Frac}_{\text{LEACH}}$ – The amount of applied N that leaches or runs off, kg N/kg (Table 4.61);

⁷³ IPCC 2000. Agriculture. Equation 4.34, pp. 4.71

Table 4.61. Factors used in the algorithm of the estimation of leaching/runoff

Factor	Value
Frac _{LEACH}	0.3 kg N/kg nitrogen of fertilizer or manure ⁷⁴
EF ₅	0.025 kg N ₂ O-N per kg NH ₃ -N and NO _x -N emitted ⁷⁵

4.4.3.2. Quantitative overview – Leaching/Run-off of applied or deposited nitrogen in 2007

The N₂O emission from leaching and run-off was 0.55 Gg in 2007 in Estonia (Figure 4.39). The emission decreased by 2.5 fold by 2007 in comparison with the base year.

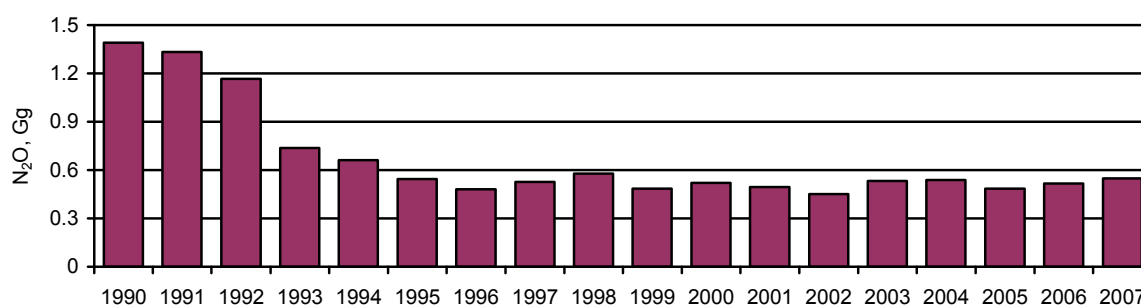


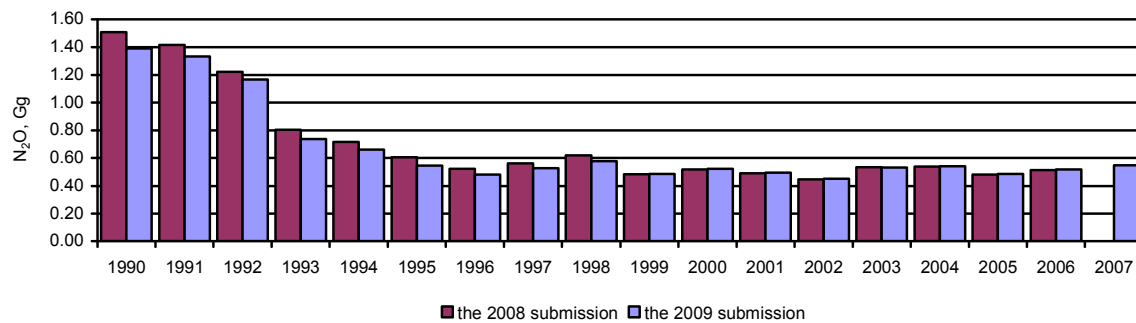
Figure 4.39. Leaching and run-off of NO_x and NH₄ in 1990–2007 in Estonia, Gg

4.4.3.3. Source-specific recalculations

There is one recalculation in the ‘Nitrogen leaching and run-off’ category of the 2009 submission: the activity data on livestock population structure, on milk production and fat content were updated.

⁷⁴ IPCC 1996. Agriculture. Workbook. Table 4-17 Summary of default values for parameters. pp. 4.35

⁷⁵ IPCC 2000. Agriculture. Table 4-18 –Default emission factors for estimating indirect N₂O emissions from N used in agriculture. pp 4.73

Figure 4.40. N₂O emissions due to nitrogen leaching and run-off in 1990–2007 in Estonia, Gg**Table 4.62. N₂O emissions due to nitrogen leaching and run-off in Estonia in 1990–2007, Gg**

Year	Reported emissions of N ₂ O in 1990–2006 (the 2008 submission)	Recalculated emissions of N ₂ O (the 2009 submission)
1990	1.509	1.390
1991	1.416	1.332
1992	1.221	1.166
1993	0.804	0.736
1994	0.717	0.661
1995	0.605	0.546
1996	0.521	0.482
1997	0.564	0.526
1998	0.619	0.579
1999	0.484	0.487
2000	0.517	0.521
2001	0.491	0.496
2002	0.446	0.450
2003	0.532	0.532
2004	0.537	0.540
2005	0.482	0.485
2006	0.514	0.517
2007		0.549

4.4.3.4. Uncertainties and time-series consistency

4.4.3.4.1. Atmospheric Deposition (CRF 4.D.3.1)

The estimation of N₂O emissions from atmospheric deposition is carried out based on activity data (synthetic fertilizers and animal manure applied to soils) and emission factors (N emission

factor, fraction of synthetic N fertilizers that volatilizes as NH_3 and NO_x and fraction of animal manure N that volatilizes as NH_3 and NO_x).

Uncertainties of fractions of synthetic fertilizers and animal manure that volatilize as NH_3 and NO_x were estimated by a Finnish expert (Monni S., *et al.*, 2003). These values were used in the estimates in order to calculate Estonia's uncertainties.

Nitrogen (N_2O) emission factor was used from (IPCC, 1997). IPCC Guidelines give the factor at 0.01 with a range 0.002–0.02, which means that the uncertainty of the factor is -80%...+100% (Table 4.63).

4.4.3.4.2. Nitrogen Leaching and Run-off (CRF 4.D.3.2)

The estimation of N_2O emission from nitrogen leaching is carried out based on activity data (synthetic fertilizers and animal manure applied to soils) and emission factors (fraction of the fertilizer, manure nitrogen lost to leaching and surface run-off and N_2O emission factor).

Nitrogen (N_2O) emission factor is reported in the 1996 IPCC Guidelines (IPCC, 1997). The value of the factor is 0.025 with a range 0.002–0.12. The uncertainty of the emission factor is -92%...+380% (Table 4.63).

Table 4.63. Estimated values of uncertainties used in agriculture sector

Input	Uncertainties	References
<i>Activity data</i>		
Estonia's Livestock Population (cattle, swine, sheep, goats, horses, poultry)	$\pm 10\%$	Rypdal K., <i>et al.</i> , 2001
Synthetic Fertilizers (applied to agricultural soils)	$\pm 5\%$	Rypdal K., <i>et al.</i> , 2001
<i>Emission factors</i>		
Fraction of synthetic N fertilizers that volatilizes as NH_3 and NO_x	$\pm 30\%$	Monni S., <i>et al.</i> , 2003
Fraction of animal manure N that volatilizes as NH_3 and NO_x	$\pm 40\%$	Monni S., <i>et al.</i> , 2003
Emission factor (Atmospheric Deposition)	-80%...+100%	Table 4-23 of the 1996 IPCC, pp. 4.105
Emission factor (N leaching and Run-off)	-92%...+380%	Table 4-23 of the 1996 IPCC, pp. 4.105

Input	Uncertainties	References
Fraction of the fertilizer and manure nitrogen lost to leaching and surface run-off	-67%...167%	Table 4-24 of the 1996 IPCC, pp. 4.106
Emission factor (Nitrogen Leaching and Run-off)	-92%...380%	Table 4-23 of the 1996 IPCC, pp. 4.105

The combined uncertainties related to 'Indirect emissions from agricultural soils' sub-sector (CRF 4.D) as percent from the total national emission in 2007 are follows⁷⁶:

4.D.3.1	Atmospheric Deposition (N ₂ O)	0.1732%
4.D.3.2	Nitrogen Leaching and Run-off (N ₂ O)	3.2091%

4.4.4. Field Burning of Agricultural Residues (CRF 4.F)

The process is the open burning of crop residue on arable land after harvesting.

The trends in production of agricultural crops are demonstrated in Figure 4.41–Figure 4.43.

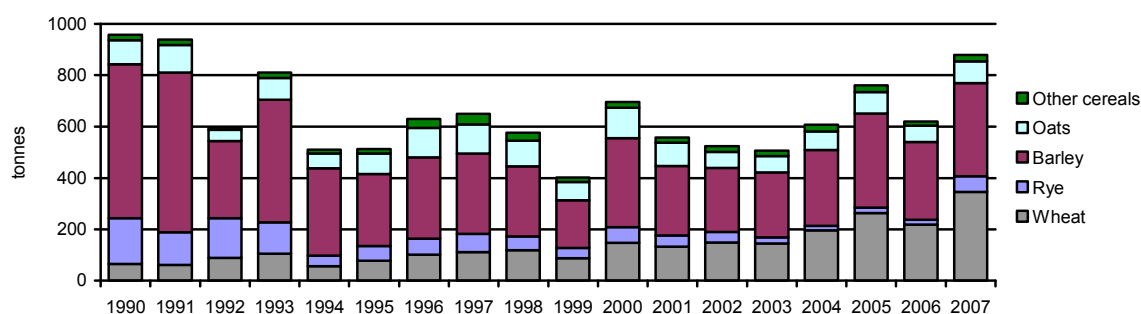


Figure 4.41. Cereals production in 1990–2007 in Estonia, tonnes

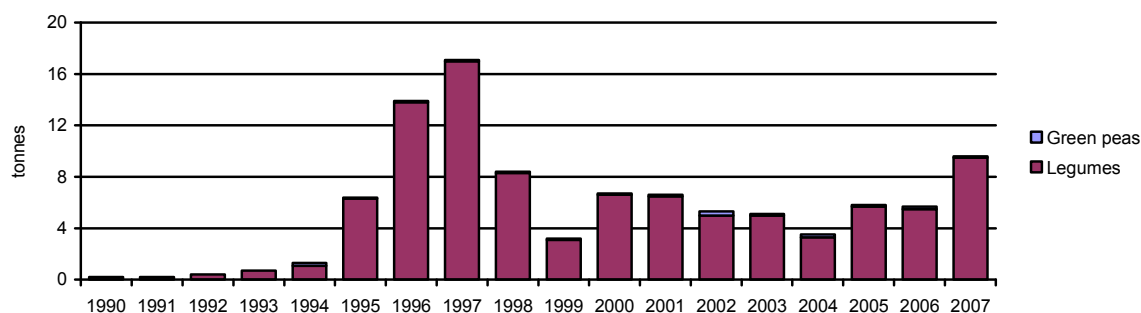


Figure 4.42. Pulse production in 1990–2007 in Estonia, tonnes

⁷⁶ Uncertainty calculation for the Estonian GHG inventory **excluding** LULUC (following IPCC Tier 1)

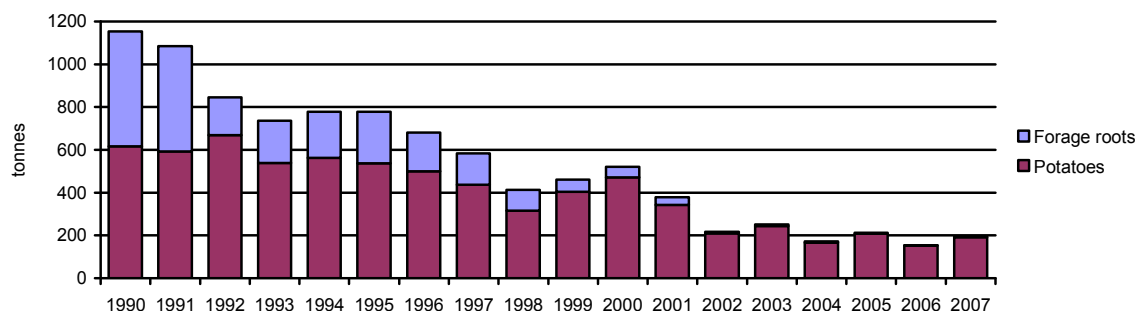


Figure 4.43. Tuber and root production in 1990–2007 in Estonia, tonnes

4.4.4.1. Methodology, data availability, data sources and emission factors

The method of the Revised 1996 IPCC Guidelines was employed in the estimates:

$$DM_{BN} = Crop_{BN} \times RC_{RATIO} \times DM_{FRACTION} \quad (4.32)$$

DM_{BN} – Dry Matter of crop residues burned in fields, Gg

$Crop_{BN}$ – Quantity of crops, which produce residues burned in fields, Gg

RC_{RATIO} – Residue to Crop Ratio for each type of crops

$DM_{FRACTION}$ – Dry Matter Fraction of each crop residue, Gg DM/Gg FM

$$TBB = DM_{BN} \times OX \quad (4.33)$$

TBB – Total Biomass Burned, Gg

OX – Fraction of Biomass oxidized for each crop type (default 0.9⁷⁷)

$$\text{Emission of Carbon} = TBB \times \text{Carbon_Fraction} \times \text{Ratios_for_CH}_4\text{_or_CO} \quad (4.34)$$

$$\text{Emission of Nitrogen} = TBB \times \text{Nitrogen_Fraction} \times \text{Ratios_for_N}_2\text{O_or_NO}_x$$

Emission of Carbon – Emission of carbon as methane (CH₄) and carbon monoxide (CO), Gg

⁷⁷ IPCC 1996. Agriculture. Workbook. pp. 4.30

Carbon Fraction – carbon content of each crop type, GgC/Gg DM

Ratios for CH₄ or CO – Emissions ratios for CH₄ or CO (IPCC, 1997⁷⁸)

Emission of Nitrogen – Emission of carbon as nitrous oxide (N₂O) and nitrogen oxides (NO_x), Gg

Nitrogen Fraction – nitrogen content of each crop type, GgN/Gg DM

Ratios for N₂O or NO_x – Emissions ratios for N₂O or NO_x (IPCC, 1997)

4.4.4.2. Quantitative overview – Emissions from Field Burning of Agricultural Residues in 2007

The CH₄ and N₂O emission from field burning of agricultural residues was 0.21 Gg and 0.003 Gg respectively in 2007.

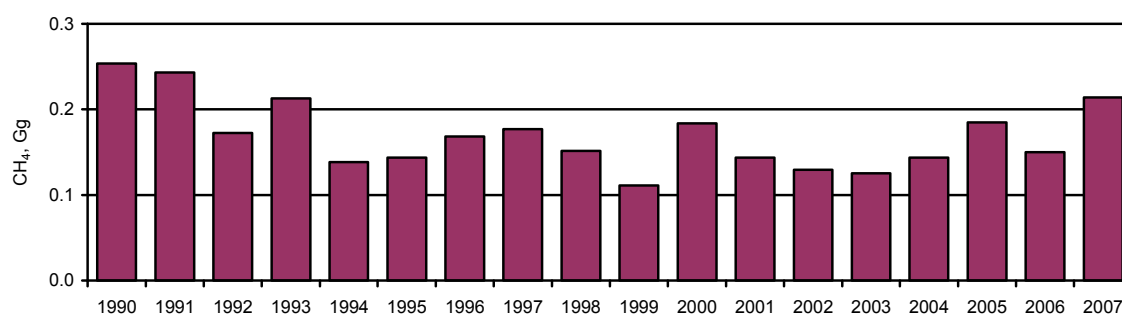


Figure 4.44. CH₄ emissions from Field Burning of Agricultural Residues in 1990–2007, Gg

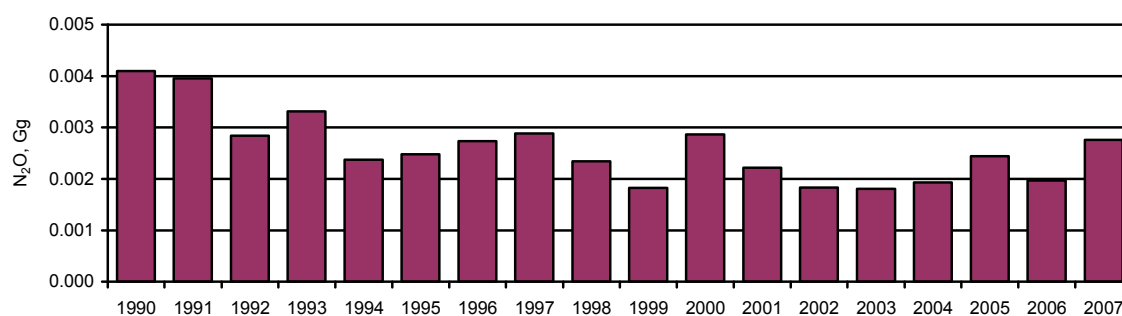


Figure 4.45. N₂O emissions from Field Burning of Agricultural Residues in 1990–2007, Gg

⁷⁸ Table 4-16 Default Emission Rates for Agricultural Residue Burning Calculations, pp. 4.31

4.4.4.3. Uncertainties and time-series consistency

The estimation of N₂O and CH₄ emissions from agricultural residue burning is carried out based on activity data (crop residue left on fields) and emission factors is reported in the 1996 and 2000 IPCC Guidelines (Table 4.64).

Table 4.64. Estimated values of uncertainties used in agriculture sector

Input	Uncertainties	References
<i>Activity data</i>		
Crop residue left on agricultural fields	± 20%	IPCC 2001. Agriculture. pp.4.20
<i>Emission factors</i>		
Default emission factor for CH ₄	± 40%	Table 4-16 of the IPCC 1996 Guidelines, pp.4.31
Default emission factor for N ₂ O	± 29%	Table 4-16 of the IPCC 1996 Guidelines, pp.4.31

The combined uncertainties related to ‘Field Burning of Agricultural Residues’ sub-sector (CRF 4.F) as percent from the total national emission in 2007 are follows⁷⁹:

4.F Field Burning of Agricultural Residues (CH₄ and N₂O) 0.0105%

⁷⁹ Uncertainty calculation for the Estonian GHG inventory **excluding LULUC** (following IPCC Tier 1)

CHAPTER 5. LAND USE, LAND USE CHANGE AND FORESTRY (CRF 5)

5.1. Overview of source category

Estonia, as a Party of Annex I, is required to prepare a full LULUCF inventory. In order to uphold this responsibility in the next year, Estonia is currently developing all datasets and methods needed to report estimated carbon flows associated with LULUCF in accordance with the common IPCC Guidelines (LULUCF, 2003). In 2009 submission, Estonia reported the first time carbon flows related to cropland, grassland and wetlands (peatland). The estimates carried out have high rates of uncertainty, as the process of data collection is still under development.

Table 5.1. Methods and emission factors used to estimate the emissions/removals of GHG in the LULUCF sector of Estonia

Greenhouse gases source and sink categories	CO ₂		CH ₄		N ₂ O	
	Method Applied	EF	Method Applied	EF	Method Applied	EF
A. Forest land						
Forest Land remaining Forest Land						
Managed Native Forests	T1	IPCC				
Biomass Burning	T1	IPCC	T1	IPCC	T1	IPCC
Land converted to Forest Land	NE	NA				
B. Cropland						
Cropland remaining Cropland	NE	NA				
Land converted to Cropland	T1	IPCC				
C. Grassland						
Grassland remaining Grassland	NE	NA				
Land converted to Grassland	T1	IPCC				
D. Wetlands⁸⁰						
Wetlands remaining Wetlands	T1	IPCC				
Land converted to Wetlands	NE	NA				
Non-CO ₂ emission from drainage of soils and wetlands (Peatland)	NO	NA			T1	IPCC
E. Settlements						
Settlements remaining Settlements	NE	NA				
Land converted to Settlements	NE	NA				
F. Other land						
Other Land remaining Other Land	NE	NA				
Land converted to Other Land	T1	IPCC				

EF – Emission Factor; NE – not estimated; NA – Not Applicable; T1 – *Tier 1* method

⁸⁰ Organic soils managed for peat extraction

Carbon emissions/removals associated with ‘Forest Land remaining Forest Land’ were estimated in the 2009 submission. Carbon flows related to ‘Cropland remaining Cropland’ and ‘Grassland remaining Grassland’ etc were not calculated, as it was assumed that land use management regimes, defined in the IPCC Guidelines, were not changed during the past 20 years.

In the 2009 submission, the attention was paid on carbon stock change in mineral soils due to changes in the practice of land use (the conversion from one land use category to another). The changes in carbon stock were estimated as 20 year differences in land use change.

5.1.1. References – sources of information

The inventory in LULUCF sector was carried out by a research group at Tallinn University of Technology. The main institutions which provided activity data used in the estimates are listed in Table 5.2.

Table 5.2. List of institutions (datasets) involved in the inventory of the LULUCF sector

References	Link	Abbreviation	Activity
Tallinn University of Technology	www.ttu.ee	TUT	- activities data processing; - estimations of emissions/removals; - reporting of emissions/removals (the CRF tables, the NIR).
Centre of Forest Protection and Silviculture	www.metsad.ee	CFPS	- collecting and providing data of the National Forest Inventory; - collecting and providing data on land cover by land category (forest, grassland, wetlands, build-up area); - collecting and providing data on forest biomass stock, biomass increment;
Statistics of Estonia	www.stat.ee	ESO	- collecting and providing data on forest fire areas;
Estonian Land Board	www.maaamet.ee	ELB	- collecting and providing data on land areas by land use categories (Land Balances) for 1970–1990;

5.2. Definitions of land use categories

Forest land

The National Forest Inventory (NFI)

The estimation of emitted/removed quantities of carbon was carried out based on data received in the process of the NFI.

Until 1999, forest biomass was monitored using the Complete Forest Inventory with a ten year taxation cycle. The attention was mainly focused on the biomass in government managed forests. The data on private forest were mostly interpolated and therefore quality of the data was low.

The NFI based on the SMI was implemented in Estonia in 1999. This increased remarkably quality of the data and reduced uncertainties related to the data collected.

Forest land definitions

Paragraph 1 of the definitions, modalities, rules and guidelines relating to land use, land-use change and forestry activities under the Kyoto Protocol, as contained in the Annex to decision 16/CMP.1 defines ‘forest’ as a minimum area of land of 0.05–1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10–30 per cent with trees with the potential to reach a minimum height of 2–5 meters at maturity *in situ*. A forest may consist either of closed forest formations where trees of various storeys and undergrowth cover a high portion of the ground or open forest. Young natural stands and all plantations which have yet to reach a crown density of 10–30 per cent or tree height of 2–5 meters are also included as forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention such as harvesting, or natural causes (fires etc.) but which are expected to revert to forest.

The Estonian Forest Act stipulates forest as ‘...any land with an area of 0.1 ha or more, which is covered with trees higher than 1.3 m with a canopy closure of at least 30%, and which is

managed in order to produce forest products, or in order to preserve forest vegetation for other objectives’.

The definition of forest established by FAO ([FRA, 2005](#)) is ‘land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds *in situ*. It does not include land that is predominantly under agricultural or urban land use’.

Due to the difference between the current definition of forest stipulated in the Estonian Forest Act and that given in the decision 16/CMP.1, Estonia has established the Estonian ‘definition of forest in the context of the Kyoto Protocol’, and the main parameters of forest definition are reported in Table 5.3.

Table 5.3. Parameters for forest definition

Minimum tree cover	30%
Minimum land area	0.1 ha
Minimum tree height	2 m

Cropland

Land where the soil is regularly cultivated, and where annual and perennial crops are growing (crops, fodder crops, annual forage crops, multiannual forage crops, other temporary grasslands (seeded once in less than five years), fallow and orchards, see also Appendix 6_I).

Abandoned cropland is defined as grassland.

The data on cropland areas were extracted from Estonian national statistics (reported by ESO) and Land Balances (published by Estonian Land Board).

Grassland

The NFI grassland (natural grassland) and unused arable land and seeded once over five years grassland are defined as IPCC grassland.

The data on grassland areas were obtained from the Estonian national statistics (reported by ESO), Land Balances (published by Estonian Land Board) and the NFI.

Wetlands

The NFI wetland areas were defined as IPCC wetlands. The data used were from the NFI (for 1999–2007) and Land Balances (for 1970–1990).

Peat extraction areas were excluded from wetland land use category and reported separately (Table 5.4.).

Settlements

The built-up areas, traffic and power lines were reported under settlement land use category (Table 5.4).

The data on settlement areas were obtained from the NFI (for 1999–2007) and Land Balances (for 1970–1990). The data of 1991–1998 were interpolated.

Other land

Bushes (reported separately in Table 5.4), rocky lands and mining areas were defined as other land and reported together as a separate category in the CRF Reporter.

The data on these categories were obtained from the NFI (for 1999–2007) and Land Balances (for 1970–1990).

5.3. Quantitative overview

Land use has changed in recent decades (Figure 5.1). The area covered by forest was increased from 38% in 1970 to 49% in 2007 (increase 491 thousand hectares, Table 5.4). The increase has taken place mostly due to abandonment of grassland areas and overgrowing of wetlands. The area of grassland and wetlands decreased for 142 and 198 thousand hectares respectively during the same period.

The total area of cropland increased for 215 thousand hectares in 1970–1990 and decreased for 348 thousand hectares in 1987–2007 due to the economical processes taking place in Estonian agriculture sector.

Built-up area (settlements and roads) increased by more than 2-fold (for 167 thousand hectares) in Estonia in 1970–2007.

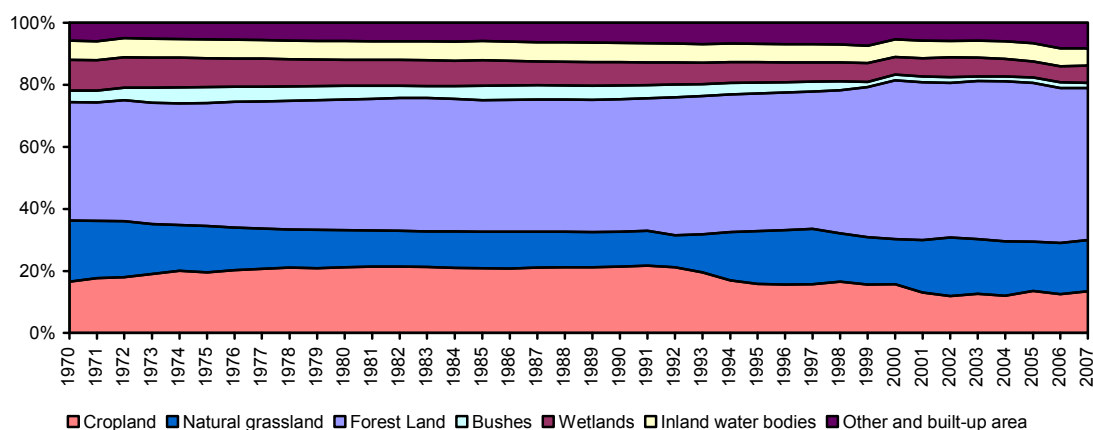


Figure 5.1. Land use in Estonia in 1970–2007, %⁸¹

The areas of land use defined in accordance with the IPCC land use definitions are reported in Table 5.4. The changes in land use in 1970–1990, and in 1987–2007 are reported in Table 5.5.

⁸¹ 1945–1985 – Eesti NSV maafond 1945–1985; 1986 – Eesti NSV 1986 a. maabilanss; 1987 – Eesti NSV 1987 a. maabilanss; 1988 – Eesti NSV 1988 a. maabilanss; 1989 – Eesti NSV 1989 a. maabilanss; 2000 – Eesti Metsad 2000; 2001 – Eesti Metsad 2001; 2002 – Eesti Metsad 2002; 2003 – Eesti Metsad 2003; 2004 – Eesti Metsad 2004; 2005 – Eesti Metsad 2005; 2006 – Eesti Metsad 2006; 2007 – Eesti Metsad 2007.

Table 5.4. The areas of IPCC land-use classes in 1990–2007, 1000 ha

	Forest land	Cropland ⁸²	Grassland	Wetlands	Peatland	Settlements	Bushes	Other land	Inland water bodies
1990	1,926.7	965.8	512.5	338.4	12.0	152.2	207.5	126.5	280.4
1991	1,931.6	978.2	514.1	330.8	15.0	159.6	192.9	121.8	278.0
1992	2,016.0	957.2	469.8	323.2	15.0	166.9	178.4	120.1	275.5
1993	2,021.8	888.6	551.4	315.7	15.0	174.2	163.8	118.4	273.1
1994	2,016.6	771.2	703.1	308.1	15.0	181.5	149.2	106.6	270.6
1995	2,016.2	721.2	772.5	300.5	15.0	188.9	134.7	104.9	268.1
1996	2,016.2	712.8	799.9	292.9	15.0	196.2	120.1	103.2	265.7
1997	2,015.5	719.4	813.1	285.3	15.0	203.5	105.5	101.5	263.2
1998	2,101.6	755.4	710.0	277.7	15.0	210.8	91.0	99.8	260.7
1999	2,187.7	708.3	689.6	273.6	15.0	226.4	76.7	93.7	251.0
2000	2,249.4	692.6	638.1	247.4	20.0	239.7	84.2	99.7	250.9
2001	2,250.7	579.1	750.1	255.0	20.0	254.2	86.7	73.3	252.9
2002	2,205.8	527.2	835.7	284.5	20.0	256.3	79.3	75.3	237.9
2003	2,267.3	559.9	784.0	267.5	20.0	255.7	66.0	59.4	242.2
2004	2,284.6	532.1	782.2	250.8	20.0	263.5	70.9	65.1	252.8
2005	2,264.2	598.8	706.4	230.8	20.0	288.2	76.2	76.4	261.0
2006	2,251.9	564.3	739.6	232.3	20.0	290.9	82.4	79.4	261.2
2007	2,212.7	607.0	850.9	253.0	20.0	290.2	77.9	59.8	250.5

Table 5.5. 20 year time-period changes in land use in Estonia, 1000 ha (Appendix 6_I)

Land use category	1990/1970	2007/1987
Forest land	204.7	288.7
Bushes	42.0	-134.4
Cropland	215.3	-347.7
Grassland	-380.8	228.5
Wetlands	-112.7	-94.7
Peatland	-14.6	9.7
Settlements	29.9	139.8
Other land	16.1	-60.0
Inland water bodies	0.0	-29.9

As seen from Table 5.4 and in Table 5.5, remarkable changes have taken place in the land use practice in Estonia leading to the noticeable changes in soil carbon stock and terrestrial biomass on converted areas.

In the 2009 submission the first attempt was made in order to estimate changes in soil carbon stock in 'Cropland', 'Grassland' and 'Other Land' use categories. The results of the estimations

⁸² Appendix 6_I

which were highly uncertain, were reported in the CRF reporter. In the process of the estimation a lot of other required data to carry out complete GHG inventory in the LULUCF sector were collected, the data collection are still being under development. The results of the complete GHG inventory in the LULUCF sector will be presented in the next submission.

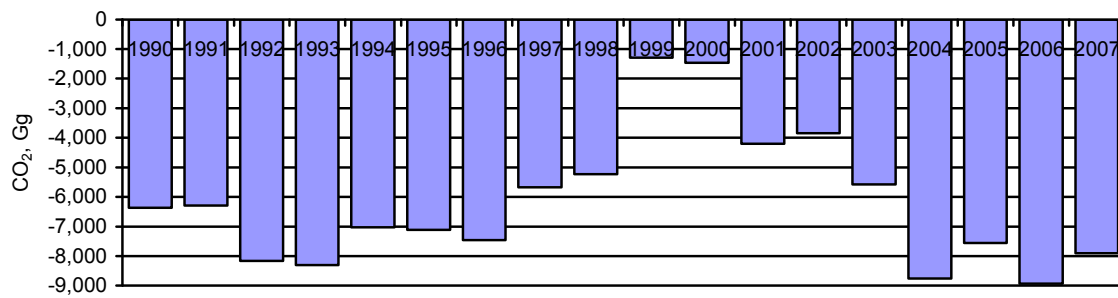
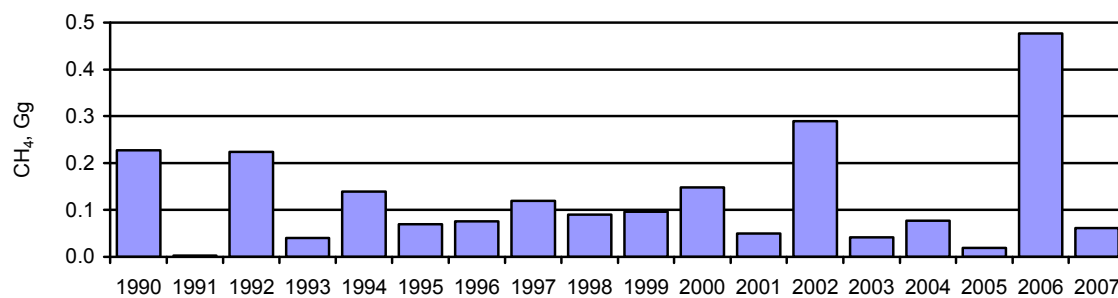
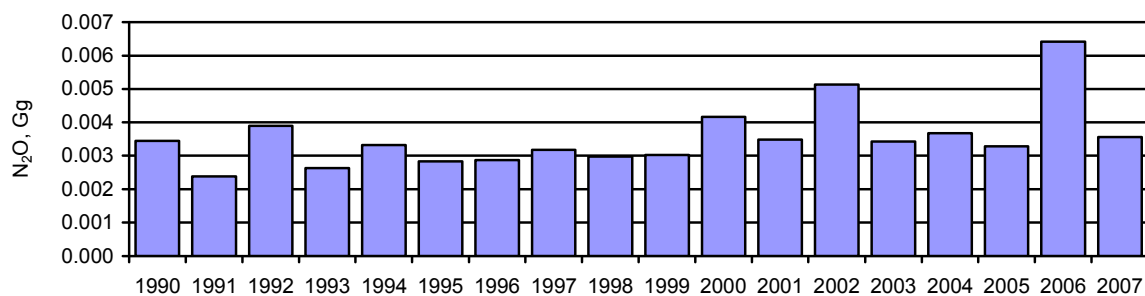
The net emissions/removals of the Estonian LULUCF sector are presented in Table 5.6, Figures 5.1 and 5.2. The main sink of CO₂ in Estonia is forest land. Due to remarkable changes/decreases in cropland areas, mineral carbon stock of this land use category lost carbon calculated as CO₂ at the rate of about 1.6 to 3 Tg CO₂ per year. Grassland and Shrubland mineral soil carbon stock gained about 0.07 to 1.5 Gg of CO₂ annually.

The total quantities of CO₂ sequestered and CH₄ and N₂O emitted are presented in Figure 5.2., Figure 5.3, Figure 5.4.

Table 5.6. Greenhouse gas emissions and removals from the LULUCF sector in 1990–2007 (Gg CO₂eq)⁸³

Year	Forest land	Cropland	Grassland	Wetlands (Peatlands)	Other Land
1990	-8,032.3	1,605.8	66.5	-8.2	-
1991	-7,784.8	1,439.4	66.7	-10.3	-
1992	-9,537.6	1,328.3	61.0	-10.3	-
1993	-9,234.0	869.3	71.6	-10.3	-
1994	-6,970.9	518.7	-96.4	-10.3	-470.7
1995	-6,895.6	497.8	-388.1	-10.3	-317.7
1996	-7,026.6	491.8	-796.6	-10.3	-111.5
1997	-5,122.9	476.5	-1,018.9	-10.3	-
1998	-4,846.5	501.4	-645.9	-10.3	-225.1
1999	-888.8	668.5	-538.5	-10.3	-524.4
2000	-694.8	457.6	-394.6	-13.7	-813.6
2001	-2,706.6	314.9	-998.7	-13.7	-794.5
2002	-2,281.7	500.2	-1,433.1	-13.7	-614.9
2003	-4,486.4	788.3	-1,191.8	-13.7	-674.3
2004	-7,100.5	299.6	-1,145.2	-13.7	-803.1
2005	-7,252.2	1,296.9	-757.7	-13.7	-833.7
2006	-8,095.4	910.5	-900.9	-13.7	-834.7
2007	-6,883.3	606.0	-1,041.3	-13.7	-570.8

⁸³ Negative values indicate removals, positive – emissions

Figure 5.2. Net removal of CO₂ by Estonian LULUCF sector in 1990–2007, CO₂ GgFigure 5.3. Emissions of CH₄ from Estonian LULUCF sector in 1990–2007, CH₄ GgFigure 5.4. Emissions of N₂O from Estonian LULUCF sector in 1990–2007, CH₄ Gg

5.4. Key category assessment

LULUCF key categories in 2007 calculated employing the IPCC Tier 1 approach:

5.A	Forest Land	L, T
5.B	Cropland	L
5.C	Grassland	L, T
5.F.	Other Land	L, T

5.5. Forest Land (CRF 5.A)

GHG emissions/removals related to “Forest Land Remaining Forest Land” and “Biomass Burning” are estimated in the 2009 submission.

5.5.1. Source category description

Since 1970 forest area has been increasing in Estonia mostly due to abandonment of grassland used for hay production and overgrowing of wetlands, bushes (Figure 5.5).

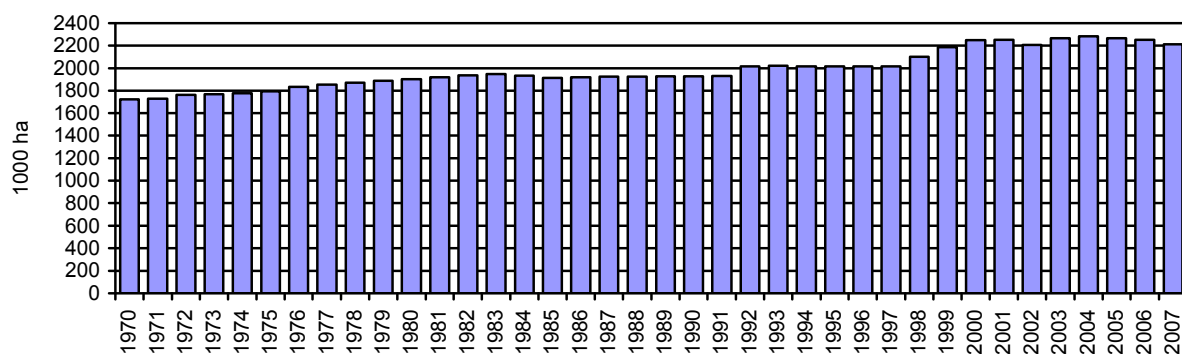


Figure 5.5. Forest land area in Estonia in 1970–2007, 1000 ha

The comparison of the forest areas defined in accordance with different definitions of forest land is presented in Table 5.7.

Table 5.7. Forest area in Estonia in 1990–2007, 1000 ha

Year	Reported by ESO	Annual change rate (ESO), ha	Reported in the FAO dataset ⁸⁴	Annual change rate (FAO), ha
1990	1,921		2,163 ⁸⁵	
1991	1,926	5.0	2,171 ⁸⁶	8.0
1992	2,016	90.0	2,179	8.0
1993	2,022	6.0	2,187	8.0
1994	2,017	-5.0	2,195	8.0
1995	2,016	-1.0	2,203	8.0
1996	2,016	0.0	2,211	8.0
1997	2,016	0.0	2,219	8.0

⁸⁴ www.fao.org

⁸⁵ FRA 2005

⁸⁶ The area was interpolated.

Year	Reported by ESO	Annual change rate (ESO), ha	Reported in the FAO dataset ⁸⁴	Annual change rate (FAO), ha
1998	2,102	86.0	2,227	8.0
1999	2,188	86.0	2,235	8.0
2000	2,249	61.0	2,243	8.0
2001	2,251	2.0	2,251	8.0
2002	2,206	-45.0	2,259	8.0
2003	2,267	61.0	2,268	9.0
2004	2,285	18.0	2,276	8.0
2005	2,264	-21.0	2,284 ⁴	8.0
2006	2,252	-12.0	2,391 ⁸⁷	107.0
2007	2,213	-39.0	2,346 ⁸⁸	45.0

5.5.2. Methodological issues

The algorithm employed in order to estimate carbon flows related to 'Forest Land remaining Forest Land' is presented below:

$$\Delta C_{FF} = (\Delta C_{FFLB} + \Delta C_{FFDOM} + \Delta C_{FFSoils}) \quad (5.1)^{89}$$

ΔC_{FF} – annual change in carbon stocks from forest land remaining forest land, tC yr⁻¹;

ΔC_{FFLB} – annual change in carbon stocks in living biomass (includes above- and below-ground biomass) in forest land remaining forest land, tC yr⁻¹;

ΔC_{FFDOM} – annual change in carbon stocks in dead organic matter (includes dead wood and litter) in forest land remaining forest land, tC yr⁻¹;

$\Delta C_{FFSoils}$ – annual change in carbon stocks in soils in forest land remaining forest land; tC yr⁻¹;

$$\Delta C_{FFLB} = (\Delta C_{FFG} - \Delta C_{FFL}) \quad (5.2)^{90}$$

ΔC_{FFLB} – annual change in carbon stocks in living biomass (includes above- and below-ground biomass) in forest land remaining forest land, tC yr⁻¹;

ΔC_{FFG} – annual increase in carbon stocks due to biomass growth, tC yr⁻¹;

⁸⁷ Eesti Metsad 2006

⁸⁸ Eesti Metsad 2007

⁸⁹ LULUCF 2003, Equation 3.2.1., pp 3.23

⁹⁰ LULUCF 2003, Equation 3.2.2., pp 3.24

ΔC_{FFL} – annual decrease in carbon stocks due to biomass loss, tC yr⁻¹;

In order to estimate carbon removals due to forest biomass increment the *Tier 1* approach was employed.

$$G_{\text{TOTAL}} = G_{\text{W}} \cdot (1 + R) \quad (5.3)^{91}$$

where:

$$G_{\text{W}} = I_{\text{V}} \cdot D \cdot \text{BEF}_1$$

G_{TOTAL} – average annual biomass increment above and below-ground, tonnes of dry matter ha⁻¹ yr⁻¹;

G_{W} – average annual aboveground biomass increment, tonnes of dry matter ha⁻¹ yr⁻¹;

R – root-to-shoot ratio appropriate to increments, dimensionless;

I_{V} – average annual net increment in volume suitable for industrial processing, m³ ha⁻¹ yr⁻¹;

D – wood density, tonnes of dry matter m⁻³ (Table 5.10);

BEF_1 – biomass expansion factor for conversion of annual net increment (including bark) to aboveground tree biomass increment, dimensionless (Table 5.8).

Table 5.8. Default values of BEF⁹²

Forest type	BEF ₂	BEF ₁
Conifer	1.35	1.15
Broadleaf	1.3	1.1

Table 5.9. Average below-ground to above-ground biomass ratio (root-shoot ratio, R)⁹³

Forest type	Aboveground biomass, t/ha	Root-shoot ratio
Conifer forest/plantation	50–150	0.32
Other broadleaf forest	75–150	0.26

⁹¹ LULUCF 2003, Equation 3.2.3., pp 3.24

⁹² LULUCF 2003, Table 3A.1.10., pp. 3.178

⁹³ LULUCF 2003, Table 3A.1.8., pp. 3.168

Table 5.10. Wood density of main tree species⁹⁴

Tree species	Wood density
Pine	0.42
Spruce	0.40
Birch	0.51
Aspen	0.35
Common Alder	0.45
Grey Alder	0.45
Other	0.45

Annual decrease in carbon stocks due to biomass loss in forest land remaining forest land

The *Tier 1* method was employed in order to estimate carbon emission from biomass felling (emission is considered to be immediate).

$$\Delta C_{FFL} = L_{\text{felling}} + L_{\text{other_losses}} \quad (5.4)^{95}$$

ΔC_{FFL} – annual decrease in carbon stocks due to biomass loss in forest land remaining forest land, tC yr⁻¹;

L_{fellings} – annual carbon loss due to commercial felling, tC yr⁻¹;

$L_{\text{other losses}}$ – annual other losses of carbon, tC yr⁻¹.

$$L_{\text{felling}} = H \cdot D \cdot BEF_2 \cdot (1 - f_{BL}) \cdot CF \quad (5.5)^{96}$$

L_{fellings} – annual carbon loss due to commercial felling, tC yr⁻¹;

H – annually extracted volume, round-wood, m³ yr⁻¹;

D – wood density, tonnes of dry matter. m⁻³;

BEF_2 – biomass expansion factor for converting volumes of extracted round-wood to total aboveground biomass (including bark), dimensionless;

f_{BL} – fraction of biomass left to decay in forest (transferred to dead organic matter);

CF – carbon fraction of dry matter (default=0.5), tC (tonne d.m.)⁻¹.

⁹⁴ LULUCF 2003, Table 3.A1.9-1., pp.3.171

⁹⁵ LULUCF 2003, Equation 3.2.6, pp. 3.26

⁹⁶ LULUCF 2003, Equation 3.2.7, pp. 3.27

Table 5.11. Default values for fraction out of total harvest left to decay in the forest⁹⁷, f_{BL}

	f_{BL}
Boreal intensively managed	0.07

CO₂ emissions from drained organic forest soils

$$\Delta C_{FFOrganic} = A_{Drained} \bullet EF_{Drainage} \quad (5.6)^{98}$$

$\Delta C_{FFOrganic}$ – CO₂ emissions from drained organic forest soils, tonnes C yr⁻¹;

$A_{Drained}$ – area of drained organic forest soils, ha;

$EF_{Drainage}$ – emission factor for CO₂ from drained organic forest soils, tonnes C ha⁻¹ yr⁻¹ (Table 5.12);

Table 5.12 Default values for CO₂-C emission factor for drained organic soils in managed forests⁹⁹

Biomes	Emission Factors (tonnes C ha ⁻¹ yr ⁻¹)	
	Value	Ranges
Boreal	-0.16	0.08–1.09

5.5.3. Quantitative overview – Carbon emissions/removals from forest land

The forest area increased 1.2-fold by 2007 in comparison with the base year. The changes in forest area covered by trees are presented in Figure 5.6. As seen, more than 50% of forest area is covered by conifer trees and less than 50% is covered by broad-leaf forest. The main parameters of Estonian forest in 2007 are presented in Table 5.13.

⁹⁷ LULUCF 2003, Table 3A.1.11, pp. 3.178

⁹⁸ LULUCF 2003, Equation 3.2.15, pp. 3.42

⁹⁹ LULUCF 2003, Table 3.2.3, pp. 3.42

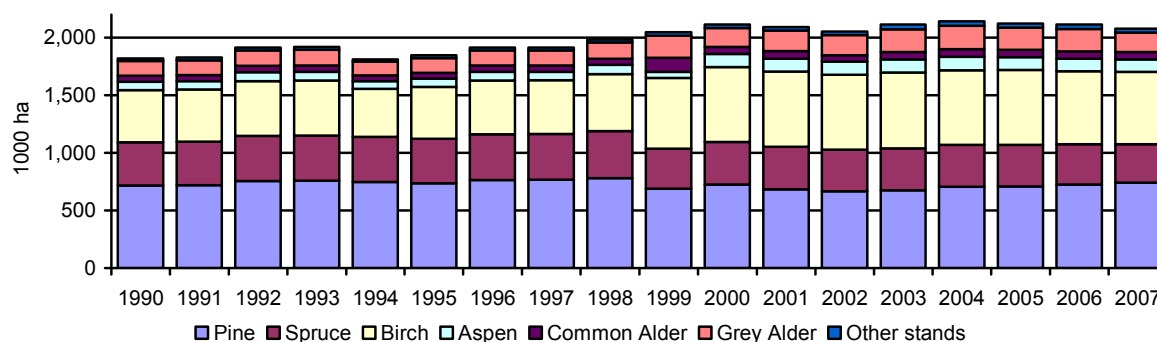
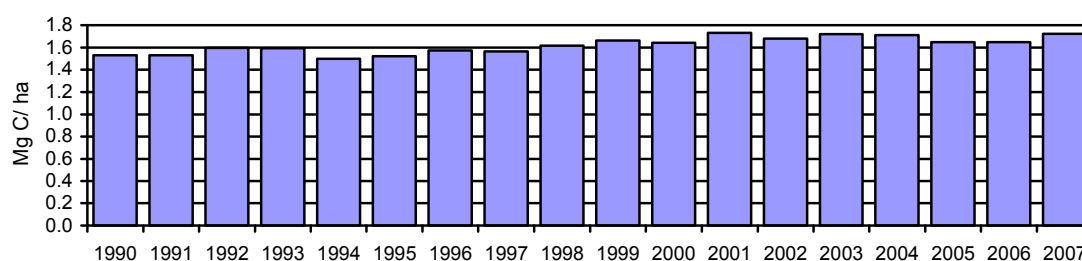


Figure 5.6. Forest area (area of stands) in Estonia in 1990–2007, 1000 ha

Table 5.13. General characteristics of Estonian forest stands in 2007¹⁰⁰ (Appendix 6_II)

	Area of stands, 1000 ha	Stock, 1000 m ³	Increment, 1000 m ³
Pine	740.6	177,924	3,691
Spruce	334.1	77,590	2,691
Birch	629.5	112,677	3,062
Asp	107.5	28,515	707
Common Alder	62.4	15,438	332
Grey Alder	168.6	30,499	1,239
Others	36.6	6,388	197
Total	2,079.3	449,032	11,919

The data presented in Figure 5.7 characterize averaged values of carbon sequestered per hectare in Estonian forest in 1990–2007.

Figure 5.7. Carbon gain by forest biomass in Estonia in 1990–2007, Mg C/ha¹⁰¹

¹⁰⁰ Eesti Metsad 2007

¹⁰¹ It should be noted that values reported under 'Carbon gain by forest biomass per ha' do not reflect a transparent picture, as the forest areas reported in the CRF include areas covered and not by trees. However, the estimates were carried out taken into account only areas of stands (forested areas) and average increment.

The data on forest felling is collected by ESO and in the process of the NFI. ESO collects forest harvesting data based on forest licenses applied. The data collected in the process of the NFI and by ESO is illustrated in Table 5.14. The data of the NFI and corrected data of ESO based on interpolation approach were used in the estimates (Figure 5.8).

Table 5.14. Amounts and areas of forest biomass harvested, ha and m³

	Forest harvest documentation ¹⁰²		The NFI (the SMI) ¹⁰³		Used in the estimates
	Total felling area, ha	Felling outturn, m ³	Total felling area, ha	Felling out-turn, m ³	Felling outturn, m ³
1990		2,937,803			3,819,144
1991	94,864	3,212,377			4,176,090
1992	77,327	2,245,805			2,919,547
1993	92,864	2,547,647			3,311,941
1994	102,731	3,745,383			4,868,998
1995	102,315	3,992,746			5,190,570
1996	92,658	4,250,738			5,525,959
1997	102,496	5,737,170			7,458,321
1998	109,349	6,319,070			8,214,791
1999	108,189	7,049,299	81,100	12,697,000	12,697,000
2000	113,391	6,891,981	71,000	12,748,000	12,748,000
2001	116,292	7,217,132	77,500	11,525,000	11,525,000
2002	128,364	7,558,731	77,000	11,526,000	11,526,000
2003	122,549	7,810,554	63,700	9,717,000	9,717,000
2004	132,097	7,632,843	57,600	7,012,000	7,012,000
2005	129,721	5,124,588	60,100	6,380,000	6,380,000
2006	101,414	5,899,053	53,200	5,197,000	5,197,000
2007	96,872	6,900,727			6,900,727

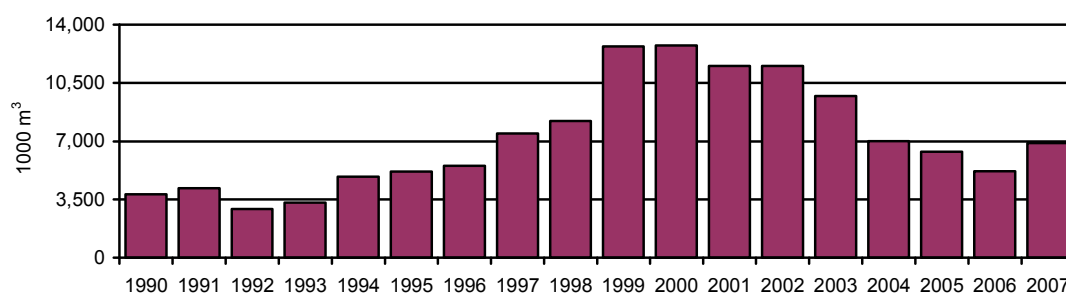


Figure 5.8. Volumes of stems harvested in Estonia in 1990–2007, 1000 m³

¹⁰² www.stat.ee

¹⁰³ Eesti Metsad 2001,...,2007

The total quantities of carbon sequestered by forest and emitted due to forest felling are reported in Figure 5.9. The quantities of carbon sequestered due to biomass increment are higher than the amount of carbon emitted due to forest felling during the all period of the inventory (in 1990–2007).

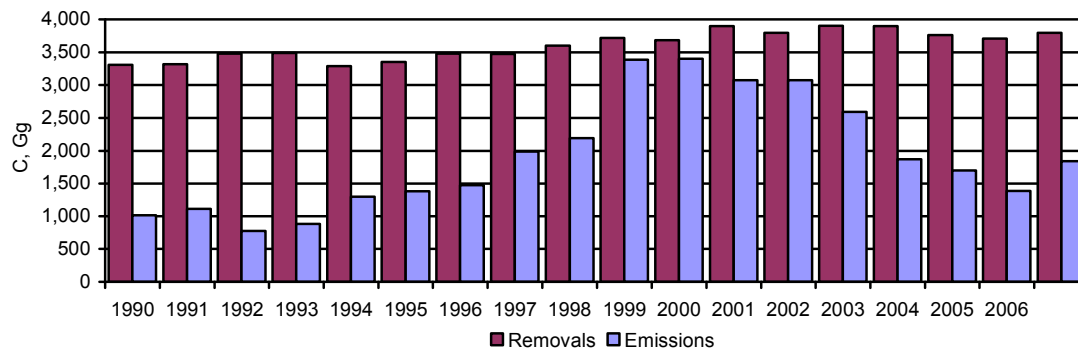


Figure 5.9. Volumes of carbon emitted due to forest felling and sequestered due to biomass increment in Estonia in 1990–2007, C Gg ¹⁰⁴

FOREST SOILS

The allocation of forest land by soil types (mineral and organic) is presented in Table 5.15. It should be noted that forest soil areas are reported in accordance with the Estonian definition of forest land.

Table 5.15. Areas of mineral and organic soils of Forest land in 1990–2007¹⁰⁵, % and 1000 ha

Year	Mineral soils, %	Organic soils, %	Total, 1000 ha ¹⁰⁶
1990	73	27	1,921
1991	73	27	1,926
1992	74	26	2,016
1993	75	25	2,022
1994	75	25	2,017
1995	75	25	2,016
1996	75	25	2,016
1997	75	25	2,016
1998	76	24	2,102
1999	77	23	2,188
2000	77	23	2,249

¹⁰⁴ Values of removals are reported in absolute value

¹⁰⁵ The data were calculated based on CORINE 1990, 2000 datasets and Eesti Metsad 2006 report.

¹⁰⁶ Forest area is reported in accordance with the Estonian definition

Year	Mineral soils, %	Organic soils, %	Total, 1000 ha ¹⁰⁶
2001	77	23	2,251
2002	77	23	2,206
2003	77	23	2,267
2004	77	23	2,285
2005	77	23	2,264
2006	77	23	2,252
2007	77	23	2,213

Mineral soils

Due to the lack of more advanced methods the Tier 1 approach was implemented, and it was assumed that carbon stock in mineral soil organic matter does not change, regardless of changes in forest management, types and disturbance regimes.

Organic soils

CO₂ emission from forest organic soils is reported in Figure 5.10. The activity data on areas of organic soils were interpolated taking into account the datasets of CORINE 1990 and 2000 maps and the data reported in Estonian Forest 2006 and Estonian Forest 2007.

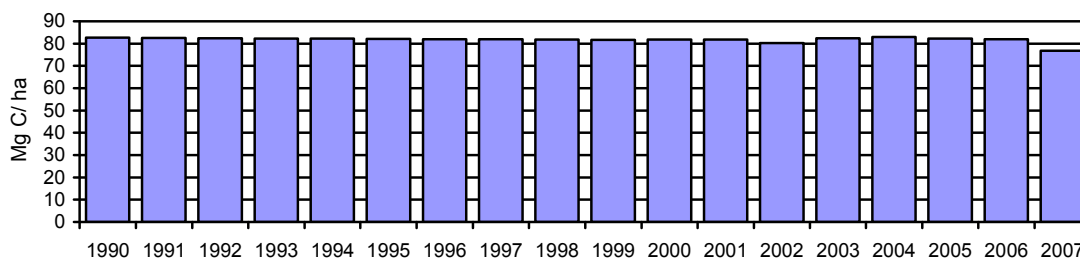


Figure 5.10. Carbon emissions from organic soils under forest in 1990–2007 in Estonia, C Gg

The total net CO₂ removals by forest biomass in 1990–2007 are presented in Figure 5.11. The sharp decreases in 1999 and in 2000 are explained by the sharp increase of the forest felling in these years.

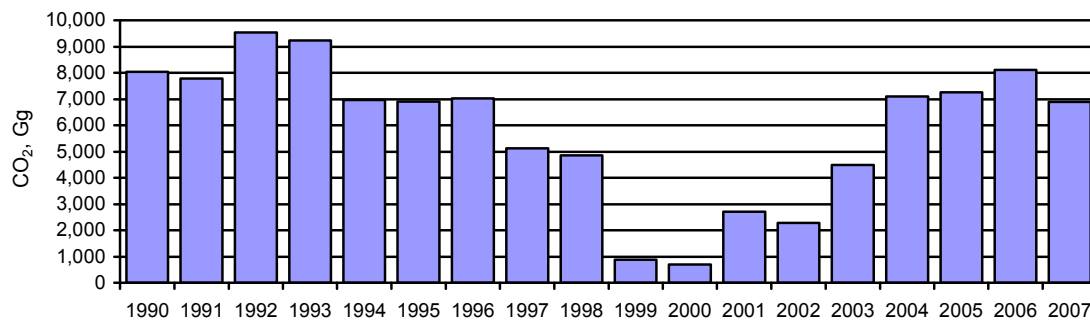


Figure 5.11. The net CO₂ removals in forest biomass and soils in Estonia in 1990–2007, Gg CO₂

5.5.4. Source-specific recalculations

Forest felling

There is one recalculation carried out in the 2009 submission: the quantity of forest biomass harvested in 2006 was updated.

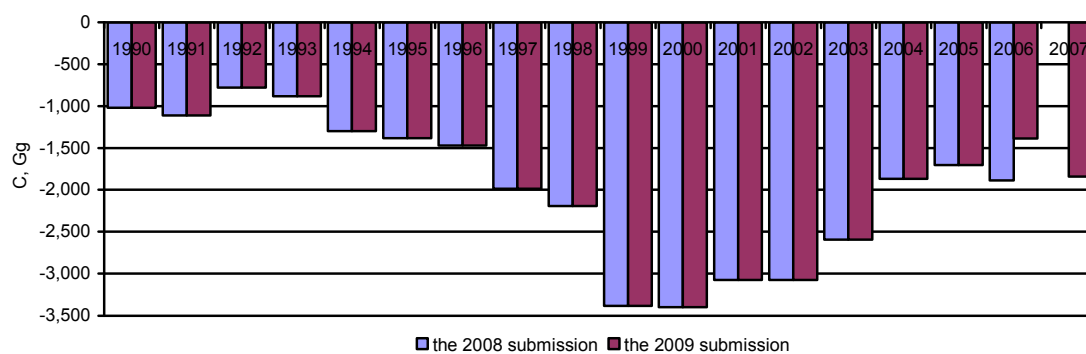


Figure 5.12. Carbon emissions due to forest felling in Estonia in 1990–2007, Gg

Table 5.16. Carbon emissions due to forest felling in Estonia in 1990–2007, Gg

Year	Reported emissions of carbon in 1990–2006 (the 2008 submission)	Recalculated emissions of carbon (the 2009 submission)
1990	-1,019	-1,019
1991	-1,114	-1,114
1992	-779	-779
1993	-883	-883
1994	-1,299	-1,299
1995	-1,384	-1,384

Year	Reported emissions of carbon in 1990–2006 (the 2008 submission)	Recalculated emissions of carbon (the 2009 submission)
1996	-1,474	-1,474
1997	-1,989	-1,989
1998	-2,191	-2,191
1999	-3,386	-3,386
2000	-3,400	-3,400
2001	-3,074	-3,074
2002	-3,074	-3,074
2003	-2,591	-2,591
2004	-1,870	-1,870
2005	-1,702	-1,702
2006	-1,888	-1,386
2007		-1,840

Organic forest soils

Two recalculations were carried out in the ‘Organic forest soils’ sub-section: 1) areas of organic soils were updated, 2) emission factor value was updated. In the 2008 submission the total area of drained soils areas were considered as forest organic soils (organic soils under grassland, cropland were included). The average emission factor was applied in the estimates in order to guarantee consistency with other parties as in the 2008 submission the highest emission factor was implemented ($1.09 \text{ tonnes C ha}^{-1} \text{ yr}^{-1}$).

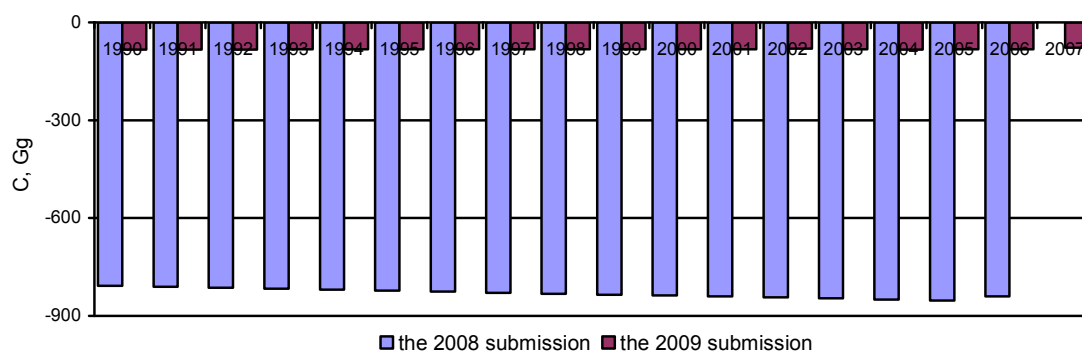


Figure 5.13. The quantities of carbon emitted from organic forest soils in Estonia in 1990–2007, Gg

Table 5.17. The quantities of carbon emitted from organic forest soils in Estonia in 1990–2007, Gg

Year	Reported removals of carbon in 1990–2006 (the 2008 submission)	Recalculated removals of carbon (the 2009 submission)
1990	-807.9	-82.73
1991	-810.9	-82.61
1992	-813.8	-82.50
1993	-816.8	-82.38
1994	-819.8	-82.26
1995	-822.8	-82.14
1996	-825.8	-82.02
1997	-828.8	-81.90
1998	-831.8	-81.78
1999	-834.8	-81.66
2000	-837.7	-81.78
2001	-840.8	-81.83
2002	-843.9	-80.20
2003	-846.9	-82.43
2004	-850.0	-83.06
2005	-853.1	-82.32
2006	-841.1	-81.87
2007		-76.81

5.5.5. Uncertainties and time-series consistency

CO₂ emissions/removals from forest biomass are estimated according to the LULUCF GPG (2003). The activity data are obtained from ESO and CFPS, the emission factors are used from the LULUCF GPG (2003). The uncertainty rates in the activity data and the emission factors are presented in Table 5.18.

Table 5.18. Estimated values of uncertainties used in ‘Forest Land’ sub-section

Input	Uncertainties	References
<i>Activity data</i>		
Forest land, ha	± 15%	LULUCF, 2003, pp. 3.32
Stand biomass increment, m ³ /ha	± 1.7%	‘Eesti Metsad’ report
Stand stock per hectare, m ³ /ha	± 2.2%	‘Eesti Metsad’ report
Felling area, ha	± 15.0%	Estonian Statistical Office
<i>Emission factors</i>		
BEFs (used in calculating increment data)	± 30%	LULUCF, 2003, pp. 3.31
BEFs (used in case of growing stock biomass data)	± 30%	LULUCF, 2003, pp. 3.178
Wood density	± 20%	LULUCF, 2003, pp. 3.31

Input	Uncertainties	References
Value of combustion factor for fires	-85...124%	LULUCF, 2003, pp. 3.179
Emission ratio factor for open burning (CH ₄)	± 25%	The 1996 IPCC Guidelines, pp. 5.33
Emission ratio factor for open burning (N ₂ O)	± 29%	The 1996 IPCC Guidelines, pp. 5.33

5.5.6. Source-specific planned improvements

A wide number of improvements are required to be carried out in order to guarantee complete, transparent and accurate GHG inventory in the 'Forest Land' sub-section: forest land areas will be revised in the next submissions for 1970–2007; carbon stock change in litter and dead biomass will be calculated, carbon losses due to forest disturbances will be estimated, carbon stock change in forest mineral soils will be calculated.

5.6. Cropland (CRF 5.B)

5.6.1. Source category description

The cropland area has remarkably decreased since 1992 due to the economic processes taken place in Estonia (Figure 5.14). Areas of cultivation of annual/multiannual crops started to decrease since 1992 which in turn led to the increase of areas of abandoned arable land (Table 5.19). The area of unused arable land has increased 20.4-fold by 2007 compared to 1991 (these areas are considered under grassland land use category).

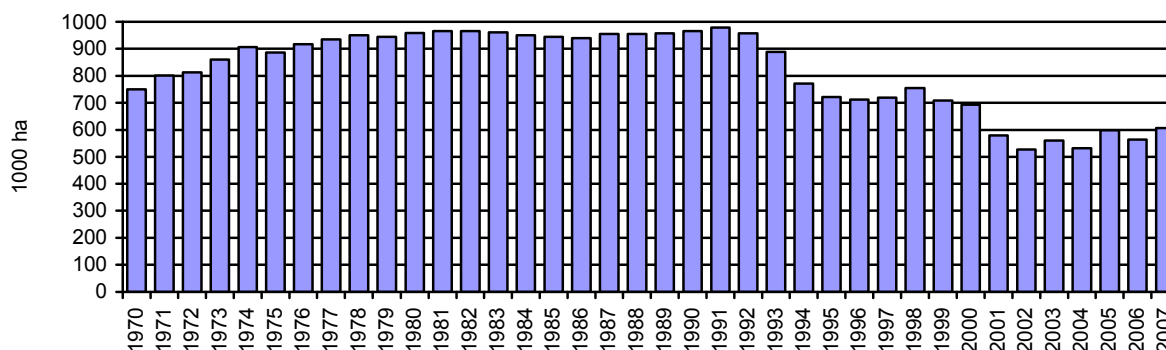


Figure 5.14. Cropland area in Estonia in 1970–2007, 1000 ha

Table 5.19. Unused arable land, 1000 ha¹⁰⁷

Year	Area
1991	14.0
1992	12.7
1993	62.9
1994	179.1
1995	254.0
1996	243.5
1997	231.1
1998	233.4
1999	260.1
2000	276.4
2001	277.7
...	
2007	286.4 ¹⁰⁸

Due to the decrease in the total area of cropland remarkable changes in soil carbon stock have taken place. Changes in soil carbon stock were estimated under ‘Land converted to Cropland’ sub-section. It was assumed that switches in land use practice took place between cropland and grassland (a 20-year difference in land use area). Needless to say that it is necessary to consider each parcel of land separately in order to complete accurate GHG inventory. However, at the present stage the inventory was carried out mostly based on the assumption as the ongoing process of data collection is taken place.

5.6.2. Methodological issues

Carbon stock changes in mineral soils under ‘Cropland’ were estimated using the Tier 1 approach of the LULUCF GPG (2003).

Mineral soils

The *Tier 1* approach of the LULUCF GPG (2003) was implemented in order to estimate carbon changes in carbon stock of mineral soils.

¹⁰⁷ Agricultural yearbooks

¹⁰⁸ Muiste et al., 2007

$$\Delta C_{\text{LCSoils}} = \Delta C_{\text{LCMineral}} - \Delta C_{\text{LCOrganic}} - \Delta C_{\text{LCLiming}} \quad (5.7)^{109}$$

$\Delta C_{\text{LCSoils}}$ – annual change in carbon stocks in soils in land converted to cropland, tonnes C yr⁻¹;

$\Delta C_{\text{LCMineral}}$ – change in carbon stocks in mineral soils in land converted to cropland, tonnes C yr⁻¹;

$\Delta C_{\text{LCOrganic}}$ – annual C emissions from cultivated organic soils converted to cropland (estimated as net annual flux), tonnes C yr⁻¹;

$\Delta C_{\text{LCLiming}}$ – annual C emissions from agricultural lime application on land converted to cropland, tonnes C yr⁻¹;

$$\Delta C_{\text{CCMineral}} = [(SOC_0 - SOC_{(0-T)} \cdot A) / T] \quad (5.8)^{110}$$

$$SOC = SOC_{\text{REF}} \cdot F_{\text{LU}} \cdot F_{\text{MG}} \cdot F_{\text{I}}$$

$\Delta C_{\text{CCMineral}}$ – annual change in carbon stocks in mineral soils, tonnes C yr⁻¹;

SOC_0 – soil organic carbon stock in the inventory year, tonnes C ha⁻¹;

$SOC_{(0-T)}$ – soil organic carbon stock T years prior to the inventory, tonnes C ha⁻¹;

T – inventory time period, yr (default is 20 yr);

A – land area of each parcel, ha;

SOC_{REF} – the reference carbon stock, tonnes C ha⁻¹; see Table 5.20;

F_{LU} – stock change factor for land use or land-use change type, dimensionless; see Table 5.21;

F_{MG} – stock change factor for management regime, dimensionless; see Table 5.21;

F_{I} – stock change factor for input of organic matter, dimensionless; see Table 5.21;

Table 5.20. Default reference (under native vegetation) soil organic C stocks (SOC_{REF}) (tonnes C per ha for 0-30 cm depth)¹¹¹

Region	HAC soils	Spodic Soils	Wetland soils
Boreal	68	117	146

¹⁰⁹ LULUCF 2003, Equation 3.3.12, pp. 3.89

¹¹⁰ LULUCF 2003, Equation 3.3.3, pp. 3.75

¹¹¹ LULUCF 2003, Table 3.3.3, pp. 3.76

Table 5.21. Relative stock change factors (F_{LU} , F_{MG} and F_I) (over 20 years) for different management activities on cropland¹¹²

Factor value type	Level	Moisture regime	GPG revised default
Land use - F_{LU}	Long-term cultivated	Wet	0.71
Tillage - F_{MG}	Full	Dry and Wet	1.0
Input - F_I	Medium	Dry and Wet	1.0

Carbon emission due to carbon stock change of mineral soil is presented in Table 5.22. The increases in carbon stock of cropland were due to change of grassland area to cropland. Since 1994, cropland area has remarkably decreased - this has led to losses of carbon in mineral soils.

Table 5.22. Net carbon stock change due to grassland converted to cropland activities, C Gg

Year	Carbon stock change
1990	251.2
1991	207.4
1992	168.9
1993	33.6

Organic soils

The *Tier 1* method of LULUCF Guidelines ([LULUCF, 2003](#)) was applied in order to estimate CO₂ emissions from cultivated organic soils.

$$\Delta C_{CCOrganic} = \sum_c (A \bullet EF)_c \quad (5.9)^{113}$$

$\Delta C_{CCOrganic}$ – CO₂ emissions from cultivated organic soils in cropland remaining cropland, tonnes C yr⁻¹;

A – land area of organic soils in climate type c , ha;

EF – emission factor for climate type c (see Table 5.23), tonnes C ha⁻¹ yr⁻¹;

¹¹² LULUCF 2003, Table 3.3.4, pp. 3.77

¹¹³ LULUCF 2003, Equation 3.3.5., pp. 3.79

Table 5.23. Annual emission factor (EF) for cultivated organic soils¹¹⁴

Climatic temperature regime	IPCC Guidelines default, tonnes C ha ⁻¹ yr ⁻¹
Cold Temperate	-1.0

The total area of organic soils under cropland is illustrated in Figure 5.15. The area of organic soils was interpolated based on CORINE maps (1990, 2000).

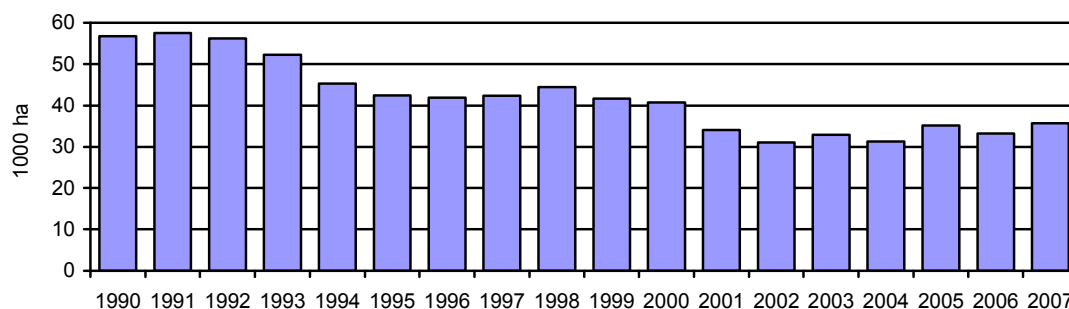


Figure 5.15. Areas of organic soils under cropland in Estonia in 1990–2007, 1000 ha

Carbon emission from organic soils is presented in Figure 5.16. The emission of 2007 was 131 Gg of carbon.

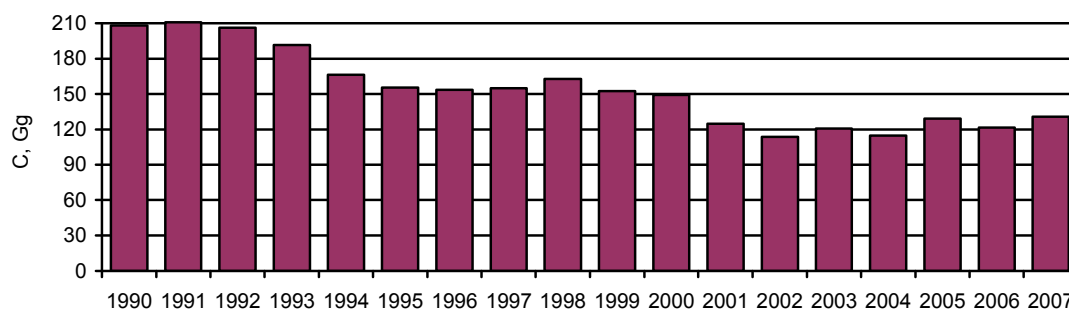


Figure 5.16. Carbon emission from cultivated organic soils in 1990–2007, C Gg

Fruit trees

The *Tier 1* approach of LULUCF Guidelines (LULUCF, 2003) was used in order to estimate CO₂ emissions/removals related to orchards in Estonia in 1990–2007. The data on orchard areas were obtained from Estonian national statistics (ESO).

¹¹⁴ LULUCF 2003, Table 3.3.5., pp. 3.79

$$\Delta C_{FFLB} = (\Delta C_{FFG} - \Delta C_{FFL}) \quad (5.10)^{115}$$

ΔC_{FFLB} – annual change in carbon stocks in living biomass (includes above- and belowground biomass), tonnes C yr⁻¹;

ΔC_{FFG} – annual increase in carbon stocks due to biomass growth, tonnes C yr⁻¹;

ΔC_{FFL} – annual decrease in carbon stocks due to biomass loss, tonnes C yr⁻¹;

Table 5.24. Default coefficients for aboveground woody biomass and harvest cycles in cropping systems containing perennial species¹¹⁶

Climate region	Biomass accumulation rate (G), tonnes C ha ⁻¹ yr ⁻¹	Biomass carbon loss (L), tonnes C ha ⁻¹
Temperate	2.1	63

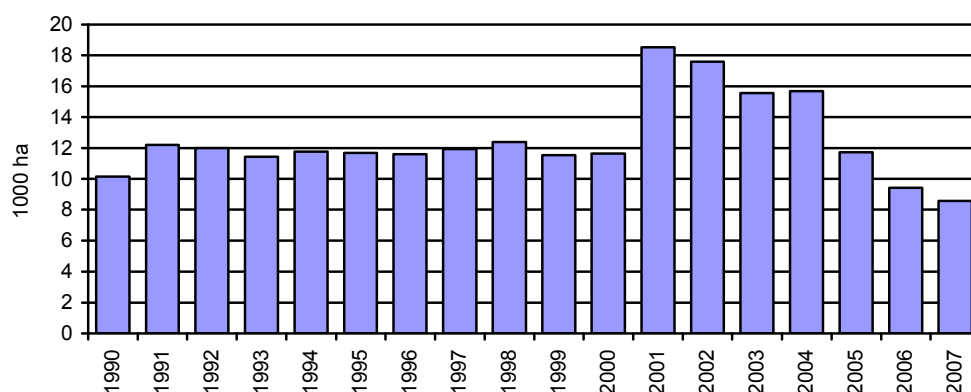


Figure 5.17. Areas of fruit trees in Estonia in 1990–2007, 1000 ha

The carbon flows of orchards are presented in Table 5.25. The sharp increase in carbon sequestration took place in 2001 when area of orchards increased from 11.6 to 18.5 thousand hectares (see also Figure 5.17). However, in 2005 and in 2006 losses of carbon increased due to the drop of the area of orchards.

¹¹⁵ LULUCF 2003, Equation 3.2.2., pp. 3.24

¹¹⁶ LULUCF 2003, Table 3.3.2., pp.3.71

Table 5.25. Net emissions and removals of carbon from orchards, Gg

	Gains/Losses of area, ha	Carbon accumulation, Gg C	Carbon losses, Gg C	Net carbon emissions / removals, C Gg
1990	2,032	21.3	0	21.3
1991	2,032	25.6	0	25.6
1992	-195	25.2	-12.3	12.9
1993	-571	24.0	-36.0	-12.0
1994	349	24.7	0.0	24.7
1995	-78	24.6	-4.9	19.6
1996	-78	24.4	-4.9	19.5
1997	323	25.1	0.0	25.1
1998	459	26.0	0.0	26.0
1999	-856	24.2	-53.9	-29.7
2000	101	24.5	0.0	24.5
2001	6,882	38.9	0.0	38.9
2002	-948	36.9	-59.7	-22.8
2003	-2,016	32.7	-127.0	-94.3
2004	128	32.9	0.0	32.9
2005	-3,957	24.6	-249.3	-224.7
2006	-2,325	19.8	-146.5	-126.7
2007	-833	18.0	-52.5	-34.5

5.6.3. Uncertainty and time series' consistency

The estimates of the changes in mineral soil carbon stock, CO₂ emissions from organic soils, and CO₂ emissions due to the changes in the total area of fruit trees were carried out in the 2009 submission. The activity data were obtained from Estonian national statistics, emission factors were employed from the LULUCF GPG (2003). The uncertainty rates in the activity data and the emission factors used in the estimates are reported in Table 5.26.

Table 5.26. Estimated values of uncertainties used in 'Cropland' sub-section

Input	Uncertainties	References
<i>Activity data</i>		
Cropland, ha	NA	
Area of orchards, ha	NA	
<i>Emission factors</i>		
Default reference soil organic C stock (SOC _{REF})	± 95%	LULUCF, 2003, pp. 3.76
Relative stock change factor (F _{LU})	± 12%	LULUCF, 2003, pp. 3.77
Relative stock change factor (F _{MG})	NA	LULUCF, 2003, pp. 3.77
Relative stock change factor (F _I)	NA	LULUCF, 2003, pp. 3.77

Input	Uncertainties	References
Annual emission factor for cultivated organic soils	$\pm 90\%$	LULUCF, 2003, pp. 3.79
Default coefficients for aboveground woody biomass and harvest cycles in cropping systems containing perennial species	$\pm 75\%$	LULUCF, 2003, pp. 3.71

5.6.4. Source-specific planned improvements

The estimates were carried out for the first time in the 2009 submission. Several improvements should be made in order to guarantee accurate, complete and transparent inventory in the future: areas of cropland should be checked, areas of changed land use practice should be revised based on new data obtained and carbon emissions/removals related to below- and above-ground biomass should be estimated.

5.7. Grassland (CRF 5.C)

5.7.1. Source category description

The total area of grassland started to increase since 1993 in the result of abandonment of cultivated (cropland) land (Table 5.18).

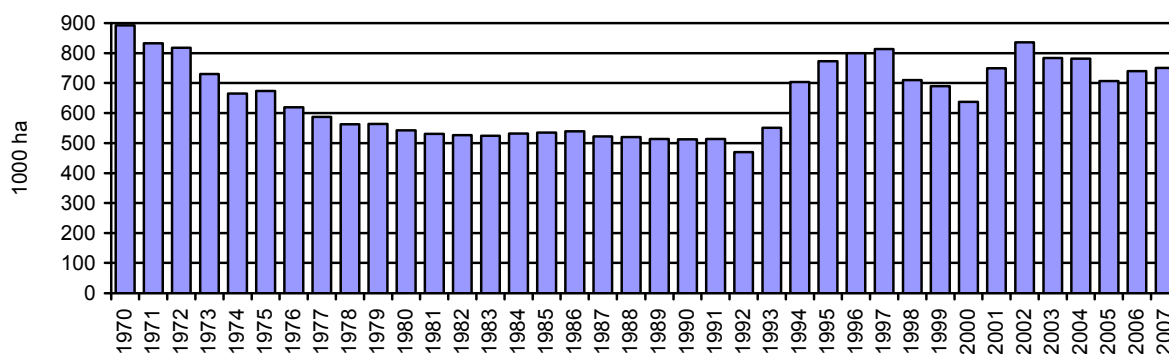


Figure 5.18. Grassland area in Estonia in 1970–2007, 1000 ha

5.7.2. Methodological issues

Carbon stock change in mineral soils was calculated in the 2009 submission. It was assumed that the total area of grassland has increased mostly due to decrease in the area of cropland taken into account as unused arable land and increase of areas of seeded once over five years grassland.

Carbon emissions/removals associated with Grassland remaining Grassland and carbon flows related to grassland above- and below-ground biomass were not estimated due to the lack of activity data, which are collected currently.

Mineral soils

The *Tier 1* approach was implemented in order to estimate carbon emissions/removals associated with land converted to grassland (LULUCF, 2003).

$$\Delta C_{LGSoil} = \Delta C_{LGMineral} - \Delta C_{LGOrganic} - \Delta C_{LGLime} \quad (5.11)^{117}$$

$\Delta C_{LGSoils}$ – annual change in stocks in soils in land converted to grassland, tonnes C yr⁻¹;

$\Delta C_{LGMineral}$ – change in carbon stocks in mineral soils in land converted to grassland, tonnes C yr⁻¹;

$\Delta C_{LGOrganic}$ – annual C emissions from organic soils converted to grassland (estimated as net annual flux), tonnes C yr⁻¹;

$$\Delta C_{CCMineral} = [(SOC_0 - SOC_{(0-T)}) \cdot A] / T \quad (5.12)^{118}$$

$$SOC = SOC_{REF} \cdot F_{LU} \cdot F_{MG} \cdot F_I$$

$\Delta C_{GMineral}$ – annual change in carbon stocks in mineral soils, tonnes C yr⁻¹;

SOC_0 – soil organic carbon stock in the inventory year, tonnes C ha⁻¹;

$SOC_{(0-T)}$ – soil organic carbon stock T years prior to the inventory, tonnes C ha⁻¹;

T – inventory time period, yr (default is 20 yr);

¹¹⁷ LULUCF 2003, Equation 3.4.17, pp. 3.126

¹¹⁸ LULUCF 2003, Equation 3.4.8., pp. 3.112

A – land area of each parcel, ha;

SOC_{REF} – the reference carbon stock, tonnes C ha⁻¹; see Table 5.27;

F_{LU} – stock change factor for land use or land-use change type, dimensionless; see Table 5.28;

F_{MG} – stock change factor for management regime, dimensionless; see Table 5.28;

F_I – stock change factor for input of organic matter, dimensionless; see Table 5.28.

Table 5.27. Default reference (under native vegetation) soil organic stocks (SOC_{REF}) (tonnes C per ha for 0-30 cm depth)¹¹⁹

	HAC soils	Spodic Soils	Wetland soils
Boreal	68	117	146

Table 5.28. Relative stock change factors for grassland management¹²⁰

Factor	Level	GPG revised default
Land Use - F _{LU}	All	1.0
Management - F _{MG}	Nominally managed (non-degraded)	1.0
Input (applied only to improved grassland) - F _I	Nominal	1.0

Mineral soil carbon stock of grassland started to grow since 1994 (Figure 5.19) in the result of the increase of the total grassland area.

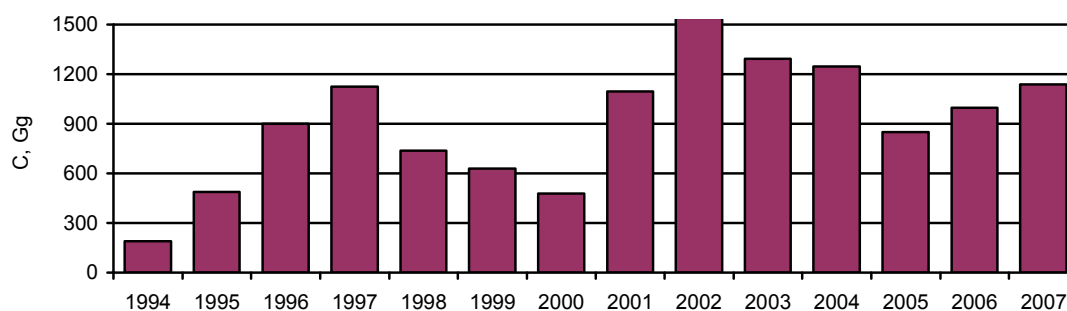


Figure 5.19. CO₂ removals by grassland soils in Estonia in 1990–2007, CO₂ Gg

¹¹⁹ LULUCF 2003, Table 3.4.4., pp.3.117

¹²⁰ LULUCF 2003, Table 3.4.5., pp.3.118

Organic soils

The *Tier 1* approach was used in order to calculate CO₂ emission from organic soils under grassland (LULUCF, 2003). The activity data were interpolated based on datasets of CORINE 1990 and 2000 maps.

The carbon flows related to organic soils under grassland are presented in Figure 5.20.

$$\Delta C_{GGOrganic} = \sum_c (A \bullet EF)_c \quad (5.13)^{121}$$

$\Delta C_{GGOrganic}$ – CO₂ emissions from cultivated organic soils in grassland remaining grassland, tonnes C yr⁻¹;

A – land area of organic soils in climate type *c*, ha;

EF – emission factor for climate type *c*, tonnes C ha⁻¹ yr⁻¹;

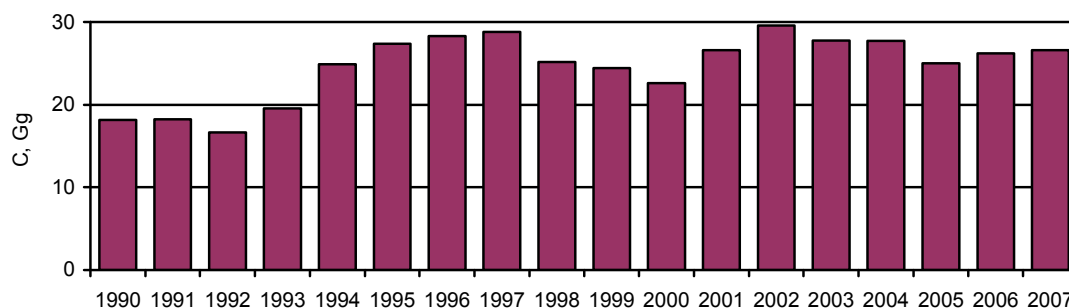


Figure 5.20. Carbon emission from organic soils in Estonia in 1990–2007, C Gg

5.7.3. Uncertainty and time series' consistency

The estimates of carbon flows associated with Grassland land use category were carried out in accordance with the LULUCF GPG (2003). The activity data were employed from Estonian national statistics and literature, the emission factors were taken from the LULUCF GPG (2003).

¹²¹ LULUCF 2003, Equation 3.4.10., pp.3.114

The uncertainty rates related to the activity data and the emission factors used in the estimates are presented in Table 5.29.

Table 5.29. Estimated values of uncertainties used in ‘Grassland’ sub-section

Input	Uncertainties	References
<i>Activity data</i> Grassland, ha	NA	
<i>Emission factors</i> Default reference soil organic C stock (SOC _{REF})	± 95%	LULUCF, 2003, pp. 3.117
Annual emission factor for cultivated organic soils	± 90%	LULUCF, 2003, pp. 3.118

5.7.4. Source-specific planned improvements

The estimates of carbon were carried out for the first time in the 2009 submission. Several improvements should be made in the future in order to provide accurate and complete GHG inventory: areas of grassland should be checked carefully in accordance with IPCC definition, changes in areas from/to grassland land use category should be revised and carbon emissions/removals associated with above- and below-ground biomass should be estimated.

5.8. Other Land (CRF 5.C)

Shrubland, rocky lands and mining areas were defined as other land in the 2009 submission. It was assumed that a part of cropland area abandoned was re-growing by bushes or other natural vegetation leading to the increase in carbon stock in mineral soils.

Methodology used in the estimates where obtained from Chapter 5.7.2, the carbon removals estimated are reported in Figure 5.21.

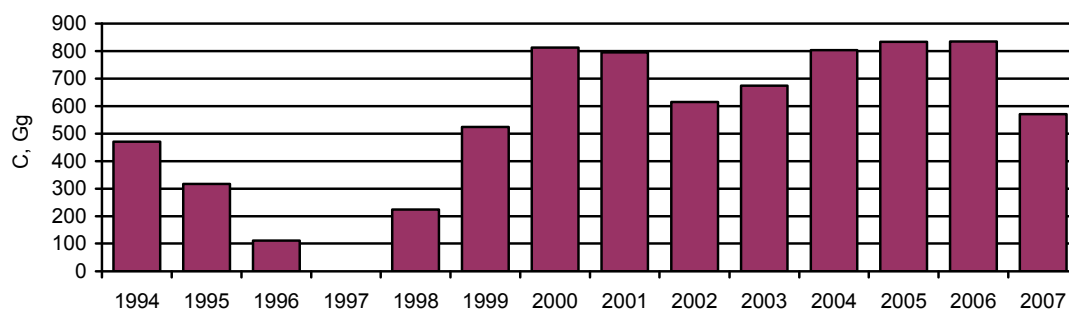


Figure 5.21. Carbon removals associated with other land in Estonia in 1990–2007, C Gg

5.8.1. Uncertainty and time series' consistency

The estimates of carbon removals were carried out employing the LULUCF GPG (2003). The activity data on 'Other Land' use category were obtained from Estonian national statistics, the rates of emission factors were used from the LULUCF GPG (2003). The uncertainty rates of default reference soil organic C stock typical 'Grassland' land use category were used in the estimates.

The uncertainty rates employed are listed in Table 5.30.

Table 5.30. Estimated values of uncertainties used in 'Other Land' sub-section

Input	Uncertainties	References
<i>Activity data</i> Other land, ha	NA	
<i>Emission factors</i> Default reference soil organic C stock (SOC _{REF}) ¹²²	± 95%	LULUCF, 2003, pp. 3.117

5.8.2. Source-specific planned improvements

In the 2009 submission the first attempt was made to estimate carbon flows associated with other land use categories. A wide range of improvements should be done in the future: areas of 'Other Land' land use category should be checked and re-defined, as it could be that a part of Shrubland

¹²² The value of SOC_{REF} defined for Forest land was used in the estimates.

area could be defined as ‘Forest Land’; above- and belowground biomass should be estimated in ‘Other Land’ sub-section; carbon emissions/removals associated with ‘Other Land’ use category will be re-calculated.

5.9. Wetland (CRF 5.D)

5.9.1. Source category description

Carbon emissions/removals associated with ‘Wetlands’ land use category (carbon stock change in living biomass, carbon stock change in dead organic matter) were not estimated due to the lack of activity data, as the data are still under development.

Non-CO₂ emissions related to peatland were estimated based on Estonian activity data and the *Tier 1* approach of LULUCF GPG (LULUCF, 2003).

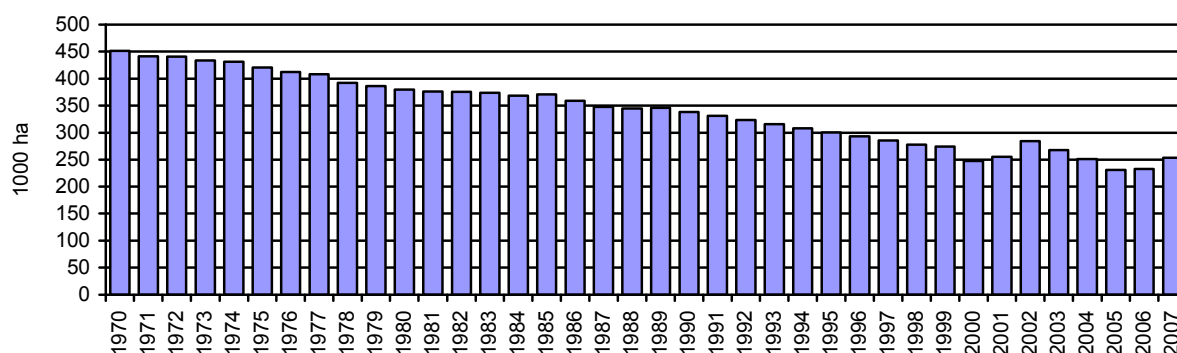


Figure 5.22. Area of wetlands in Estonia in 1970–2007, 1000 ha

5.9.2. Methodological issues

The approach presented in LULUCF GPG (2003) was employed in order to estimate Non-CO₂ emission from peatland.

$$\Delta C_{WW_{peat_Soil,extraction}} = A_{peat_Nrich} \bullet EF_{peat_Nrich} + A_{peat_Npoor} \bullet EF_{peat_Npoor} \quad (5.14)^{123}$$

¹²³ LULUCF, 2003. Equation 3a.3.6, pp.3.279

$\Delta C_{WW \text{ peat Soils, extraction}}$ – CO₂ emission from organic soils managed for peat extraction expressed as carbon, tonnes C yr⁻¹;

$A_{\text{peatNrich}}$ – area of nutrient rich organic soils managed for peat extraction, including abandoned areas in which drainage is still present, ha;

$A_{\text{peat Npoor}}$ – area of nutrient poor organic soils managed for peat extraction, including abandoned areas in which drainage is still present, ha;

$EF_{\text{peatNrich}}$ – emission factors for CO₂ from nutrient rich organic soils managed for peat extraction, tonnes C ha⁻¹ yr⁻¹;

Table 5.31. Emission factors for CO₂-C and associated uncertainty for organic soils after drainage

Region / Peat Type	Emission Factor, tonnes C ha ⁻¹ yr ⁻¹	Emission Factor, kg N ₂ O-N ha ⁻¹ yr ⁻¹
Nutrient Poor, EF_{Npoor}	0.2 ¹²⁴	0.1 ¹²⁵

The data on industrial peat extraction were obtained from the literature ([Orri jt, 2005](#)).

Table 5.32. Area of industrial peat production, 1000 ha

Year	Peat extraction fields
1990	12.0
1991	15.0
1992	15.0
1993	15.0
1994	15.0
1995	15.0
1996	15.0
1997	15.0
1998	15.0
1999	15.0
2000	20.0
2001	20.0
2002	20.0
2003	20.0
2004	20.0
2005	20.0
2006	20.0
2007	20.0

¹²⁴ LULUCF, 2003. Equation 3a.3.6, pp.3.280

¹²⁵ LULUCF, 2003, Table 3a.3.4, pp. 3.284

The emissions of N₂O due to industrial peat extraction are presented in Figure 5.23.

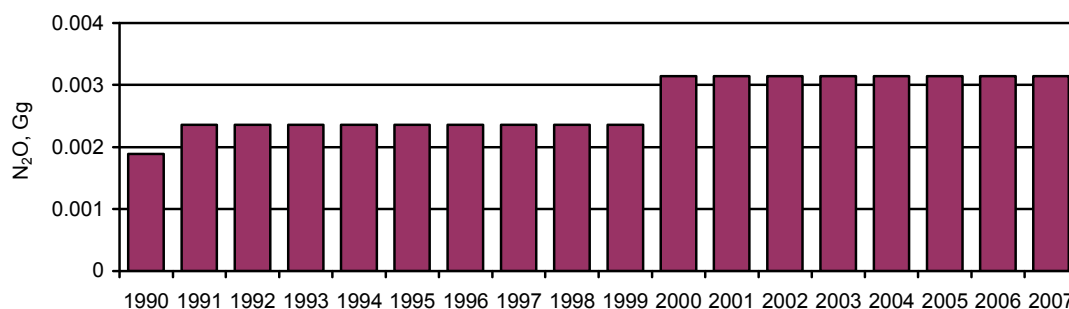


Figure 5.23. N₂O emission due to industrial peat extraction in 1990–2007, N₂O Gg

5.9.3. Uncertainty and time series' consistency

The estimates of GHG flows were carried out based on the LULUCF GPG (2003). The activity data were obtained from Estonian national statistics, the emission factors – from the LULUCF GPG (2003). The uncertainty rates are listed in Table 5.33.

Table 5.33. Estimated values of uncertainties used in 'Other Land' sub-section

Input	Uncertainties	References
<i>Activity data</i>		
Peatland area, ha	NA	
<i>Emission factors</i>		
Emission factor for CO ₂ -C	-100...215%	LULUCF, 2003, pp. 3.280
Emission factor for N ₂ O	-100...200%	LULUCF, 2003, pp. 3.284

5.9.4. Source-specific planned improvements

The estimates of the emissions related to Wetland land use category were carried out for the first time in the 2009 submission. Several improvements should be made in the future in order to report complete and accurate GHG inventory in 'Wetlands' sub-section: carbon flows related to wetland living biomass will be estimated, areas of land converted to/from wetlands will be checked.

5.10. Settlements (CRF 5.E)

5.10.1. Source category description

The areas of settlements in 1990–2007 are reported in Table 5.34. Carbon flows related to settlements were not calculated in the 2009 submission.

Table 5.34. Areas of settlements (in accordance with IPCC definition) in 1990–2007, 1000 ha¹²⁶

Year	Total	...roads	...settlements
1990	152.2	76.9	75.3
1991	159.6	79.9	79.7
1992	166.9	82.8	84.1
1993	174.2	85.8	88.5
1994	181.5	88.7	92.8
1995	188.9	91.6	97.2
1996	196.2	94.6	101.6
1997	203.5	97.5	106.0
1998	210.8	100.4	110.4
1999	226.4	107.7	118.7
2000	239.7	112.2	127.5
2001	254.2	109.6	144.6
2002	256.3	110.5	145.8
2003	255.7	112.6	143.1
2004	263.5	108.3	155.2
2005	288.2	118.6	169.6
2006	290.9	119.2	171.7
2007	290.2	125.1	165.1

5.11. Emissions of Greenhouse Gases from Biomass Burning

This source category includes non-CO₂ greenhouse gas emissions (CH₄ and N₂O) and CO₂ from biomass burning on forested land due to wildfires.

¹²⁶ 1986 – Eesti NSV 1986 a. maabilanss; 1987 – Eesti NSV 1987 a. maabilanss; 1988 – Eesti NSV 1988 a. maabilanss; 1989 – Eesti NSV 1989 a. maabilanss; 2000 – Eesti Metsad 2000; 2001 – Eesti Metsad 2001; 2002 – Eesti Metsad 2002; 2003 – Eesti Metsad 2003; 2004 – Eesti Metsad 2004; 2005 – Eesti Metsad 2005; 2006 – Eesti Metsad 2006; 2007 – Eesti Metsad 2007.

5.11.1. Biomass burning (CRF 5 (V))

This source category includes non-CO₂ greenhouse gas emissions (only CH₄ and N₂O) from biomass burning on forested land due to wildfires. CO₂ emission from biomass burning was reported also in the chapter.

5.11.2. Methodology, data availability and sources, emission factors

Equation (5.15) was used to estimate the emissions of non-CO₂ greenhouse gases. The combustion factor (0.34) was taken from Table 3A.1.12 (LULUCF, 2003), and the Nitrogen-Carbon ratio (0.01)¹²⁷ of burned biomass was taken from (IPCC, 1997).

$$L_{\text{fire}} = A \bullet B \bullet C \bullet D \bullet 10^{-6} \quad (5.15)^{128}$$

L_{fire} – quantity of GHG released due to fire, tonnes of GHG;

A – area burnt, ha;

B – mass of ‘available’ fuel, kg dry matter ha⁻¹;

C – combustion efficiency (or fraction of the biomass combusted), dimensionless;

D – emission factor, g (kg dry matter.)⁻¹ (Table 5.35);

Table 5.35. Factors used to estimate emission of non-CO₂ greenhouse gases emitted due to forest fires¹²⁹

	Emission ratios
CH ₄	0.012
CO	0.06
N ₂ O	0.007
NO _x	0.121

¹²⁷ IPCC, 1997, Workbook, Chapter 5. pp. 5.18

¹²⁸ LULUCF 2003, Equation 3.2.20, pp. 3.49

¹²⁹ LULUCF 2003, Table 3A.1.15 – Emissions ratios for open burning of cleared prests

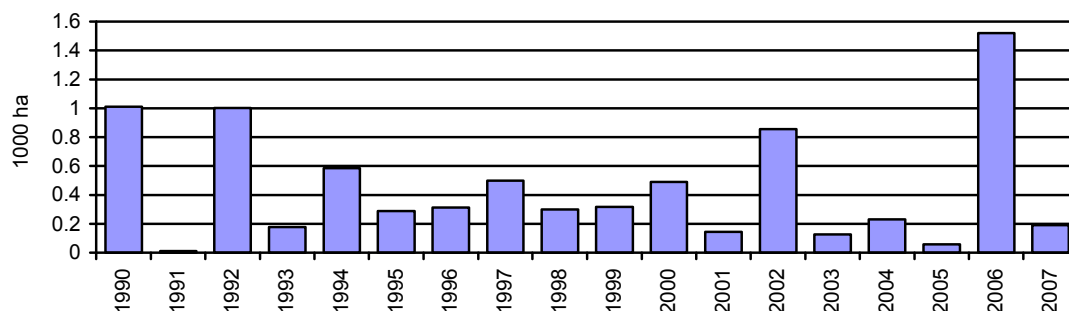
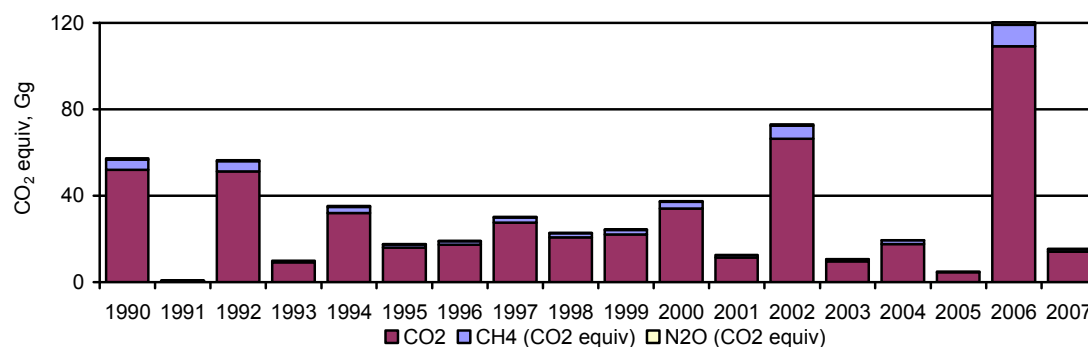


Figure 5.24. Area of Estonian forest affected by fires in 1990–2007, 1000 ha

Figure 5.25. CO₂ equiv emissions from forest biomass wildfires in Estonia in 1990–2007, Gg

5.11.3. Uncertainties and time-series consistency

Estimates of CO₂, CH₄ and N₂O emissions from forest fires are carried out based on the data of forest area burned, average biomass stock per hectare, BEFs, value of combustion factor for fires and emission ratios for open burning. The uncertainty rates employed in the estimates are reported in Table 5.36.

Table 5.36. Estimated values of uncertainties used in ‘Biomass Burning’ sub-section

Input	Uncertainties	References
<i>Activity data</i>		
Stand biomass increment, m ³ /ha	± 1.7%	‘Eesti Metsad’ report
Stand stock per hectare, m ³ /ha	± 2.2%	‘Eesti Metsad’ report
<i>Emission factors</i>		
Wood density	± 20%	LULUCF 2003, pp. 3.31
Value of combustion factor for fires	-85...124%	LULUCF 2003, pp. 3.179
Emission ratio for open burning (CH ₄)	± 25%	The 1996 IPCC Guidelines, pp. 5.33
Emission ratio for open burning (N ₂ O)	± 29%	The 1996 IPCC Guidelines, pp. 5.33

CHAPTER 6. WASTE (CRF 6)

6.1. Overview of source category description and methodology

The Estonian inventory emissions include CH₄ emissions from solid waste disposal sites including solid municipal and industrial wastes, domestic and industrial sludge. The Waste Sector covers GHG emissions from waste incineration and composting. N₂O emissions from sludge application in agriculture are reported in the Agriculture Sector. However, the estimates are provided in the waste chapter. Emissions from wastewater handling do not occur in Estonia, as all wastewater is treated using aerobic processes.

Table 6.1 summarizes the data on approaches and emissions employed for estimation of GHG emissions from each sub-sector of the waste sector.

Table 6.1. Methods and emission factors used for estimations of emissions from waste sector

Greenhouse gases source and sink categories	CO ₂		CH ₄		N ₂ O	
	Method Applied	EF	Method Applied	EF	Method Applied	EF
6. Waste						
A. Solid Waste Disposal on Landfills			T1 (The FOD)	IPCC		
B. Wastewater handling (anaerobic)			NO	NA	NO	NA
B. Human sewage					T1	IPCC
C. Waste Incineration	T1	IPCC			T1	IPCC
D. Biological treatment			T1	IPCC	T1	IPCC
E. Sludge application in agriculture					T1	IPCC

NO – Not Occurring; NA – Not Applicable; T1 – *Tier 1* method; the FOD – the First Order Decay method; CS – country specific.

6.1.1. References – sources of information

The inventory is carried out by researchers at Tallinn University of Technology. The main providers of activity data used in the estimates are the Statistical Office of Estonia (ESO) and Estonian Environment Information Centre (EEIC) (Table 6.2).

Table 6.2. List of institutions (datasets) involved in the inventory for the waste sector

Reference	Link	Abbreviation	Activity/Data
Tallinn University of Technology	www.ttu.ee	TUT	- activity data gathering; - estimation of emissions; - reporting;
Statistics of Estonia	www.stat.ee	ESO	- collection and reporting of data on product production in Estonia - data collection on quantities of biogas produced
Estonian Environment Information Centre - Waste Data Bureau	www.keskkonnainfo.ee	EEIC	- collection of data on solid waste generation and disposal, waste incineration and biological treatment;

6.1.2. Quantitative overview of the waste sector

CO₂ equiv emission from the waste sector was 697 Gg in Estonia in 2007. It made up 3.2% of the total GHG emission in 2007 (Figure 6.1). CH₄ emission from solid waste landfilled and GHG emissions (CH₄ and N₂O) from composting processes are the most significant emissions of the waste sector in Estonia in 2007.

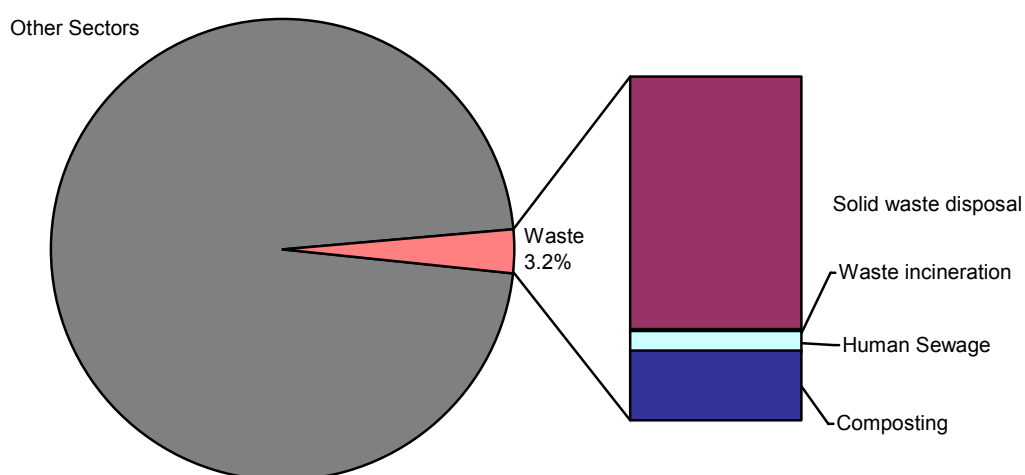


Figure 6.1. CO₂ equiv emissions from the waste sector compared with the total GHG emissions in Estonia in 2007, Gg¹³⁰

¹³⁰ Emissions/Removals of LULUCF sector are excluded.

The total CO₂ equiv emission from the waste sector increased negligibly – by 3.8% compare with the base year: the emission from solid waste landfilled decreased by 14% and emission from waste composting processes increased more than 100 fold – from 1.26Gg in 1990 to 138Gg in 2007 (Figure 6.2, Table 6.3).

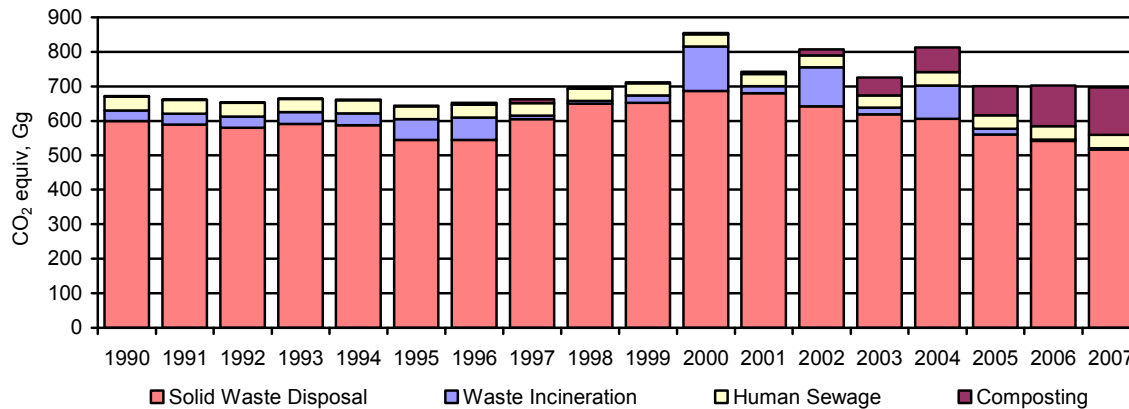


Figure 6.2. Trends of GHG emissions in the waste sector by source categories in 1990–2007, Gg

Table 6.3. Waste sector's greenhouse gases emissions in Estonia in 1990–2007, Gg

Year	Solid waste disposal	Waste incineration		Biological treatment		Human Sewage	Total CO ₂ emissions	Total CH ₄ emissions	Total N ₂ O emissions	Total CO ₂ equiv emissions
	CH ₄	CO ₂	N ₂ O	CH ₄	N ₂ O	N ₂ O	CO ₂	CH ₄	N ₂ O	CO ₂ equiv
1990	28.57	0.051	0.098	0.029	0.002	0.130	0.051	28.60	0.230	671.87
1991	28.03	0.051	0.101	0.030	0.002	0.129	0.051	28.06	0.233	661.48
1992	27.60	0.051	0.105	0.032	0.002	0.128	0.051	27.63	0.235	653.19
1993	28.15	0.051	0.108	0.033	0.002	0.125	0.051	28.18	0.235	664.75
1994	27.95	0.051	0.112	0.035	0.003	0.122	0.051	27.98	0.236	660.79
1995	25.95	0.088	0.193	0.037	0.003	0.120	0.088	25.99	0.316	643.60
1996	25.96	0.035	0.209	0.126	0.009	0.118	0.035	26.08	0.337	652.09
1997	28.81	0.046	0.032	0.262	0.020	0.116	0.046	29.07	0.168	662.52
1998	30.92	0.063	0.025	0.026	0.002	0.115	0.063	30.95	0.143	694.10
1999	31.05	0.068	0.070	0.043	0.003	0.114	0.068	31.09	0.188	711.12
2000	32.67	0.154	0.416	0.107	0.008	0.113	0.154	32.78	0.537	854.73
2001	32.38	0.109	0.068	0.143	0.011	0.113	0.109	32.52	0.192	742.37
2002	30.59	0.113	0.364	0.396	0.030	0.112	0.113	30.98	0.506	807.49
2003	29.44	0.167	0.066	1.192	0.089	0.112	0.167	30.63	0.267	726.06
2004	28.86	0.370	0.311	1.614	0.121	0.125	0.370	30.48	0.558	812.88
2005	26.69	0.125	0.053	1.920	0.144	0.125	0.125	28.61	0.322	700.65
2006	25.81	0.071	0.011	2.682	0.201	0.125	0.071	28.49	0.337	702.66
2007	24.59	0.042	0.013	3.119	0.234	0.124	0.042	27.71	0.372	697.14

6.1.3. Key categories

Waste key categories in 2007 calculated with the *Tier 1* method¹³¹ were:

6.A	Solid Waste Disposal on Land/Managed Waste Disposal on Land (CH ₄)	L, T ¹³²
6.D	Biological treatment (N ₂ O)	T
6.D	Biological treatment (CH ₄)	T

6.1.4. Uncertainty assessment

The combined uncertainties related to waste sector as percent from the total national emission in 2007 are follows:

6.A	Solid Waste Disposal on Land (CH ₄)	1.4816%
6.B.2.2	Human Sewage (N ₂ O)	0.1752%
6.C.	Waste Incineration (CO ₂)	0.0002%
6.C.	Waste Incineration (N ₂ O)	0.0188%
6.D.	Biological Treatment (CH ₄)	0.2986%
6.D.	Biological Treatment (N ₂ O)	0.2986%
CRF 6	Waste sector total	1.6568%

6.2. Solid waste disposal on landfills (CRF 6.A)

6.2.1. Activity data

In 2007, 21 million tonnes of waste were generated in Estonia. About 65% of waste generated was produced by oil shale industry.

The quantity of municipal waste generated in 2007 is presented in Table 6.4. Municipal waste include waste from households (mixed municipal waste, 66% of the total amount of municipal waste), institutional and commercial waste (waste from markets and street-cleaning residues, etc. – 7%) and separately collected fractions – 10% of the total amount of municipal waste generated.

¹³¹ GHG emissions/removals of LULUCF sector are not included.

¹³² L – Level Assessment method; T – Trend Assessment method.

Table 6.4. Amounts of municipal waste generated in 2007 by counties of Estonia

	Amounts of municipal waste generated, tonnes ¹³³
Harju County	256,926
Hiiu County	2,031
Ida-Viru County	51,581
Jõgeva County	7,141
Järva County	8,810
Lääne County	7,341
Lääne-Viru County	17,681
Põlva County	5,513
Pärnu County	29,515
Rapla County	11,604
Saare County	13,933
Tartu County	135,336
Valga County	8,192
Viljandi County	14,873
Võru County	8,130
Whole Country	578,607

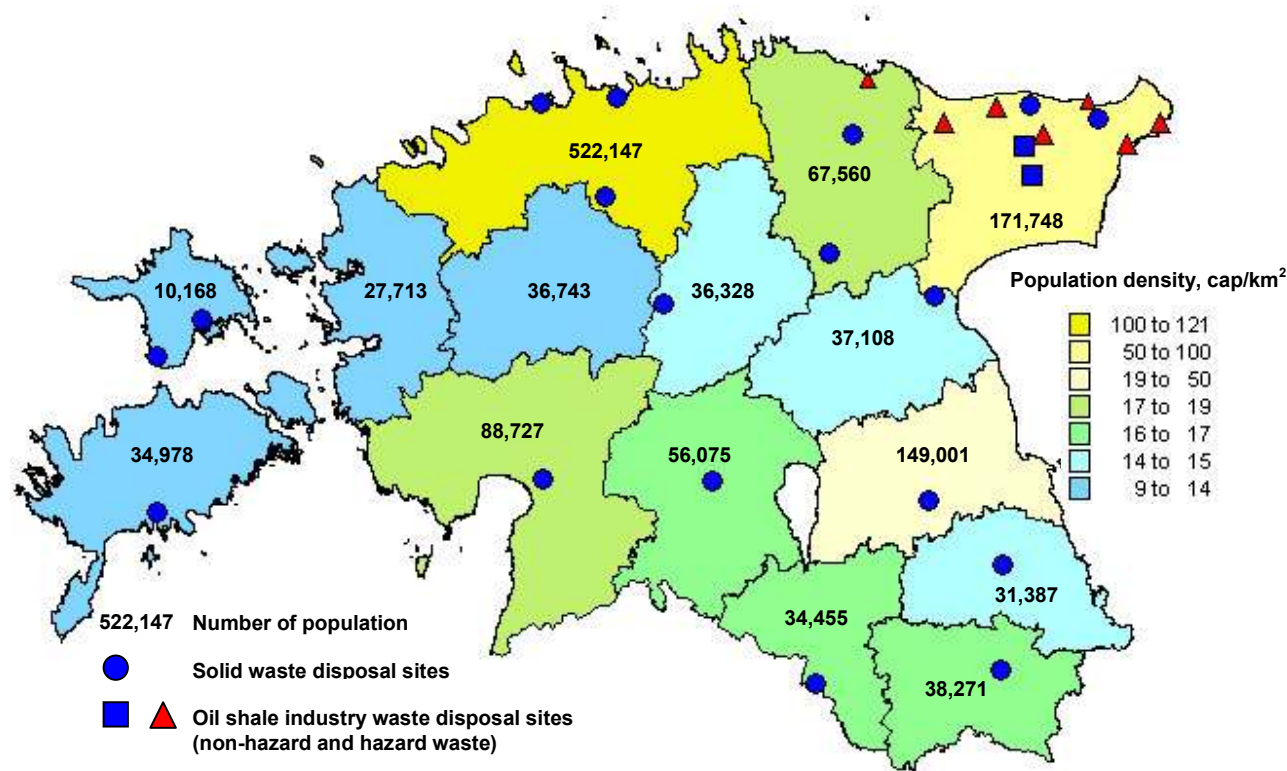


Figure 6.3. The map of Estonia's population, population density and operating landfills in Estonia in 2007 (see also Figure 4.9)

¹³³ Code 20 of the European Waste catalogue (2002)

The annual trend of inert and degradable waste generated in Estonia in 1990–2007 is presented in Figure 6.4. Since 1992 the EEIC has started to collect data in accordance with the Estonian waste classification (Estonian NIR, 2006), however in 1999 the classification system adapted was changed and the European Waste Catalogue was employed. The data for 1990–1991 were interpolated basing on the data of 1992–1998 (Estonian NIR, 2006).

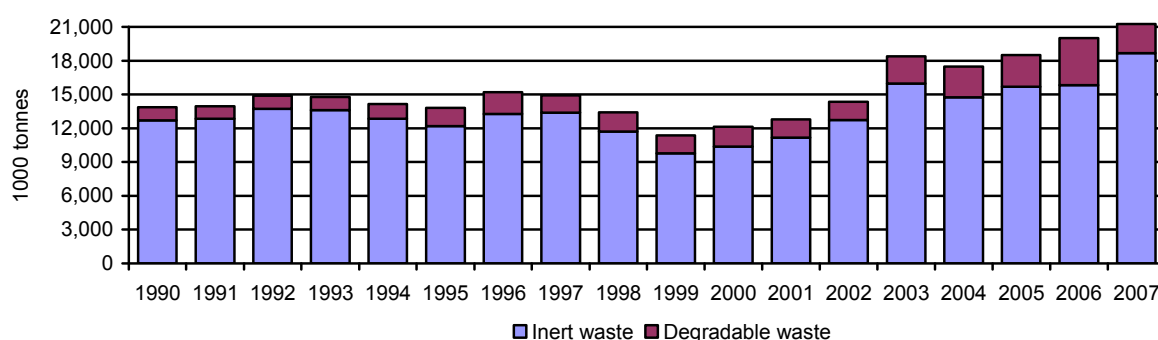


Figure 6.4. Amounts of waste generated in Estonia in 1990–2007, 1000 tonnes

As seen from Figure 6.5, the quantity of DOC¹³⁴ generated increased by 3.9 fold by 2007 in comparison with the base year. Recycling of biodegradable waste increased from 60% to 90% in 2005–2007.

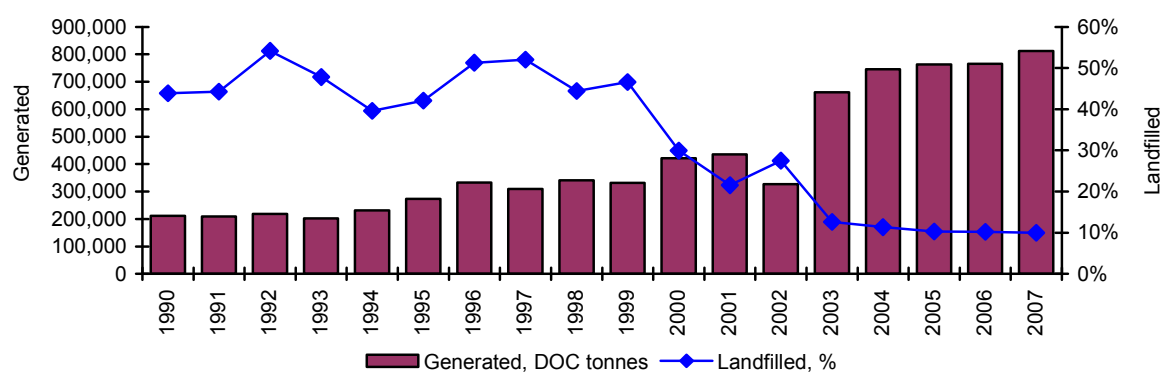


Figure 6.5. Quantity of DOC generated [tonnes] and ratio of DOC landfilled to DOC generated [%] in 1990–2007

¹³⁴ Degradable Organic Carbon

The data presented in Figure 6.6–Figure 6.9 illustrate flows of the most important waste flows of biodegradable waste in Estonia in 2007.

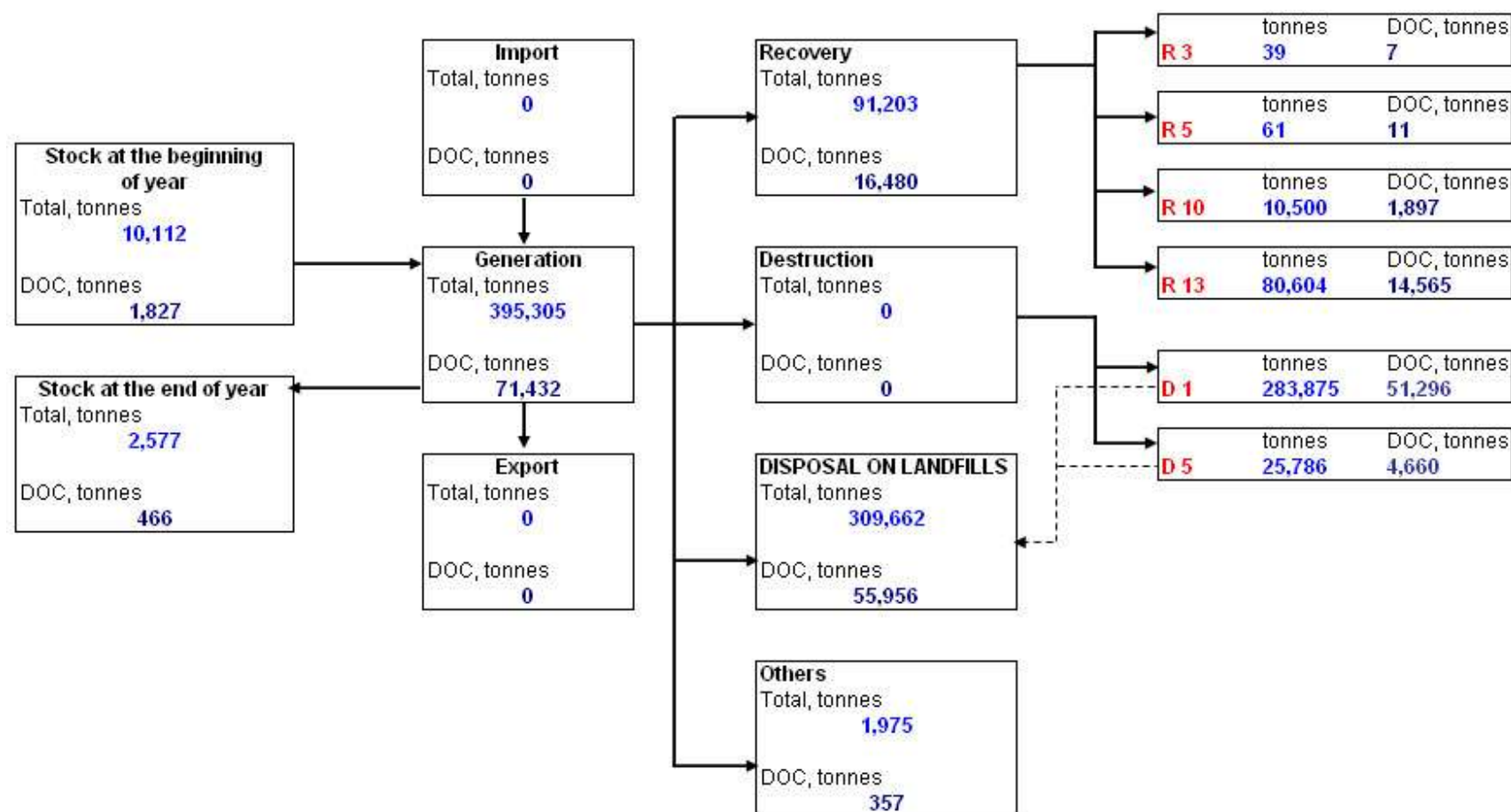


Figure 6.6. Flows of mixed municipal waste in Estonia in 2007, tonnes

Input ¹³⁵	Output ¹³⁶
405,417	405,417

¹³⁵ Input flows: Stock at the beginning of year, Generation, Import

¹³⁶ Out flows: Stock at the end of year, Export, Recovery, Destruction, Disposal on Landfills, Other activities

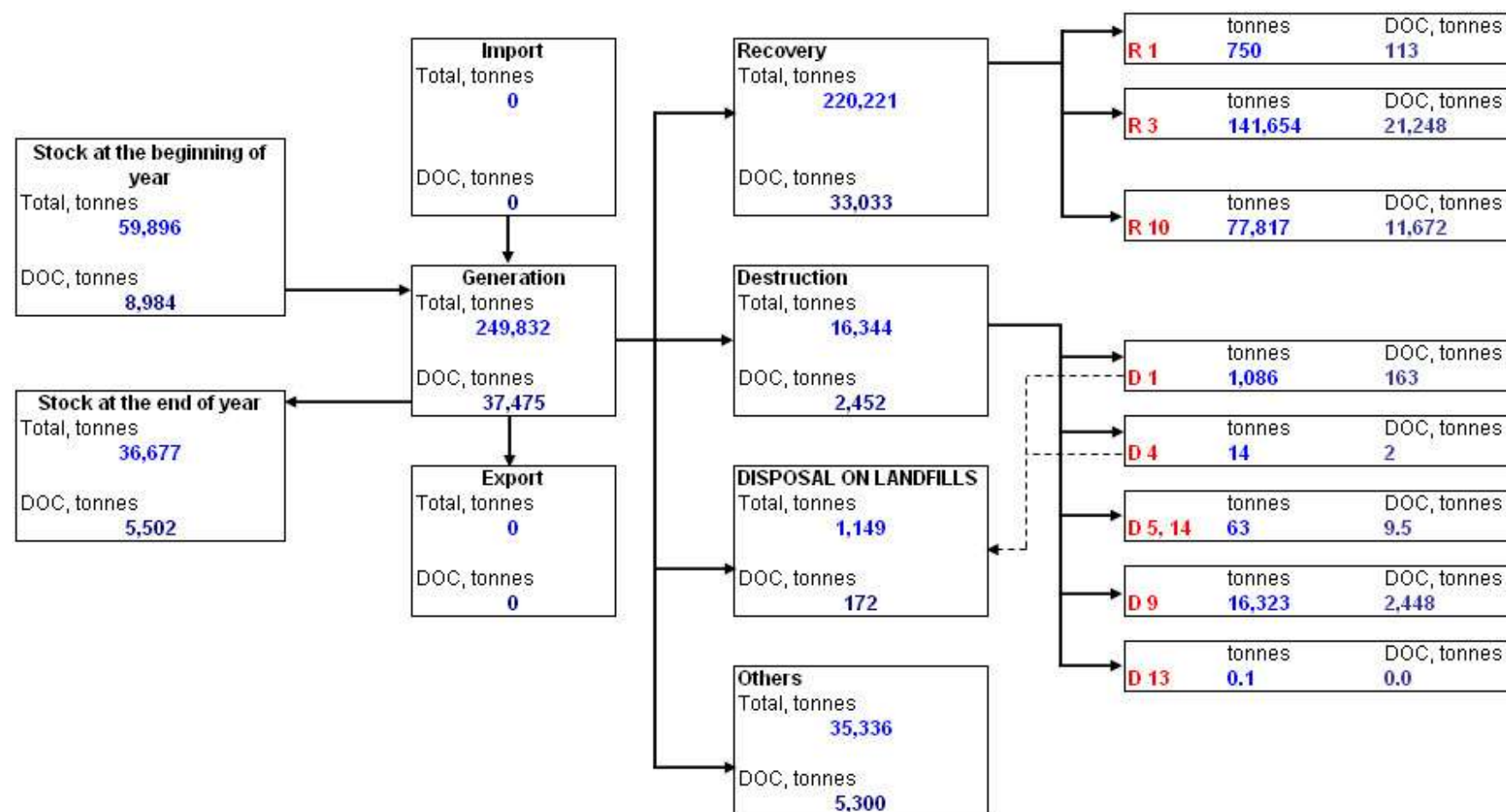


Figure 6.7. Flows of organic waste in Estonia in 2007, tonnes

Input	Output
309,728	309,728

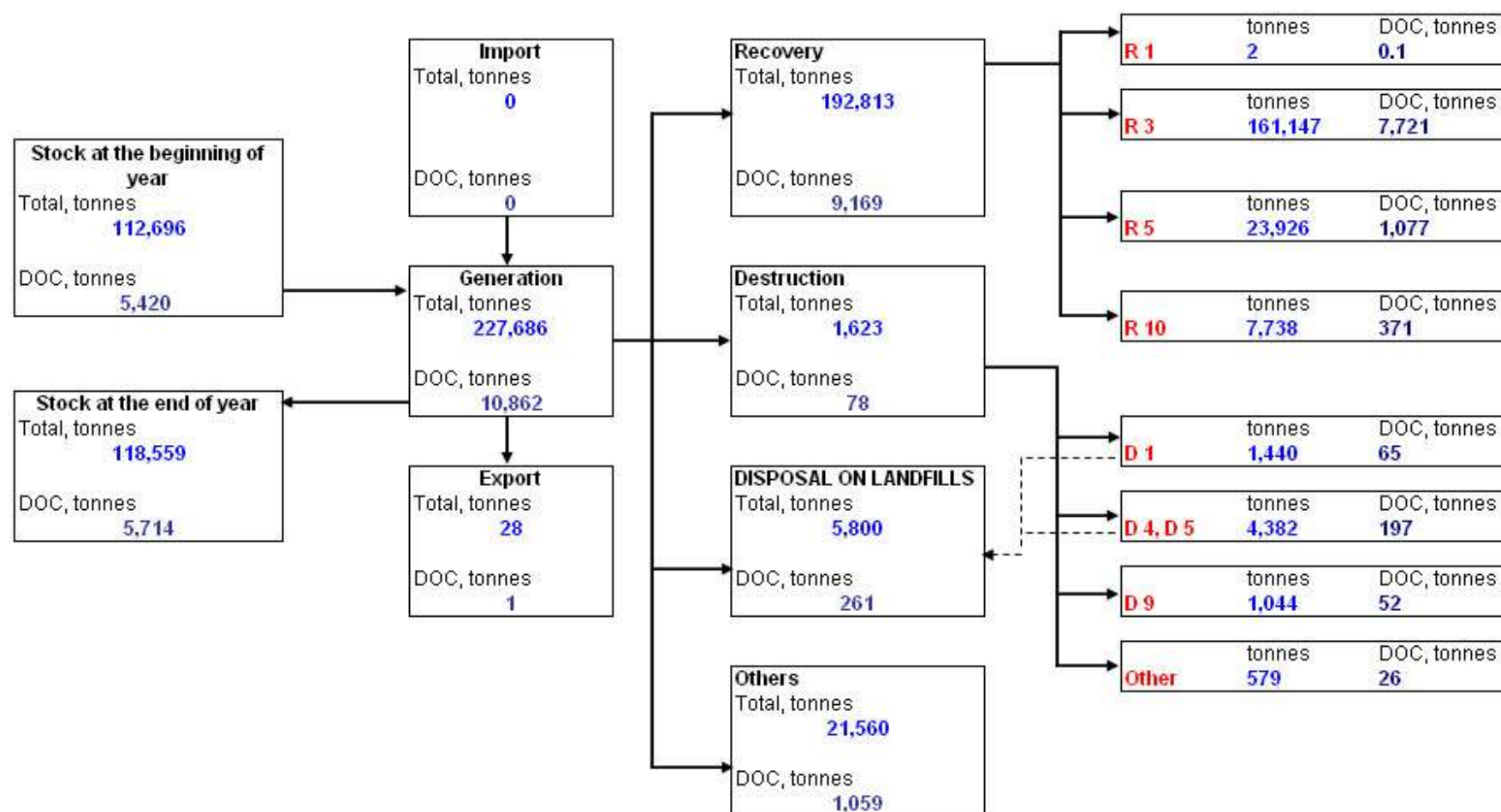


Figure 6.8. Flows of sludge (municipal and industrial) waste in Estonia in 2007, tonnes

Input	Output
340,382	340,382

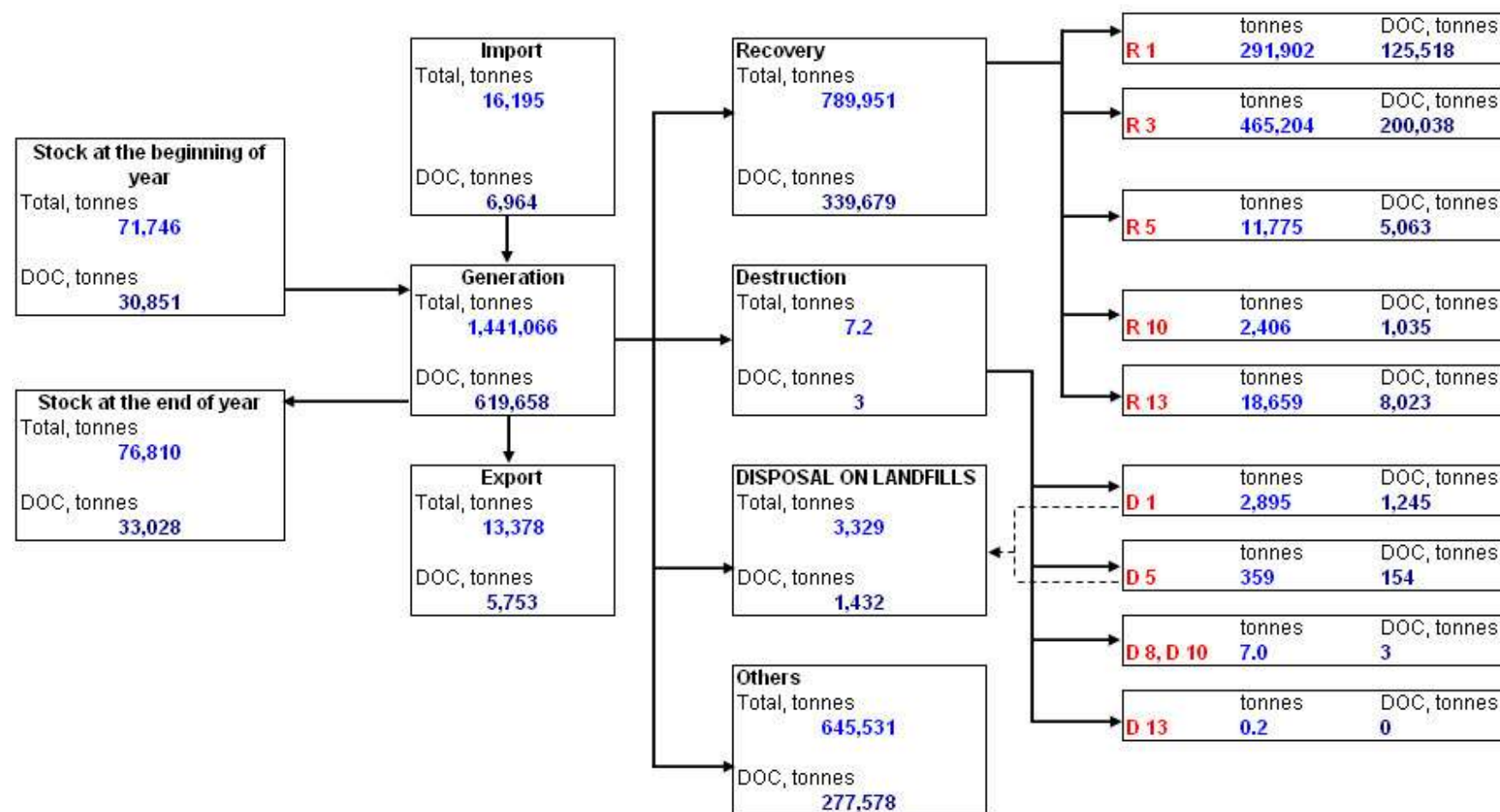


Figure 6.9. Flows of wood waste in Estonia in 2007, tonnes

Input	Output
1,529,007	1,529,007

The data on methane recovery were obtained from datasets of ESO. The quantity of CH₄ recovered in 2007 reported was 3.43 Gg.

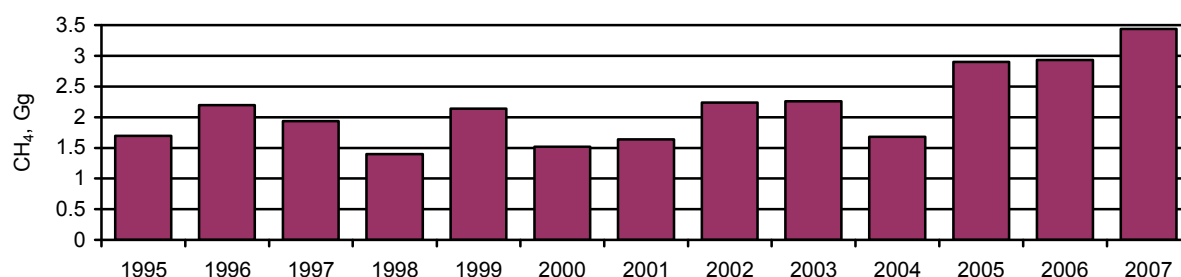


Figure 6.10. CH₄ recovered from landfills in the years 1995–2007, Gg

6.2.2. Methodology, data availability and sources, emission factors

In order to estimate CH₄ emission from solid waste disposed on landfills the First Order Decay (the FOD) approach was employed (IPCC, 2000).

$$\text{CH}_4, \text{Gg/year} = \sum_x [(A \cdot k \cdot \text{SW}_{T(x)} \cdot \text{SW}_{F(x)} \cdot L_0(x) \cdot e^{-k(t-x)})] \quad (6.1)^{137}$$

for x = initial year to t

t – year of inventory;

x – years for which input data should be added;

$A = (1 - e^{-k}) / k$; normalization factor which corrects the summation;

k – Methane generation rate constant, 1/yr;

$\text{SW}_{T(x)}$ – Total solid waste (SW) generated in year x, Gg/yr;

$\text{SW}_{F(x)}$ – Fraction of SW disposed at SWDS in year x.

$L_0(x)$ – Methane generation potential:

$$L_0(x) = \text{MCF}_{(x)} \cdot \text{DOC}_{(x)} \cdot \text{DOC}_F \cdot F \cdot 16/12, \text{GgCH}_4/\text{Gg_waste} \quad (6.2)$$

$\text{MCF}_{(x)}$ – Methane correction factor in year x (fraction);

$\text{DOC}(x)$ – Degradable organic carbon (DOC) in year x (fraction), Gg C/Gg waste;

¹³⁷ IPCC, 2000. Waste. pp 5.6

DOC_F – Fraction of DOC degraded;

F – Fraction by volume of CH_4 in landfill gas;

16/12 – Conversion from C to CH_4 .

Sum the obtained results for all years (x).

$$\text{CH}_4, \text{Gg/year} = [\text{CH}_4_{\text{generated_in_year_t}} - R(t)] - (1 - \text{OX}) \quad (6.3)^{138}$$

$R(t)$ – Recovered CH_4 in inventory year t, Gg/yr;

OX – Oxidation factor (fraction).

The data used in the estimates are reported in Table 6.5–Table 6.8.

Table 6.5. Emission factors and parameters used in the calculations

Factor/Parameter	Value	Reference
MCF	1	IPCC 2000. Waste. pp 5.9
DOC_F	0.5	IPCC 2000. Waste. pp 5.9
F	0.5	1996 IPCC, Waste, Reference Manual, pp 6.5
OX	0	IPCC 2000. Waste. pp 5.10
Methane generation rate constant:		
k1 = paper/textiles waste	0.06	IPCC 2006, pp 3.17
k2 = wood/rubber waste	0.03	IPCC 2006, pp 3.17
k3 = organic/garden and park waste	0.1	IPCC 2006, pp 3.17
k4 = food waste/sewage sludge	0.185	IPCC 2006, pp 3.17
k5 = industrial waste	0.09	IPCC 2006, pp 3.17

Table 6.6. Default DOC content of different waste types (wet basis)¹³⁹

Waste group	DOC content
Solid municipal waste	
Food, Grease	0.15
Municipal	(Table 6.8)
Garden	0.20
Glass	-
Inert	-
Paper	0.40
Plastic	-
Textile	0.24
Wood	0.43
Other	-
Municipal Sludge	
Sludge	0.05
Industrial waste	
Organic	0.15

¹³⁸ Equation 5.2 of the IPCC 2000, pp 5.7

¹³⁹ Table 2.4 and Table 2.5 of the 2006 IPCC Guidelines, pp 2.14 -2.16

Waste group	DOC content
Textile	0.24
Wood	0.43
Paper	0.40
Plastic	-
Leather	0.39
Glass	-
Clinical	-
Pottery	-
Rubber	0.39
Inert	-
Metal	-
Petroleum-products	-
Oil	-
Solvents	-
Asphalt	-
Industrial Sludge	
Sludge	0.045

The earlier data on waste composition is not available, a waste composition analysis from the Netherlands was employed in earlier estimates of the FOD (for 1940–2000). However, since 2000, some research was carried out in Estonia. Thus, in order to estimate CH₄ emissions from solid waste landfilled, country-specific data were used since 2000.

Table 6.7. The waste composition of solid municipal waste, %¹⁴⁰

	1940	1958	1971	1980	1990	2000-onward
Organic household waste, bread, animal waste and non-defined non-separated waste	64	56	52	53	52	42.1
Paper and cardboard	22	20	26	21	25	25.3
Wood			3.3 ¹⁴¹	3.3	3.3	3.3
Textiles	2	1	2	2	2	0.9

Table 6.8. DOC content of mixed municipal waste in Estonia in 1940–2007

	1940	1958	1971	1980	1990	2000-onward
DOC content	0.2208	0.1944	0.2270	0.2090	0.2230	0.2018

¹⁴⁰ The data on waste composition of 1940, 1958, 1971, 1980 and 1990 was taken from <http://www.mnp.nl/mnc/i-en-0141.html>, the data on waste composition of 2000 was taken from (Olmejäätmete koostise... 2000)

¹⁴¹ (Olmejäätmete koostise... 2000)

6.2.3. Quantitative overview – CH₄ emission from solid waste disposal (CRF 6.A)

The total emission from solid waste disposed onto landfills was 24.59Gg in Estonia in 2007. The breakdown of CH₄ emission emitted from disposal of different type of waste is presented in Table 6.9.

Table 6.9. Quantities of CH₄ emission and recovery from biodegradable solid waste disposed in Estonian landfills in 1990–2007, Gg

Year	Organic/Food	Garden	Paper	Wood	Textiles	Sludge	Leather/Rubber	Recovery
1990	14.24	0.000	11.44	1.52	0.60	0.64	0.116	
1991	13.62	0.000	11.45	1.58	0.60	0.66	0.116	
1992	13.11	0.000	11.46	1.62	0.60	0.69	0.116	
1993	13.18	0.000	11.64	1.71	0.62	0.88	0.123	
1994	12.90	0.000	11.69	1.76	0.62	0.85	0.123	
1995	12.38	0.000	11.70	1.80	0.61	1.03	0.123	-1.70
1996	12.71	0.000	11.92	1.84	0.62	0.94	0.122	-2.20
1997	14.12	0.000	12.33	1.97	0.64	1.56	0.123	-1.94
1998	14.97	0.000	12.80	2.07	0.66	1.69	0.125	-1.40
1999	15.41	0.000	13.18	2.20	0.68	1.60	0.127	-2.14
2000	16.07	0.020	13.52	2.32	0.69	1.44	0.124	-1.52
2001	15.71	0.059	13.82	2.35	0.68	1.28	0.121	-1.64
2002	14.68	0.079	13.80	2.40	0.66	1.08	0.118	-2.24
2003	13.71	0.099	13.82	2.41	0.64	0.91	0.115	-2.26
2004	12.73	0.118	13.74	2.46	0.62	0.77	0.112	-1.68
2005	11.93	0.149	13.68	2.49	0.61	0.64	0.108	-2.93
2006	11.23	0.164	13.61	2.50	0.60	0.54	0.105	-2.93
2007	10.68	0.183	13.54	2.48	0.58	0.46	0.102	-3.43

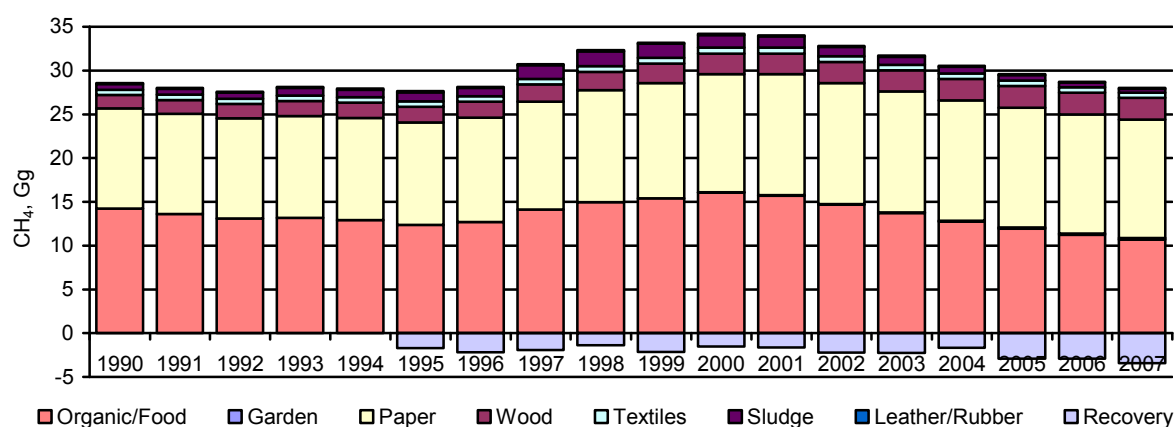


Figure 6.11. CH₄ emissions and recoveries from solid waste disposed in Estonia in 1990–2007, Gg

6.2.4. Source-specific recalculations

There is one recalculation in the estimation of CH₄ emission from solid waste disposed on landfills was carried out in the 2009 submission. The quantities of waste generated (by type of waste) in 1940–1990 were corrected.

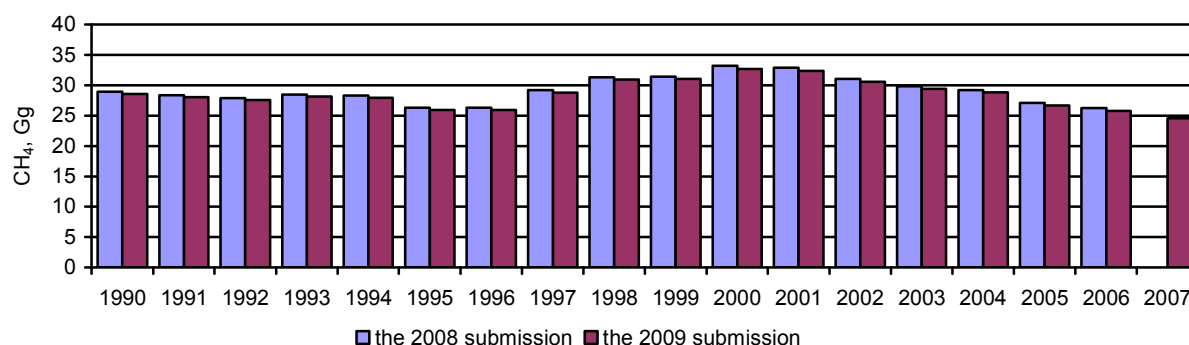


Figure 6.12. CH₄ emission from solid waste disposed onto landfills in Estonia in 1990–2007, Gg

Table 6.10. CH₄ emissions from solid waste disposed in Estonia in 1990–2007, Gg

Year	Reported emissions of CH ₄ in 1990–2006 (the 2008 submission)	Recalculated emissions of CH ₄ (the 2009 submission)
1990	28.93	28.57
1991	28.35	28.03
1992	27.89	27.60
1993	28.47	28.15
1994	28.30	27.95
1995	26.31	25.95
1996	26.32	25.96
1997	29.19	28.81
1998	31.31	30.92
1999	31.43	31.05
2000	33.21	32.67
2001	32.87	32.38
2002	31.03	30.59
2003	29.84	29.44
2004	29.23	28.86
2005	27.11	26.69
2006	26.26	25.81
2007		24.59

6.2.5. Uncertainties and time-series consistency

The estimation of CH₄ emission from municipal waste disposal is carried out based on activity data and emission factors (methane correction factor (MCF), degradable organic carbon (DOC), fraction of DOC, fraction of CH₄ in landfill gas (F)).

Uncertainties of default emission factors used in the estimations are represented in (IPCC, 2000). Values are presented in Table 6.11.

The combined uncertainty rates related to ‘solid waste disposal waste’ sub-category are reported in Chapter 6.1.4.

Table 6.11. Estimated uncertainties of parameters used in the waste sector calculations

Input	Uncertainties	References
<i>Activity data</i>		
Managed Waste Disposal on Land	± 10%	IPCC, 2000. Waste, pp. 5.12
Total uncertainty of waste composition	± 10%	2006 IPCC, Waste, Chapter 3, pp 3.27
<i>Emission factors</i>		
Degradable Organic Carbon (DOC)	-50%...+20%	IPCC, 2000. Waste, pp. 5.12
Fraction of DOC Dissimilated	-30%...0%	IPCC, 2000. Waste, pp. 5.12
Methane Correction Factor	-10%...0%	IPCC, 2000. Waste, pp. 5.12
Fraction of CH ₄ in Landfill Gas	-0%...20%	IPCC, 2000. Waste, pp. 5.12
Methane Recovery (R)	± 10%	2006 IPCC. Waste, pp 3.27
Methane generation rate constant (k)		
k1 = paper/textiles waste	± 17%	2006 IPCC. Waste, Table 3.3, pp 3.17
k2 = wood/rubber waste	± 33%	2006 IPCC. Waste, Table 3.3, pp 3.17
k3 = organic/garden and park waste	-40%...0%	2006 IPCC. Waste, Table 3.3, pp 3.17
k4 = food waste/sewage sludge	-46%...8%	2006 IPCC. Waste, Table 3.3, pp 3.17
k5 = industrial waste	± 11%	2006 IPCC. Waste, Table 3.3, pp 3.17

6.3. Waste incineration (CRF 6.C)

Waste incineration is defined as the combustion of solid and liquid waste in controlled incineration facilities (IPCC, 2006).

6.3.1. Activity data

The activity data on amounts of waste incinerated is collected and reported by the EEIC. The data are reported according to two operations: 1) waste combusted to generate energy (Table 6.12), 2) open-land waste burning (Table 6.13). The data presented in Table 6.12 partly taken into account in Energy sector, thus in order to avoid double accounting the estimates were not carried out. The data on 1990–1994 were interpolated basing on rough assumptions.

Table 6.12. Amounts of waste used to generate energy in Estonia in 1990–2007, tonnes¹⁴²

	Inert waste	Leather and Rubber	Municipal waste	Petroleum-products and Oils	Organic waste	Paper	Plastic	Sludge	Textile	Wood	Total
1990 ¹⁴³	4,166	5	35	1,020	29	31	0	70	18	23,623	29,002
1991	3,472	5	35	935	29	31	0	70	18	26,247	30,847
1992	2,893	5	35	857	29	31	0	70	18	29,164	33,107
1993	2,411	5	35	787	29	31	0	70	18	32,404	35,795
1994	2,009	5	35	723	29	31	0	70	18	36,004	38,929
1995	1,674	12	35	862	24	31	1	70	18	40,005	42,842
1996	1,315	5	6	431	29	33	0	60	35	53,326	55,245
1997	723	1	14	980	45	77	0	60	28	107,311	109,242
1998	176	3	5	1,042	15	48	0	40	5	102,632	103,975
1999	13,618			707	149	51	9	41	0	102,333	116,912
2000	1,140		2	888	94	500	30	792	0	151,586	155,034
2001	12,549		2	1,304	94	474	21	20	0	168,640	183,104
2002	31,598			3,400	246	141	19	762	12	159,086	195,265
2003	48,469		6	4,961	4,277	597	38	30	9	239,421	297,808
2004	37,822	4		6,147	7,430	574	20	80	6	215,790	267,874
2005	26,373			5,212	1,989	463	19	53	6	263,892	298,018
2006	27,561			5,141	1,048	10	0	0	197	222,607	256,567
2007	42,356			1,676	783	11	0	2	87	291,902	336,870

Table 6.13. Amounts of waste incinerated on land in Estonia in 1990–2007, tonnes¹⁴⁴

	Inert waste	Leather and Rubber	Municipal waste	Petroleum-products and Oils	Organic waste	Paper	Plastic	Sludge	Textile	Wood	Total
1990	41	6	12	165	27	117	10	1	22	7,280	7,682
1991	41	6	12	164	27	117	10	1	22	7,663	8,065
1992	41	6	12	163	27	117	10	1	22	8,067	8,467
1993	41	6	12	164	27	117	10	1	22	8,491	8,893
1994	41	6	12	167	27	117	10	1	22	8,938	9,342
1995	41	15	23	292	15	389	5	2	61	17,237	18,084
1996		2	14	149	24	35	4		25	22,445	22,699
1997		4	2	90	55	40	12		2	276	482
1998	41	5	8	135	14	7	19		0	90	319
1999	122			145		16	10			4,643	12,979
2000	466		3	2	41	2	5			815	9,301
2001	436			2	482	19		13		3	961
2002	125			124	15	10			135	272	696
2003	86			203	3	3		1	130	122	566
2004	2,063			52	1	2			321		2,457
2005	63			106	0	2			176	10	366
2006					0				40		41
2007									14	7	21

¹⁴² R1 operation of the waste recovery activities – Use principally as a fuel or other means to generate energy¹⁴³ The data of 1990-1994 was interpolated¹⁴⁴ D10 operation of the waste recovery activities – Incineration on land

Figure 6.13 and Figure 6.14 illustrate the total amounts of waste incinerated and the quantities of fossil carbon fraction contained in waste incinerated in Estonia in 1990–2007. More than 2 thousand tonnes of waste from construction activities were incinerated in 2004, this fact explains the sharp increase in 2004 in the trend.

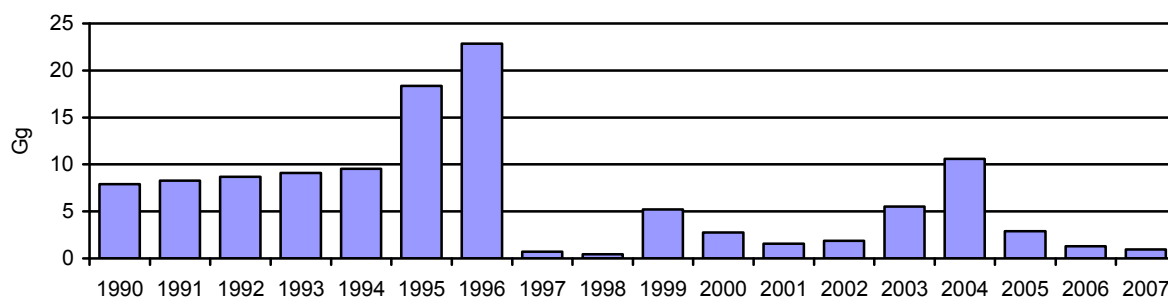


Figure 6.13. Amounts of waste incinerated in Estonia in 1990–2007, Gg

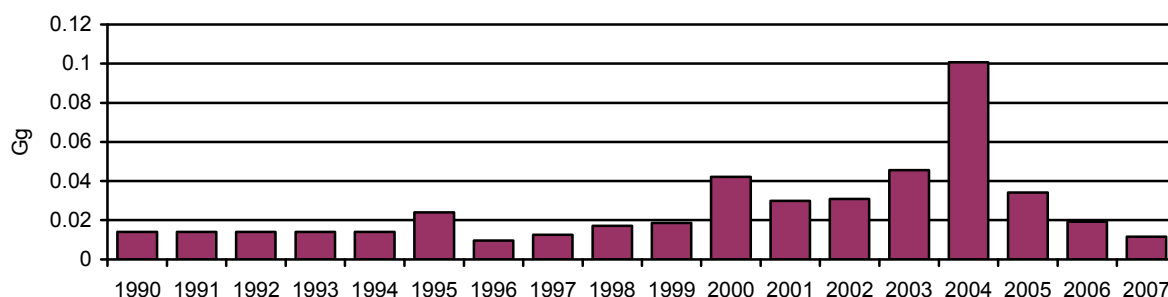


Figure 6.14. Quantity of fossil carbon fraction contained in waste burned in Estonia in 1990–2007, Gg

6.3.2. Methodology, data availability and sources, emission factors

Tier 1 approach was employed in order to estimate GHG emissions from solid waste burnt in controlled incineration facilities (IPCC, 2006).

CO₂ emission estimate based on the total amount of waste combusted

$$\text{CO}_2 \text{ emissions, Gg/yr} = \sum_i (\text{SW}_i \cdot dm_i \cdot \text{CF}_i \cdot \text{FCF}_i \cdot \text{OF}_i) \cdot 44/12 \quad (6.4)^{145}$$

CO₂ Emissions – CO₂ emissions in inventory year, Gg/yr;

SW_i – total amount of solid waste of type *i* (wet weight) incinerated or open-burned, Gg/yr;

¹⁴⁵ The 2006 IPCC Guidelines, Chapter 5: Incineration and Open Burning of Waste, pp 5.7, equation 5.1

dm_i – dry matter content in the waste (wet weight) incinerated or open-burned, (fraction);

CF_i – fraction of carbon in the dry matter (total carbon content), (fraction);

FCF_i – fraction of fossil carbon in the total carbon, (fraction);

O_i – oxidation factor, (fraction);

44/12 – conversion factor from C to CO₂;

i – type of waste incinerated/open-burned specified as follows:

MSW: municipal solid waste

ISW: industrial solid waste

SS: sewage sludge

HW: hazardous waste

CW: clinical waste, others (that must be specified)

Table 6.14. Default dry matter content, total carbon content and fossil carbon content of different waste components^{146,147,148}

Waste component	Dry matter content in % of wet weight	Total carbon content in % of dry matter	Fossil carbon fraction in % of total carbon
Municipal waste			
Paper/cardboard	90	46	1
Textiles	80	50	20
Food waste	40	38	-
Wood	85	50	-
Garden and park waste	40	49	0
Rubber and Leather	84	67	20
Plastics	100	75	100
Other, inert waste	90	3	100
Industrial waste			
Food, beverages and tobacco	40	15	-
Textile	80	40	16
Wood and wood products	85	43	-
Pulp and paper	90	41	1
Petroleum products, Solvents,			
Plastics	0	80	80
Rubber	84	56	17
Hazardous waste	10–90	NA	5–50
Clinical waste	65	40	25

N₂O emission estimate based on the waste input to the incinerators

$$N_2O_{\text{emissions}}, Gg/yr = \sum_i (IW_i \cdot EF_i) \cdot 10^{-6} \quad (6.5)^{149}$$

¹⁴⁶ Table 2.4 of the 2006 IPCC Guidelines, pp 2.14

¹⁴⁷ Table 2.5 of the 2006 IPCC Guidelines, pp 2.16

¹⁴⁸ Table 2.6 of the 2006 IPCC Guidelines, pp 2.16

N_2O Emissions – N_2O emissions in inventory year, Gg/yr;

IW_i – amount of incinerated waste of type i , Gg/yr;

EF_i – N_2O emission factor for waste of type i , kg N_2O /Gg of waste;

10^{-6} – conversion to gigagram;

i – category or type of waste incinerated/open-burned, specified as follows:

MSW: municipal solid waste

ISW: industrial solid waste

HW: hazardous waste

CW: clinical waste

SS: sewage sludge, others (that must be specified).

Table 6.15. N_2O emission factors for incineration of waste¹⁵⁰

Waste category	Emission factor, g N_2O / t waste incinerated	Weight basis
MSW	8 ¹⁵¹	wet basis
Industrial waste	100	wet basis
Sludge (except sewage sludge)	450	wet basis
Sewage sludge	900	wet basis

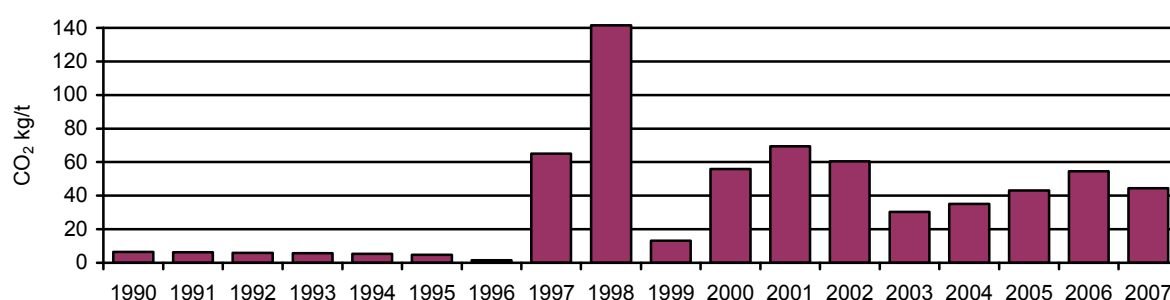


Figure 6.15. Averaged CO_2 emission factors implied in the estimates for 1990–2007, CO_2 kg/t

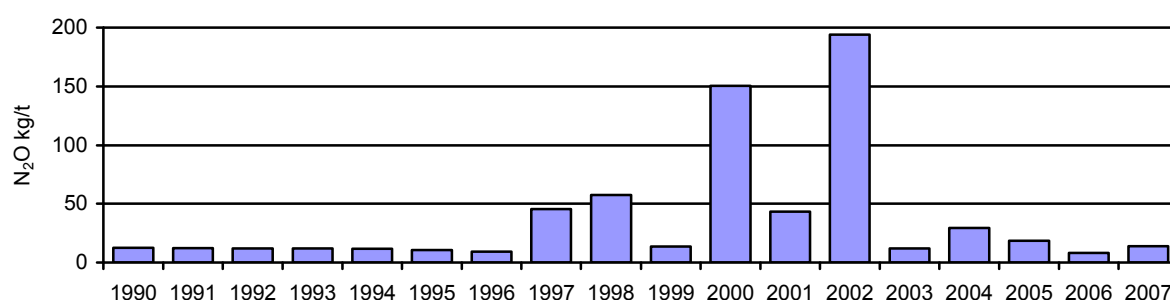


Figure 6.16. Averaged N_2O emission factors implied in the estimates for 1990–2007, N_2O kg/t

¹⁴⁹ The 2006 IPCC Guidelines, Chapter 5: Incineration and Open Burning of Waste, pp 5.14, equation 5.5

¹⁵⁰ Table 5.5 of the 2006 IPCC Guidelines, Chapter 5, pp 5.21

¹⁵¹ An experience of Germany

6.3.3. Quantitative overview – CO₂ and N₂O emissions from solid waste incineration

CO₂ and N₂O emissions from solid waste incineration made up 0.042 and 0.013Gg accordingly. The sharp increases in 1995–1996, 2000, in 2002 and in 2004 were due to large amounts of wood- and sludge-waste incinerated.

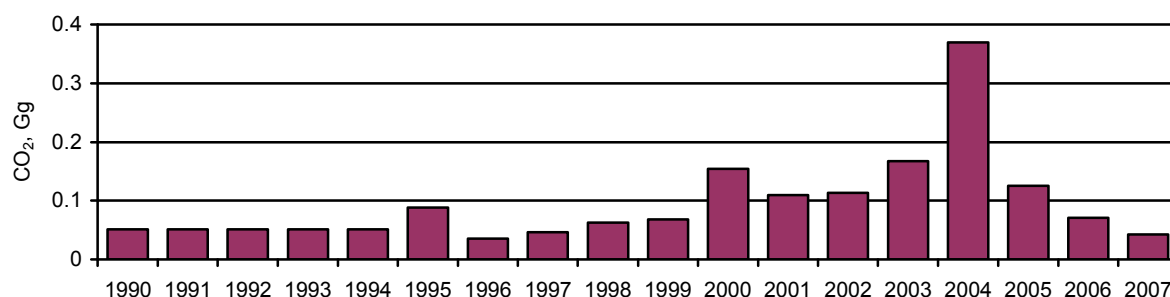


Figure 6.17. Emissions of CO₂ from waste incineration in 1990–2007, Gg

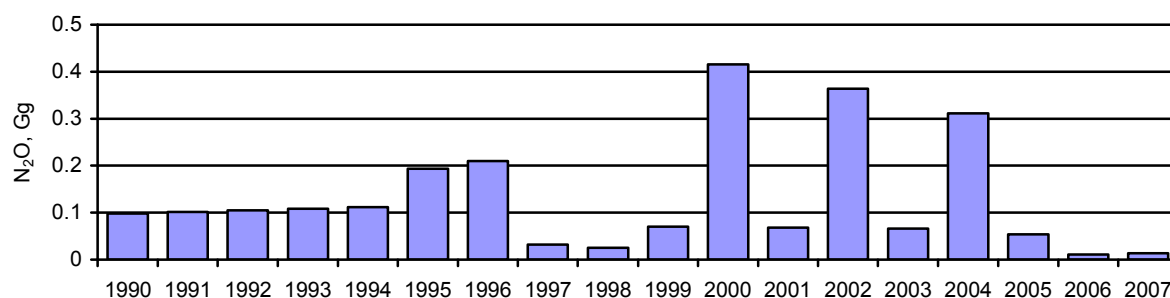


Figure 6.18. Emissions of N₂O from waste incineration in 1990–2007, Gg

6.3.4. Uncertainties and time-series consistency

The estimation of GHG emissions from waste combustion is carried out taking into account the activity data (amounts of waste burned) and emission factors. Values employed in the estimates are presented in Table 6.16.

The combined uncertainty rates related to ‘waste incineration’ sub-category are reported in Chapter 6.1.4.

Table 6.16. Estimated values of uncertainties used in ‘Waste Incineration’ category of the Waste Sector

Input	Uncertainties	References
<i>Activity data</i>		
Amounts of waste incinerated ¹⁵²	± 10%	IPCC, 2000. Waste, pp. 5.12
<i>Emission Factors</i>		
Total carbon content:		
Paper/cardboard	± 9%	IPCC 2006, Waste, Table 2.4, pp 2.14
Textiles	-50%...0%	IPCC 2006, Waste, Table 2.4, pp 2.14
Food waste	-47%...+32%	IPCC 2006, Waste, Table 2.4, pp 2.14
Wood	± 8%	IPCC 2006, Waste, Table 2.4, pp 2.14
Garden and park waste	-8%...+12%	IPCC 2006, Waste, Table 2.4, pp 2.14
Plastics	-11%...+13%	IPCC 2006, Waste, Table 2.4, pp 2.14
Other, inert waste	-100%...+67%	IPCC 2006, Waste, Table 2.4, pp 2.14
Hazardous waste	± 82%	IPCC 2006, Waste, Table 2.4, pp 2.14
Fossil carbon fraction:		
Paper/cardboard	-100%...+400%	IPCC 2006, Waste, Table 2.4, pp 2.14
Textiles	-100%...+150%	IPCC 2006, Waste, Table 2.4, pp 2.14
Plastics	-5%...0%	IPCC 2006, Waste, Table 2.4, pp 2.14
Other, inert waste	-50%...0%	IPCC 2006, Waste, Table 2.4, pp 2.14
Hazardous waste	± 82%	IPCC 2006, Waste, Table 2.4, pp 2.14

6.4. Biological Treatment (Composting) of Waste (CRF 6.D)

Composting and anaerobic digestion of organic waste, such as food waste, garden (yard) and park waste and sludge, is common in many countries (IPCC, 2006).

6.4.1. Activity data

The data on amounts of waste biologically treated in Estonia in 1990–2007 are reported in Table 6.17.

Inert and petroleum product wastes consist of soils and stone, and wastes from the oil shale industry, and plastic wastes were not taken into account in the estimates of emissions from waste composting processes.

¹⁵² Managed Waste Disposal on Land

Table 6.17. Amounts of waste used for composting in Estonia in 1990–2007, tonnes¹⁵³

	Inert waste	Leather and Rubber	Municipal waste	Petroleum-products and Oils	Organic waste	Paper	Plastic	Sludge	Textile	Wood
1990	<i>n.d.¹⁵⁴</i>	<i>n.d.</i>	<i>n.d.</i>	<i>n.d.</i>	3,751	364	<i>n.d.</i>	127	144	2,753
1991	<i>n.d.</i>	<i>n.d.</i>	<i>n.d.</i>	<i>n.d.</i>	3,948	383	<i>n.d.</i>	127	144	2,898
1992	<i>n.d.</i>	<i>n.d.</i>	<i>n.d.</i>	<i>n.d.</i>	4,156	404	<i>n.d.</i>	127	144	3,050
1993	<i>n.d.</i>	<i>n.d.</i>	<i>n.d.</i>	<i>n.d.</i>	4,375	425	<i>n.d.</i>	127	144	3,211
1994	<i>n.d.</i>	<i>n.d.</i>	<i>n.d.</i>	<i>n.d.</i>	4,605	447	<i>n.d.</i>	127	144	3,380
1995	394	1	1	60	4,847	471	15	127	366	3,558
1996	2,221	3		30	30,481	846	129		59	133
1997	17,462	11		3,113	62,341	890	17	102	72	1,993
1998	9,763	61		617	4,340	565	32	78	80	1,494
1999	5,731			11	6,226	600	29	220	319	3,480
2000	10,986			792	22,073	830		120	419	3,277
2001	2,187			782	20,241	775		12,168		2,498
2002	42,710			1	20,992	694	11	6,104	54	71,109
2003	692,465		84	1,687	130,504	2,988	214	35,904	83	128,339
2004	252,075		3,752		110,599	3,657	3,533	55,062	344	229,993
2005	465,582		1,210	861	184,907	5,032	5,377	68,527	52	220,197
2006	349,156		54	710	176,229	6,564	9,570	84,575	109	402,866
2007	436,230		39	1,408	147,632	5,757	7,763	161,147	34	465,204

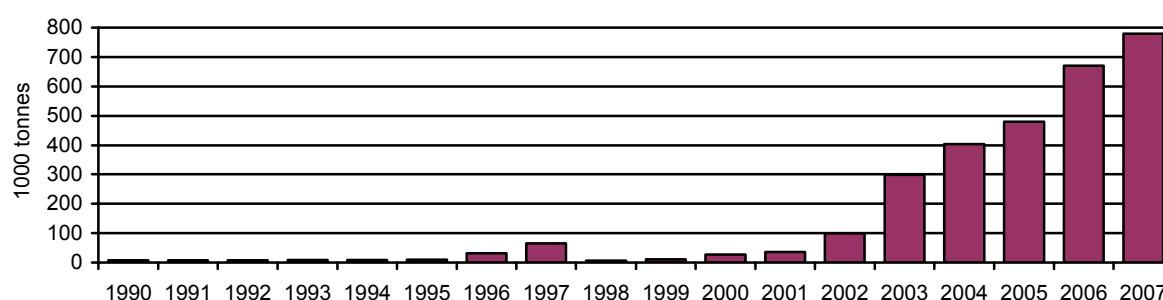


Figure 6.19. Amounts of organic waste used in composting in Estonia in 1990–2007, tonnes

6.4.2. Methodology, data availability and sources, emission factors

Tier 1 approach was used in order to estimate emissions from biological treatment of solid waste (IPCC, 2006).

$$\text{CH}_4, \text{Gg} = \sum_i (\text{M}_i \cdot \text{EF}_i) \cdot 10^{-3} - \text{R} \quad (6.6)^{155}$$

CH₄ Emissions – total CH₄ emissions in inventory year, Gg CH₄;

¹⁵³ The data of 1990–1995 were interpolated basing on rough assumptions made

¹⁵⁴ n.d. – not determined

¹⁵⁵ IPCC 2006, Chapter 4, equation 4.1, pp 4.5

M_i – mass of organic waste treated by biological treatment type i , Gg

EF – emission factor for treatment i , g CH₄/kg waste treated;

i – composting or anaerobic digestion;

R – total amount of CH₄ recovered in inventory year, Gg CH₄.

$$N_2O, Gg = \sum_i (M_i \cdot EF_i) \cdot 10^{-3} \quad (6.7)^{156}$$

N₂O Emissions – total N₂O emissions in inventory year, Gg N₂O;

M_i – mass of organic waste treated by biological treatment type i , Gg;

EF – emission factor for treatment i , g N₂O/kg waste treated;

i – composting or anaerobic digestion.

Table 6.18. Default emission factors for CH₄ and N₂O emissions from biological treatment of waste¹⁵⁷

Type of biological treatment	CH ₄ emission factors (g CH ₄ /kg waste treated)	N ₂ O emission factors (g N ₂ O/kg waste treated)
Composting	4	0.3

6.4.3. Quantitative overview – CH₄ and N₂O emissions from biological treatment of waste

CH₄ and N₂O emissions from waste biologically treated were 3.12Gg and 0.23Gg respectively in 2007. As seen from Figure 6.20–Figure 6.21, GHG emissions are increasing due to increase in amount of waste biologically treated.

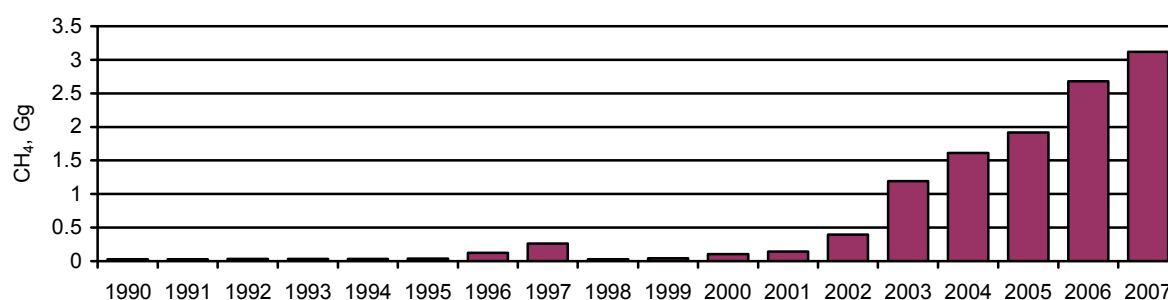


Figure 6.20. Emissions of CH₄ from biological treatment of waste in Estonia in 1990–2007, Gg

¹⁵⁶ IPCC 2006, Chapter 4, equation 4.2, pp 4.5

¹⁵⁷ on a wet basis, Table 4.1 of the 2006 IPCC, Chapter 4, pp 4.6

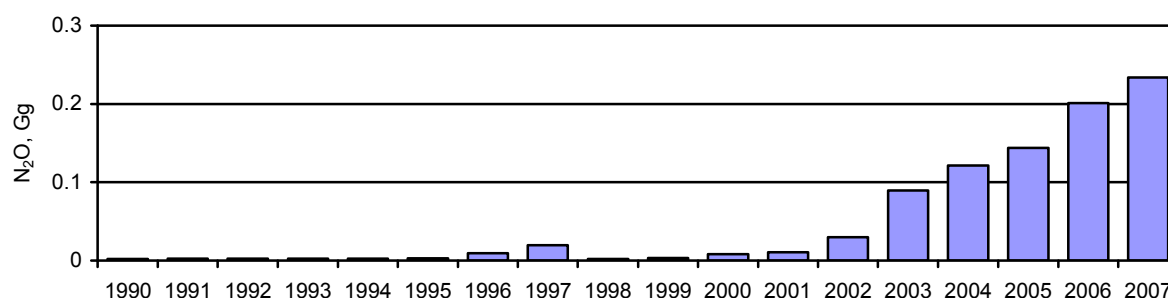


Figure 6.21. Emissions of N₂O from biological treatment of waste in Estonia in 1990–2007, Gg

6.4.4. Uncertainties and time-series consistency

The estimation of GHG emissions from biological waste treatment is carried out taking into account activity data and emission factors. Values employed in the estimates are presented in Table 6.19.

The combined uncertainty rates related to ‘biological treatment’ sub-category are reported in Chapter 6.1.4.

Table 6.19. Estimated values of uncertainties used in ‘composting’ category of the Waste Sector

Input	Uncertainties	References
<i>Activity data</i>		
Managed Waste Disposal on Land	± 10%	IPCC, 2000. Waste, pp. 5.12
<i>Emission factors</i>		
Emission factor for treatment (CH ₄)	-99%...+100%	2006 IPCC, Waste, Chapter 4, pp 4.6
Emission factor for treatment (N ₂ O)	-80%...+100%	2006 IPCC, Waste, Chapter 4, pp 4.6

6.5. Sludge Application on Agricultural Land

Sludge from domestic and industrial wastewater treatment plants is used on agricultural land. Emissions from sludge applied on land are reported in the Agriculture Sector.

6.5.1. Activity data

The activity data on amounts of sludge recycled are collected by EEIC. The data in Table 6.20 illustrates the share of sludge used for improvement of environmental situation. In 2006, the

quantity of sludge produced by a enterprise of pulp industry was 5 times higher than in the previous years, however the dry matter content of sludge generated is low – 0.06%.

Table 6.20. Amounts of Municipal Sludge Application on agricultural land, tonnes¹⁵⁸

Year	Sludge
1990	45,069
1991	53,533
1992	6,616
1993	89,666
1994	90,594
1995	134,542
1996	153,382
1997	108,813
1998	163,341
1999	174,327
2000	278,846
2001	190,515
2002	175,466
2003	237,289
2004	7,238
2005	10,739
2006	1,703,383 ¹⁵⁹
2007	7,738

6.5.2. Methodology, data availability and sources, emission factors

The *Tier 1* approach was employed in order to estimate N₂O emission from sludge applied on agricultural land (IPCC, 1997).

$$F_{SL} = N_{FERT} \times (1 - \text{Frac}_{GASF}) \quad (6.8)^{160}$$

N_{FERT} - Total use of sludge applied on agricultural land in country, kg N/year;

Frac_{GASF} – Fraction of total sludge nitrogen that is emitted as NO_x+NH₃, kg N/kg N;

$$N_2O_{direct} - N = F_{SL} \bullet EF \bullet 44/28_1 \quad (6.9)$$

EF – emission factor.

The emission factors used in the estimates are presented in Table 6.21.

¹⁵⁸ R10 of the European Waste Catalogue (2002)

¹⁵⁹ Where 1,683,690 tonnes was sludge from ‘Wood processing and the production of panels and furniture, pulp, paper and cardboard’ with dry matter at 0.06%

¹⁶⁰ The 1996 Revised IPCC Guidelines. Agriculture. Workbook. Equation1, pp 4.33

Table 6.21. Parameters and Factors used in the estimates

Factors	Value	
FracGASF	0.10 ¹⁶¹	kg NH ₃ -N + NO _x -N/kg of sludge nitrogen applied
EF for F _{SL}	1.25%	
Sludge (sewage) N content	5 ¹⁶²	% dry matter
Sludge N content (from pulp and paper industry)	0.87 ¹⁶³	% dry matter

6.5.3. Quantitative overview – N₂O emission from sludge applied on agricultural land (CRF 4.D.1.6)

The total N₂O emission from sludge applied on agricultural land was 0.001Gg in 2007 (Figure 6.22). Since 2004, the sharp decreased in N₂O emission has taken place due to decreases in amounts of sludge applied on agricultural lands.

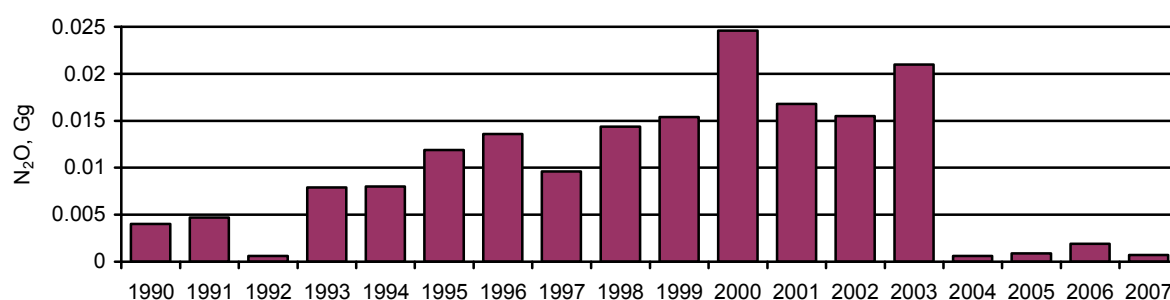


Figure 6.22. Emissions of N₂O from sludge applied on agricultural land in Estonia in 1990–2007, Gg

¹⁶¹ The 1996 Revised IPCC Guidelines. Agriculture. Reference Manual. Table 4-17- Summary of default values for parameters, pp. 4.35

¹⁶² 'CH₄ and N₂O Emissions from Waste Water Handling' background paper

¹⁶³ Tucker, 2005.

6.6. N₂O emission from human consumption followed by municipal sewage treatment (CRF 6.B.2.2)

6.6.1. Source category description

Human consumption of food results in the production of sewage, that can be processed in septic systems or wastewater treatment facilities, and may then seep into groundwater systems, be disposed of directly on land, or be discharged into a water source (e.g. rivers and estuaries) (IPCC, 2000).

6.6.2. Methodology, data availability and sources, emission factors

The default IPCC (the *Tier 1*) method was used to estimate emissions from the atmospheric deposition.

$$N_2O - N = \text{PROTEIN} \bullet N_{r_{\text{PEOPLE}}} \bullet \text{Frac}_{\text{NPR}} \bullet \text{EF}_6 \quad (6.10)^{164}$$

PROTEIN – The annual per capita protein consumption, kg protein/person-year;

$N_{r_{\text{PEOPLE}}}$ - The national population;

Frac_{NPR} - The fraction of protein that is nitrogen, kg N/kg of protein (Table 6.22);

Table 6.22. Factors used in the algorithm of human consumption followed by municipal sewage treatment

Factor	Value
Frac_{NPR}	0.16 kg N/kg of protein ¹⁶⁵
EF_6	0.01 kg N ₂ O-N/ kg N discharged sewage effluent ¹⁶⁶

The data on population of Estonia were obtained from the ESO, the annual per capita protein consumption was used from FAO statistical databases – 101 g/person/day¹⁶⁷ (for 2004–2007).

¹⁶⁴ IPCC 2000. Agriculture. Equation 4.39, pp. 4.72

¹⁶⁵ IPCC 1996. Agriculture. Workbook. Table 4-24 - Default values of parameters for indirect emissions. pp 4.106

¹⁶⁶ IPCC 1996. Agriculture. Workbook. Table 4-18 – Default emission factors for estimating indirect N₂O emissions from N used in agriculture. pp 4.73

¹⁶⁷ Dietary energy, protein and fat consumption, FAO

6.6.3. Quantitative overview – Human consumption followed by municipal sewage treatment

The total N₂O emission from human sewage was 0.124Gg in Estonia in 2007. Since 1990 and until 2004, the emissions have declined slightly due to decreasing population, however since 2004 the slight increase has taken place due to increase in protein consumption factor – from 90 (in 1990–2003) to 101 (in 2004–2007) g/person/day.

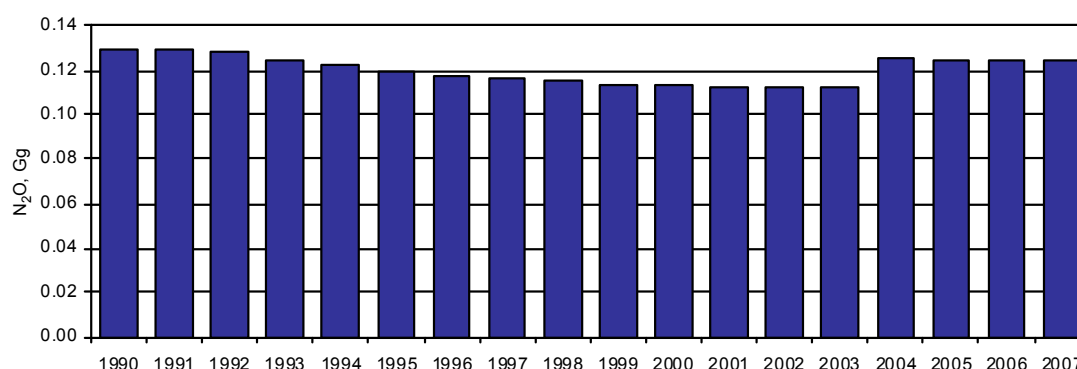


Figure 6.23. N₂O emissions from Human sewage in Estonia in 1990–2007, Gg

6.6.4. Source-specific recalculations

There is one recalculation carried out in the 2009 submission: an omission made in the 2008 submission was fixed. It was reported in the 2008 submission that protein consumption factor at 101 g/person/day was used, however the value at 90 g/person/day was employed in the estimates.

Table 6.23. N₂O emission from wastewater treatment (human sewage) in Estonia in 1990–2007, Gg

Year	Reported emissions of N ₂ O in 1990–2006 (the 2008 submission)	Recalculated emissions of N ₂ O (the 2009 submission)
1990	0.1297	0.1297
1991	0.1295	0.1295
1992	0.1284	0.1284
1993	0.1248	0.1248
1994	0.1220	0.1220
1995	0.1196	0.1196
1996	0.1177	0.1177
1997	0.1161	0.1161
1998	0.1151	0.1151
1999	0.1139	0.1139
2000	0.1133	0.1133
2001	0.1129	0.1129

Year	Reported emissions of N ₂ O in 1990–2006 (the 2008 submission)	Recalculated emissions of N ₂ O (the 2009 submission)
2002	0.1124	0.1124
2003	0.1120	0.1120
2004	0.1116	0.1252
2005	0.1113	0.1249
2006	0.1111	0.1246
2007		0.1244

6.6.5. Uncertainty and time-series consistency

The data on protein consumption per capita were plotted from FAO databases, the uncertainty of this parameter is not recorded. Thus, this factor was not considered in the 2007 submission. The uncertainty in number of population was described in the ‘Domestic and Commercial Wastewater’ chapter.

The Nitrogen (N₂O) emission factor is presented in the IPCC ([IPCC, 1997](#)). The IPCC gives an uncertainty of the factor -80%...100%, as a value of the factor is 0.01 with a range of 0.002–0.02.

The combined uncertainty rates related to ‘human sewage’ sub-category are reported in Chapter 6.1.4.

Table 6.24. Estimated values of uncertainties used in waste sector

Input	Uncertainties	References
<i>Activity data</i> Population	± 5%	IPCC, 2000. Waste, pp. 5.19
<i>Emission factors</i> Emission factor (human sewage)	-80%...100%	Table 4-23 of the 1996 IPCC Guidelines, pp. 4.105

DISPOSAL OPERATIONS

- D 1 Deposit into or onto land (e.g. landfill, etc.)
- D 2 Land treatment (e.g. biodegradation of liquid or sludgy discards in soils, etc.)
- D 3 Deep injection (e.g. injection of pumpable discards into wells, salt domes or naturally occurring repositories, etc.)
- D 4 Surface impoundment (e.g. placement of liquid or sludgy discards into pits, ponds or lagoons, etc.)
- D 5 Specially engineered landfill (e.g. placement into lined discrete cells which are capped and isolated from one another and the environment, etc.)
- D 6 Release into a water body except seas/oceans
- D 7 Release into seas/oceans including sea-bed insertion
- D 8 Biological treatment not specified elsewhere in this Annex which results in final compounds or mixtures which are discarded by means of any of the operations numbered D 1 to D 12
- D 9 Physico-chemical treatment not specified elsewhere in this Annex which results in final compounds or mixtures which are discarded by means of any of the operations numbered D 1 to D 12 (e.g. evaporation, drying, calcination, etc.)
- D 10 Incineration on land
- D 11 Incineration at sea
- D 12 Permanent storage (e.g. emplacement of containers in a mine, etc.)
- D 13 Blending or mixing prior to submission to any of the operations numbered D 1 to D 12
- D 14 Repackaging prior to submission to any of the operations numbered D 1 to D 13
- D 15 Storage pending any of the operations numbered D 1 to D 14 (excluding temporary storage, pending collection, on the site where it is produced)

RECOVERY OPERATIONS

- R 1 Use principally as a fuel or other means to generate energy
- R 2 Solvent reclamation/regeneration
- R 3 Recycling/reclamation of organic substances which are not used as solvents (including composting and other biological transformation processes)
- R 4 Recycling/reclamation of metals and metal compounds
- R 5 Recycling/reclamation of other inorganic materials
- R 6 Regeneration of acids or bases
- R 7 Recovery of components used for pollution abatement
- R 8 Recovery of components from catalysts
- R 9 Oil re-refining or other reuses of oil
- R 10 Land treatment resulting in benefit to agriculture or ecological improvement
- R 11 Use of wastes obtained from any of the operations numbered R 1 to R 10
- R 12 Exchange of wastes for submission to any of the operations numbered R 1 to R 11
- R 13 Storage of wastes pending any of the operations numbered R 1 to R 12 (excluding temporary storage, pending collection, on the site where it is produced)

PART II: Kyoto Protocol reporting

1. Information on activities under Articles 3.3 and 3.4

1. Does your country have quantitative estimates of the projected anthropogenic greenhouse gas emissions and removals from forestry activities under Article 3.3 of the Kyoto Protocol during the commitment period? If available, please indicate any projected estimates per activity (afforestation, reforestation and deforestation) as well as projected net estimates under Article 3.3 and indicate the carbon pools covered by the estimates. If no quantitative projections are available, please include qualitative information if forestry activities under Article 3.3 are expected to be a net source or a net sink during the commitment period.

Estonia has chosen to account for the activities under Article 3.3 (afforestation, reforestation and deforestation) for the whole commitment period “Report to facilitate the estimation of Estonia’s assigned amount under the Kyoto Protocol, 2007”.

The study of availability of data required for estimation carbon flows under Article 3.3 was carried out in Estonia. However, until now Estonia does not have quantitative estimates of the projected anthropogenic GHG flows (emissions and removals) from forestry under Article 3.3 of the Kyoto Protocol during the commitment period.

According to “Estonian Forestry Development Programme until 2010” Estonia plans to implement the following activities, which could be considered to be a net source or a net sink during the commitment period:

Activity	Period
Elaboration and implementation of a programme for the reconstruction of former agricultural lands overgrown with bushes	2003 - 2010

In addition to the activity set up in the Forestry Development Programme, Estonian Agricultural Register and Information Board established price supports for forest owners in order to launch actions aimed at improving conditions of disturbed and damaged forest and young forest.

2. Does your country plan to account for net emissions and removals from activities under Article 3.4 of the Kyoto Protocol? If yes, which of the individual activities, such as forest management, cropland management, grazing land management or revegetation are expected to be accounted for?

Estonia does not have reliable estimates of the GHG emissions/removals from activities under Article 3.4 for the first commitment period. “Report to facilitate the estimation of Estonia’s assigned amount under the Kyoto Protocol, 2007”.

Therefore, Estonia does not plan to account GHG flows (emissions and removals) from activities under Article 3.4 of the Kyoto Protocol.

3. In which stage of decision-making process are these plans (planned, adopted, implemented)?

All activities set up under Article 3.3 of the Kyoto Protocol are carried out (adopted and implemented through programs of development of forest sector and corresponding legislative acts) in Estonia.

4. Does your country have quantitative estimates of the projected net anthropogenic greenhouse gas emissions and removals from activities under Article 3.4 for the first commitment period? If available, please indicate the estimates per individual activity (forest management, cropland management, grazing land management or revegetation) and indicate the carbon pools covered by the estimates. If you intent to account for forest management, will the country-specific maximum for forest management activities agreed in the Marrakech Accords be fully utilized by your country?

Estonia does not have reliable estimates of the GHG emissions/removals from activities under Article 3.4 for the first commitment period. In accounting for forest management, data reported by National Forest Inventory have been used “Report to facilitate the estimation of Estonia’s assigned amount under the Kyoto Protocol, 2007”.

2. Information on Kyoto Protocol units and discrepancies

Information is presented in Standard Independent Assessment Report (Annex 10).

3. Changes in National System

There have been changes in the Energy, Industrial Processes and LULUCF sector.

CH₄ emissions of the whole time series 1990-2007 from the source category CRF 1.B.1.A Oil Shale mining and Handling are removed in the current inventory report. After consultancy with leading researchers of the Mining Department of Tallinn University of Technology become clear, that there is not CH₄ emissions from Oil Shale mines as oil shale is located very close to the surface of the earth and the methane. This resulted decreases of CO₂ emissions as follows (see Table 2.35 in NIR 1990-2007).

In 2009 submissions Estonia reports for the first time total F-gas emissions from some Refrigeration and Air Conditioning Equipment sub sectors, such as domestic refrigeration, commercial refrigeration, transport refrigeration, industrial refrigeration and mobile air conditioning, as they were previously not reported or reported partly. In 2009 Estonia reports for the first time emissions from fire extinguishers, sport shoe soles, general and novelty aerosols. Activity data, emissions factors and emissions were determined methodologically as far as possible in a country specific way (Tier 2a according to IPCC 2006 guidelines). In 2009 submissions Estonia presents F-gas time series (1995-2007).

Emissions/removals related to cropland, grassland and wetlands were estimated for the first time in the 2009 submission. The activity data on forest land were updated also in the current submission. The IPCC Tier 1 approach was employed in the estimates of carbon emissions/removals. The activity data used in the estimates are obtained from national statistics and reports. The method, activity data used still are being under development in Estonia due to wide range of datasets needed to complete high-quality inventory. Estonian experts are continuing to collect data required to improve the inventory and to estimate accurate GHG emissions/removals inventory (with low uncertainties) in the LULUCF sector.

4. Changes in National Registry

Information is presented in Standard Independent Assessment Report (Annex 10).

5. Estonia's commitment period reserve

The commitment period reserve is calculated in accordance with decision 11/CMP.1 as 90% of the proposed assigned amount or 100% of its most recently reviewed inventory times five, whichever is lowest.

Estonia has interpreted the “most recently reviewed inventory” the inventory for the year 2007. This would mean that the five times the emissions from the total inventory of 2007 would be lower, than 90% of the assigned amount. This would give an estimated commitment period reserve of **110,093,385 tonnes CO₂ eq.**

$$22018.68 \times 5 = 110093.39 \text{ Gg CO}_2 = 110\,093\,385 \text{ t CO}_2$$

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