OFFICE OF ENVIRONMENTAL PROTECTION (OEP)
PRINCIPALITY OF LIECHTENSTEIN

Liechtenstein's Greenhouse Gas Inventory 1990 - 2007

National Inventory Report 2009

Submission of 2 April 2009
under the United Nations Framework Convention on Climate Change
and under the Kyoto Protocol

LIECHTENSTEIN

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Table of Contents

Glossary

ART	Agroscope Reckenholz-Tänikon Research Station (former name: Swiss Federal Research Station for Agroecology and Agriculture)
AZV	Abwasserzweckverband der Gemeinden Liechtensteins (Liechtenstein's wastewater administration union)
CH_4	Methane
CHP	Combined heat and power production
CO	Carbon monoxide
CO_2, (CO_2 eq)	Carbon dioxide (equivalent)
CRF	Common reporting format
dm	dry matter
FAL	Swiss Federal Research Station for Agroecology and Agriculture (since 2006: ART)
FCCC	Framework Convention on Climate Change
FOEN	Swiss Federal Office for the Environment (former name SAEFL)
Gg	Giga gramme (10^9 g = 1'000 tons)
GHFL	Genossenschaft für Heizöllagerung im Fürstentum Liechtenstein (Co-operation for the Storage of Gas Oil in the Principality of Liechtenstein)
GHG	Greenhouse gas
GWP	Global Warming Potential
HFC	Hydrofluorocarbons (e.g. HFC-32 difluoromethane)
IPCC	Intergovernmental Panel on Climate Change
kilotonnes	1000 tonnes
LFO	Light fuel oil (Gas oil)
LGV	Liechtensteinische Gasversorgung (Liechtenstein's gas utility)
LKW	Liechtensteinische Kraftwerke (Liechtenstein's electric power company)
LPG	Liquefied Petroleum Gas (Propane/Butane)
LULUCF	Land-Use, Land-Use Change and Forestry
MJ	Mega Joule (10^6 Joule = 1'00'000 Joule)
MSW	Municipal solid waste
NFR	Nomenclature for reporting (IPCC code of categories)
NIC	National Inventory Compiler
NIR	National Inventory Report
NIS	National Inventory System
NMVOC	Non-methane volatile organic compounds
N_2O	Nitrous oxide (laughing gas)

NO_x	Nitrogen oxides
OA	Office of Agriculture
OEA	Office of Economic Affairs
OEP	Office of Environmental Protection
OFIVA	Office of Food Inspection and Veterenary Affairs
OFNLM	Office of Forests, Nature and Land Management
OS	Office of Statistics
PFC	Perfluorinated carbon compounds (e.g. Tetrafluoromethane)
QA/QC	Quality assurance/quality control: QA includes a system of review procedures conducted by persons not directly involved in the inventory development process. QC is a system of routine technical activities to control the quality of the inventory.
SAEFL	Swiss Agency for the Environment, Forests and Landscape (former name of Federal Office for the Environment FOEN)
SF_6	Sulphur hexafluoride
SLP	Stabstelle für Landesplanung, Office of Land Use Planning
SO_2	Sulphur dioxide
TJ	Tera Joule (10^{12} Joule = 1'00'000 Mega Joule)
UNFCCC	United Nations Framework Convention on Climate Change

Executive Summary

Introduction

In 1995, the Principality of Liechtenstein ratified the United Nations Framework Convention on Climate Change (UNFCCC). Furthermore in 2004, Liechtenstein ratified the Kyoto Protocol to the UNFCCC. A National Inventory System (NIS) according to Article 5.1 of the Kyoto Protocol has been implemented.

In 1995, 2001 and 2006, Liechtenstein submitted its National Communication Reports to the secretariat of the UNFCCC. Also, a first Greenhouse Gas Inventory (without National Inventory Report) was submitted in the Common Reporting Format (CRF) in 2005. In 2006, two submissions took place, the first on 31 May including the national greenhouse gas inventory for 1990 and 2004 as well as the National Inventory Report. The second submission on 22 December 2006 contained the national greenhouse gas inventory for the whole time period 1990–2004, National Inventory Report and the Initial Report under Article 7, paragraph 4 of the Kyoto Protocol (OEP 2006, 2006a, 2007). In May 2007 the GHG inventory 1990–2005 was submitted together with the National Inventory Report (OEP 2007). In February 2008, the GHG inventory 1990–2006 was submitted together with the National Inventory Report (OEP 2008). The present report is Liechtenstein’s fourth National Inventory Report, NIR 2009, prepared under the UNFCCC and under the Kyoto Protocol. It includes, as a separate document, Liechtenstein’s 1990–2007 Inventory in the CRF.

From 11 to 15 June 2007 an individual review (In-Country Review) took place in Vaduz: The submission documents, the Initial Report and the GHG inventory 1990-2004 including CRF tables and National Inventory Report were objects of the review. Following the recommendations of the expert review team, some minor corrections were carried out in the emission modelling leading to recalculations and some methodological changes (revision of the definition of forests). Due to the recalculation, the time series of the national total of emissions slightly changes and therefore, Liechtenstein’s assigned amount has been adjusted by -0.407%. After this correction, Liechtenstein’s assigned amount is 1055.623 Gg CO_2 equivalents.

The Office of Environmental Protection (OEP) is in charge of compiling the emission data and bears overall responsibility for Liechtenstein’s national greenhouse gas inventory. In addition to the OEP, the Office of Economic Affairs (OEA), the Office of Agriculture (OA), the Office of Forests, Nature and Land Management (OFNLM) and the Office of Land Use Planning (SLP) participate directly in the compilation of the inventory. Several other administrative and private institutions are involved in inventory preparation.

For the interpretation of the Liechtenstein’s emissions and removals it is important to recognise that Liechtenstein is a small central European State in the Alpine region with a population of 35’365 inhabitants (as of 31 December 2007) and with an area of 160 km^2. Its neighbours are therefore important partners: Liechtenstein and Switzerland form a customs and monetary union governed by a customs treaty. On the basis of this union, Liechtenstein is linked to Swiss foreign trade strategies, with few exceptions, such as trade with the European Economic Community: Liechtenstein – contrary to Switzerland – is a member of the Agreement of the European Economic Area. The Customs Union Treaty with Switzerland impacts greatly on environmental and fiscal strategies. Many Swiss taxes and regulations for special goods (for example, environmental standards) are also adapted and applied in Liechtenstein. For the determination of the GHG emissions, Liechtenstein appreciates having been authorised to adopt a number of Swiss methods and Swiss emission factors.

The **National Inventory Report (NIR)** follows in its structure the default chapters of the UNFCCC Guidelines on Reporting of Greenhouse Gas Inventories (FCCC 2002):

Chapter 1, the introduction, provides an overview of Liechtenstein's institutional arrangements for producing the inventory and the process and methodologies used for inventory preparation:

The activity data sources used to compile the national inventory and to estimate greenhouse gas emissions and removals are: The national energy statistics, separate statistics for the consumption of gasoline and diesel oil, agriculture, LULUCF and waste. The data is compiled and set up in line with the FCCC inventory guidelines (FCCC 2003). Emissions are calculated according to methodologies recommended by the IPCC and contained in the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 1997a, 1997b, 1997c) and in the IPCC Good Practice Guidances (IPCC 2000, IPCC 2003). The data is finally implemented in the CRF Reporter.

All inventory data are assembled and prepared for input by an inventory group. It is responsible for ensuring the conformity of the inventory with UNFCCC guidelines.

Moreover, Chapter 1 provides information on key categories. For 2007, 15 categories were identified as key categories in level and trend analysis for Liechtenstein, covering 95.5% of total greenhouse gas (GHG) emissions (CO_2 equivalent). 56.7% of total GHG emissions resulted from the four most important key categories:

- 1A3b Energy, Fuel Combustion, Road Transportation, gasoline: CO_2 level contribution 22.9%,
- 1A4a Energy, Fuel Combustion, Other Sectors, Commercial/Institutional, liquid fuels: CO_2 level contribution 11.4%.
- 1A4a Energy, Fuel Combustion, Other Sectors, Commercial/Institutional, gaseous fuels: CO_2 level contribution 11.3%.
- 1A3b Energy, Fuel Combustion, Road Transportation, diesel: CO_2 level contribution 11.1%,

Besides the energy sector, other key categories are found in source category 2 Industrial Processes and 4 Agriculture. In a further Key Category Analysis the LULUCF sector is included, too. Five additional key categories are identified, where 5A1 Forest Land remaining Forest Land is the predominant LULUCF category. Finally, the same analyses were also carried out for the base year 1990.

An uncertainty analysis (Tier 1) is carried out and presented in Chapter 1. It estimates the level uncertainty of total CO_2 equivalent emissions in 2007 of 6.4% (15.5 Gg CO_2 eq) and the trend uncertainty 1990-2007 of 7.2%.

Chapter 2 provides an analysis of Liechtenstein's greenhouse gas emissions. The most important results are also reported further below in this Executive Summary.

Chapters 3 to 8 provide principal source and sink category estimates. Methods used are presented, activity data and emission factors are shown. The emissions are reported for the full time period 1990–2007.

Chapter 9 Some emissions have been recalculated due to updates in several sectors. The results are discussed in Chapter 9. For the base year, an increase of 0.020 Gg CO_2 eq comes out (0.009% of the national total) due to updated emission factors for off-road vehicles.

Trend Summary: National GHG Emissions and Removals

In 2007, Liechtenstein emitted 243.5 Gg (kilotonnes) CO_2 equivalent, or 6.89 tonnes CO_2 equivalent per capita (CO_2 only: 6.03 tonnes per capita) to the atmosphere not including emissions and removals from Land Use, Land-Use Change and Forestry (LULUCF).

Figure 1 and Table 1 show Liechtenstein's annual GHG emissions by individual GHG for 1990 (base year) till 2007. Over this period, total annual GHG emissions increased by 6.1% (total excluding emissions and removals from LULUCF).

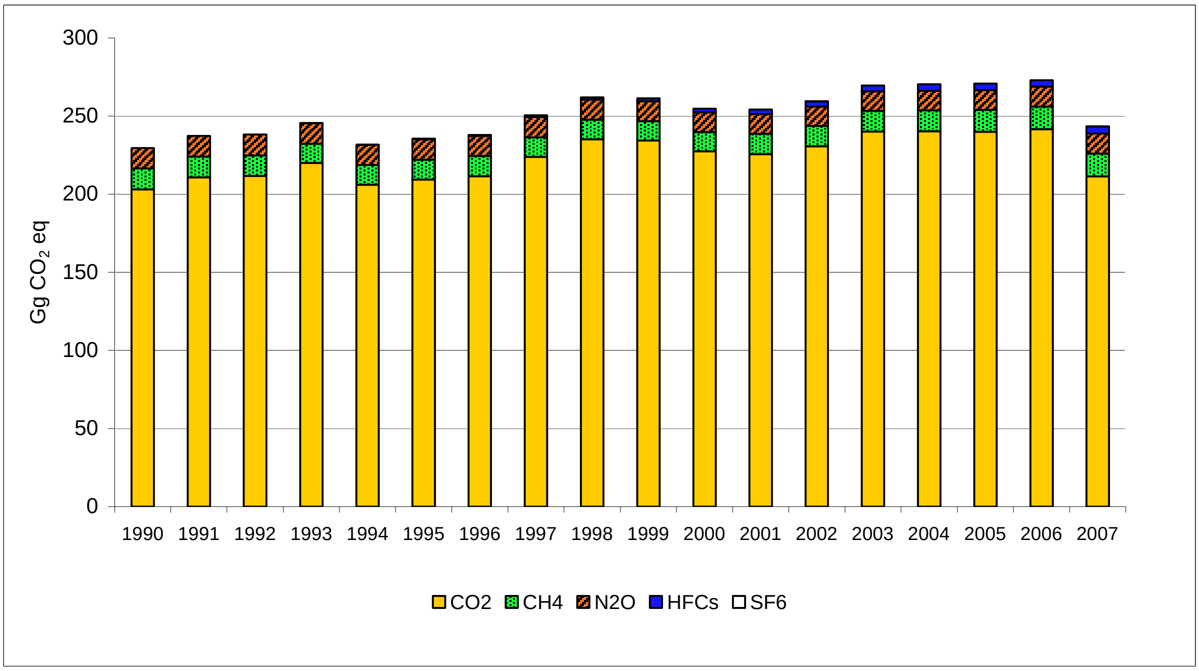

Figure 1 Trend of Liechtenstein's greenhouse gas emissions by gases1990–2007. CO_2, CH_4 and N_2O correspond to the respective total emissions excluding LULUCF.

Greenhouse Gas Emissions	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	CO_2 equivalent (Gg)									
CO_2 emissions including net CO_2 from LULUCF	194.7	202.4	203.3	211.6	197.6	200.9	203.0	218.9	230.2	229.4
CO_2 emissions excluding net CO_2 from LULUCF	203.1	210.8	211.7	220.0	206.1	209.4	211.6	223.8	235.1	234.3
CH_4 emissions including CH_4 from LULUCF	13.4	13.2	13.1	12.4	12.6	12.6	12.7	12.6	12.6	12.5
CH_4 emissions excluding CH_4 from LULUCF	13.4	13.2	13.1	12.4	12.6	12.6	12.7	12.6	12.6	12.5
N_2O emissions including N_2O from LULUCF	13.1	13.3	13.4	13.0	13.0	13.2	13.0	13.0	12.8	12.8
N_2O emissions excluding N_2O from LULUCF	13.1	13.3	13.4	13.0	13.0	13.2	12.9	13.0	12.8	12.7
HFCs	0.0	0.0	0.0	0.1	0.1	0.4	0.7	1.0	1.4	1.8
PFCs	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
SF_6	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.0	0.0	0.0	0.0
Total (including LULUCF)	**221.2**	**229.0**	**229.8**	**237.0**	**223.3**	**227.1**	**229.4**	**245.5**	**257.0**	**256.4**
Total (excluding LULUCF)	**229.6**	**237.3**	**238.2**	**245.5**	**231.7**	**235.5**	**237.9**	**250.4**	**261.9**	**261.3**

Greenhouse Gas Emissions	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	***1990-2007***
	CO_2 equivalent (Gg)								*%*
CO_2 emissions including net CO_2 from LULUCF	222.6	220.7	225.6	233.5	233.7	233.4	235.1	204.7	*5.1*
CO_2 emissions excluding net CO_2 from LULUCF	227.5	225.6	230.6	240.0	240.2	240.0	241.6	211.3	*4.0*
CH_4 emissions including CH_4 from LULUCF	12.3	13.0	13.1	13.3	13.5	14.0	14.4	14.7	*9.7*
CH_4 emissions excluding CH_4 from LULUCF	12.3	13.0	13.1	13.3	13.5	14.0	14.4	14.7	*9.7*
N_2O emissions including N_2O from LULUCF	12.5	12.7	12.5	12.5	12.6	12.7	12.8	12.9	*-1.4*
N_2O emissions excluding N_2O from LULUCF	12.5	12.7	12.5	12.5	12.5	12.6	12.8	12.9	*-1.4*
HFCs	2.3	3.0	3.2	3.7	4.2	4.2	4.2	4.5	---
PFCs	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	---
SF_6	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	---
Total (including LULUCF)	**249.8**	**249.4**	**254.5**	**263.1**	**263.9**	**264.3**	**266.5**	**236.9**	***7.1***
Total (excluding LULUCF)	**254.7**	**254.3**	**259.4**	**269.6**	**270.4**	**270.8**	**273.0**	**243.5**	***6.1***

Table 1 Summary of Liechtenstein's GHG emissions in CO_2 equivalent (Gg) by gas, 1990–2007. The column on the far right (digits in italics) shows the percent change in emissions in 2007 as compared to the base year 1990.

With regard to the distribution of emissions by individual greenhouse gases, CO_2 is the largest single contributor to emissions, accounting for about 86.8% of total GHG emissions (without LULUCF) in 2007. Over the period 1990-2007 it fluctuated between 86.8% and 89.8%. The share of CH_4 slightly increased from 5.8% (1990) to 6.0% (2007). Simultaneously, the share of N_2O decreased from 5.7% to 5.3%. The share of synthetic gases increased from 0.0% (1990) to 1.8% (2007). Figure 2 shows the share of 2007 emissions contributed by individual greenhouse gases. Since the shares of emissions contributed by the gases have remained relatively constant, the diagram is also representative for the base year 1990.

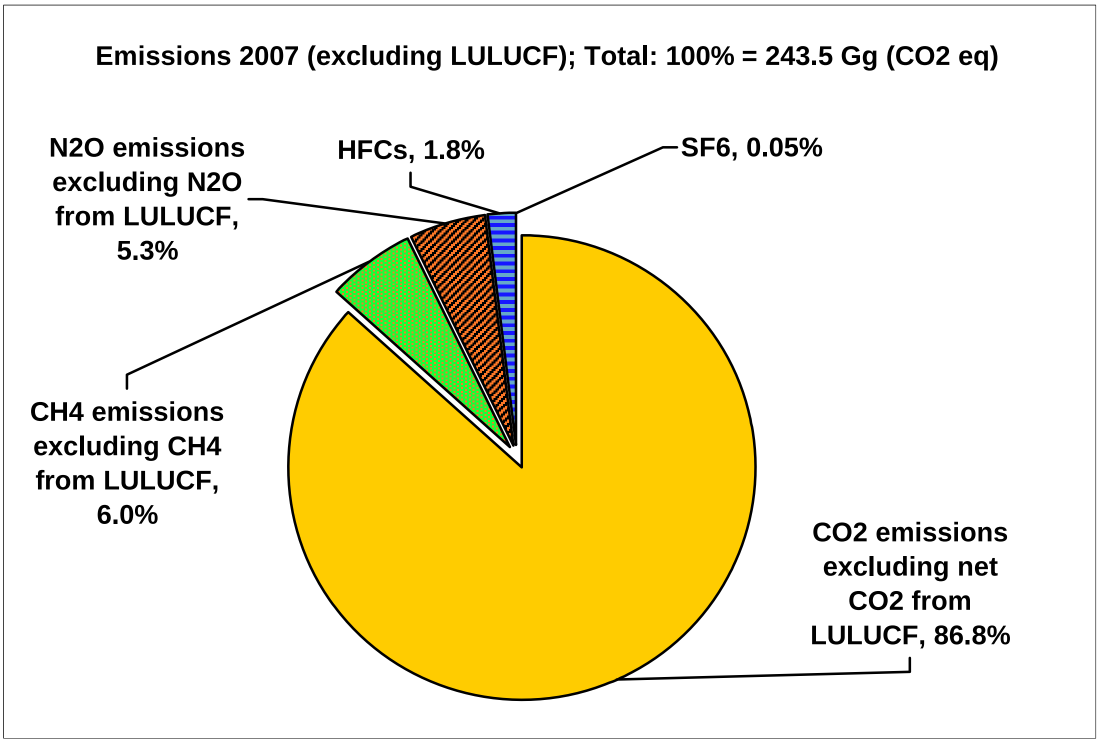

Figure 2 Liechtenstein's GHG emissions by gas (excluding LULUCF) in 2007.

Overview of Source and Sink Category Estimates and Trends

Table 2 shows the GHG emissions and removals by categories. The Energy sector is the largest source of national emissions, contributing to 87.6% of the emissions. An increase of 19.7% is found for the energy sector for the period 1990–2006 followed by a sharp decrease 2006-2007, which reduces the increase from 19.7% (1990-2006) down to 4.9% (1990-2007) due to high gas oil prices and warm winters (see Sect. 2.3). The emissions from industrial processes exclusively consist of synthetic gases, which have also increased, whereas emissions from Solvent and other Product Use have strongly decreased, more than 44%. The emissions from agriculture showed a slight decrease from 1990–2000 followed by a slight increase. In 2007, the emissions were 0.2% above the 1990’s level. Emission and removals in the LULUCF sector form a net sink with net removals in the range between -4.9 (1997) to -8.5 Gg CO_2 eq (1996).The emissions from the waste sector have increased, but one has to note that it only contains a relatively small amount of emissions (mainly from composting, municipal solid waste is exported to a Swiss incineration plant).

Source and Sink Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)									
1 Energy	**203.5**	**211.5**	**212.6**	**221.1**	**207.2**	**210.7**	**212.9**	**225.4**	**236.8**	**236.0**
1A1 Energy Industries	0.2	0.8	1.9	1.9	1.8	2.0	2.5	2.5	2.9	2.9
1A2 Manufacturing Industries and Construction	35.3	34.2	34.2	36.0	34.2	34.4	34.3	35.9	38.2	37.6
1A3 Transport	76.4	89.7	89.1	87.0	79.6	81.7	82.9	86.6	86.2	91.9
1A4 Other Sectors	88.9	83.4	84.2	93.3	88.8	89.9	90.3	97.3	105.9	99.8
1A5 Other (Offroad)	2.4	2.9	3.0	2.4	2.3	2.2	2.3	2.6	3.0	3.1
1B Fugitive emissions from oil and natural gas	0.3	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.7
2 Industrial Processes	**0.0**	**0.0**	**0.0**	**0.1**	**0.1**	**0.4**	**0.7**	**1.0**	**1.4**	**1.8**
3 Solvent and Other Product Use	**2.0**	**1.9**	**1.8**	**1.7**	**1.7**	**1.6**	**1.5**	**1.4**	**1.4**	**1.3**
4 Agriculture	**22.5**	**22.5**	**22.3**	**21.1**	**21.1**	**21.3**	**21.1**	**21.0**	**20.8**	**20.5**
6 Waste	**1.6**	**1.5**	**1.5**	**1.5**	**1.6**	**1.5**	**1.6**	**1.6**	**1.6**	**1.6**
Total (excluding LULUCF)	**229.6**	**237.3**	**238.2**	**245.5**	**231.7**	**235.5**	**237.9**	**250.4**	**261.9**	**261.3**
5 Land Use, Land-Use Change and Forestry	-8.3	-8.4	-8.4	-8.4	-8.5	-8.5	-8.5	-4.9	-4.9	-4.9
Total (including LULUCF)	221.2	229.0	229.8	237.0	223.3	227.1	229.4	245.5	257.0	256.4

Source and Sink Categories	2000	2001	2002	2003	2004	2005	2006	2007	*1990-2007*
	CO_2 equivalent (Gg)								*%*
1 Energy	**229.5**	**227.4**	**232.3**	**241.9**	**242.1**	**241.9**	**243.6**	**213.3**	***4.9***
1A1 Energy Industries	2.7	2.9	2.5	2.8	2.9	3.1	2.8	2.5	*1354*
1A2 Manufacturing Industries and Construction	34.3	34.6	35.7	38.3	37.4	36.2	37.4	30.9	*-12.5*
1A3 Transport	95.9	92.2	87.7	87.3	86.0	85.5	82.5	86.6	*13.4*
1A4 Other Sectors	92.8	94.4	102.9	109.2	111.9	112.6	116.2	88.8	*0.0*
1A5 Other (Offroad)	3.0	2.6	2.8	3.5	3.1	3.5	3.7	3.4	*41.0*
1B Fugitive emissions from oil and natural gas	0.7	0.8	0.8	0.9	0.9	1.0	1.1	1.1	*233.5*
2 Industrial Processes	**2.4**	**3.0**	**3.3**	**3.7**	**4.2**	**4.2**	**4.2**	**4.6**	***---***
3 Solvent and Other Product Use	**1.3**	**1.2**	**1.2**	**1.2**	**1.1**	**1.1**	**1.1**	**1.1**	***-44.4***
4 Agriculture	**19.8**	**21.0**	**20.9**	**21.1**	**21.2**	**21.6**	**22.3**	**22.6**	***0.2***
6 Waste	**1.7**	**1.6**	**1.8**	**1.8**	**1.8**	**1.9**	**1.8**	**1.9**	***19.2***
Total (excluding LULUCF)	**254.7**	**254.3**	**259.4**	**269.6**	**270.4**	**270.8**	**273.0**	**243.5**	***6.1***
5 Land Use, Land-Use Change and Forestry	-4.9	-4.9	-4.9	-6.5	-6.5	-6.5	-6.5	-6.6	*-21.1*
Total (including LULUCF)	249.8	249.4	254.5	263.1	263.9	264.3	266.5	236.9	*7.1*

Table 2 Summary of Liechtenstein's GHG emissions by source and sink categories in CO_2 equivalent (Gg), 1990–2007. The column on the far right (digits in italics) shows the percent change in emissions in 2007 as compared to the base year 1990.

Acknowledgement

Liechtenstein's Office of Environmental Protection (OEP) highly appreciates the generous support by the members of the GHG Inventory Core Group at the Swiss Federal Office for Environment (FOEN). The free use of methods and tools developed by the FOEN has been essential during the development of the completely revised Liechtenstein GHG inventory and the NIR.

The OEP also gratefully acknowledges the support of the Agroscope Reckenholz-Tänikon Research Station (ART). The use of the worksheet developed by ART facilitated very much the modelling of the agricultural emissions and its uncertainties. The personal and close contacts between the GHG specialists of Switzerland and Liechtenstein developed during this work laid the basis for a very promising and fruitful cooperation both on a technical and on a political level.

The OEP also thanks the data suppliers of Liechtenstein: Office of Agriculture, Office of Economic Affairs, Office of Statistics, Office of Forests, Nature and Land Management, Office of Land Use Planning, Liechtensteinische Gasversorgung, Liechtensteinische Kraftwerke, Genossenschaft für Heizöl-Lagerhaltung im Fürstentum Liechtenstein, Abwasserzweckverband der Gemeinden Liechtensteins (AZV), Rhein Helikopter AG, the sectoral experts and the NIR authors. Their effort made it possible to finalise the inventory and the NIR in due time.

1. Introduction

1.1. Background Information on Liechtenstein's Greenhouse Gas Inventory

In 1995, the Principality of Liechtenstein ratified the United Nations Framework Convention on Climate Change (UNFCCC). Furthermore in 2004, Liechtenstein ratified the Kyoto Protocol to the UNFCCC. A National Inventory System (NIS) according to Article 5.1 of the Kyoto Protocol has been implemented.

In 1995, 2001 and 2006, Liechtenstein submitted its National Communication Reports to the secretariat of the UNFCCC. Greenhouse Gas Inventories and National Inventory Reports were submitted in the following years:

- 2005: The first Greenhouse Gas Inventory of Liechtenstein was submitted in the Common Reporting Format (CRF) without National Inventory Report.
- 2006: The first submission took place on 31 May including the national greenhouse gas inventory for 1990 and 2004 as well as the National Inventory Report. A re-submission on 22 December 2006 contained the national greenhouse gas inventory for the whole time period 1990–2004, the National Inventory Report 2006 (OEP 2006) and the Initial Report under Article 7, paragraph 4 of the Kyoto Protocol including a Corrigendum (OEP 2006a, 2007b).
- 2007: Submission of the Greenhouse Gas Inventory 1990–2005 together with the National Inventory Report 2007 on 10 May 2007 (OEP 2007).
- 2008: Submission of the Greenhouse Gas Inventory 1990–2006 together with the National Inventory Report 2008 prepared under the UNFCCC and under the Kyoto Protocol on 29 February 2008 (OEP 2008).
- The present report is Liechtenstein's fourth National Inventory Report, NIR 2009, prepared under the UNFCCC and under the Kyoto Protocol. It includes, as a separate file, Liechtenstein's 1990–2007 Inventory in the CRF Reporter format.

From 11 to 15 June 2007 an individual review (In-Country Review) took place in Vaduz: The submission documents, the Initial Report and the GHG inventory 1990-2004 including CRF tables and National Inventory Report were objects of the review. Following the recommendations of the expert review team, some minor corrections were carried out in the emission modelling leading to recalculations and some methodological changes (revision of the definition of forests). The consequences are documented in the reports of the review of the initial report of Liechtenstein (FCCC IRR 2007) and of the individual review of the greenhouse gas inventory of Liechtenstein submitted in 2006 (FCCC ARR 2007). Due to the recalculation, the time series of the national total of emissions slightly changes and therefore, Liechtenstein's assigned amount will be adjusted by -0.407%. The modifications are documented in a Response by Party and a Corrigendum to the Initial Report (OEP 2007a, 2007b)

1.2. Institutional Arrangements for Inventory Preparation

The Office of Environmental Protection (OEP) is in charge of compiling the emission data and bears overall responsibility for Liechtenstein's national greenhouse gas inventory. In addition to the OEP, the Office of Economic Affairs (OEA), the Office of Agriculture (OA), the Office of Forests, Nature and Land Management (OFNLM) and the Office of Land Use Planning (SLP) participate directly in the compilation of the inventory. Several other administrative and private institutions are involved in inventory preparation.

Liechtenstein is a small central European State in the Alpine region with a population of 35'365 inhabitants (as of 31 December 2007) and with an area of 160 km^2. Its neighbours are therefore important partners: Liechtenstein and Switzerland form a customs and monetary union governed by a customs treaty. On the basis of this union, Liechtenstein is linked to Swiss foreign trade strategies, with few exceptions, such as trade with the European Economic Community: Liechtenstein – contrary to Switzerland – is a member of the Agreement of the European Economic Area. The Customs Union Treaty with Switzerland impacts greatly on environmental and fiscal strategies. Many Swiss taxes and regulations for special goods (for example, environmental standards) are also adapted and applied in Liechtenstein. For the determination of the GHG emissions, Liechtenstein appreciates having been authorised to adopt a number of Swiss methods and Swiss emission factors.

As part of a comprehensive project, the Government mandated its Office of Environmental Protection in 2005 to design and establish the NIS in order to ensure full compliance with the reporting requirements of the UNFCCC and its Kyoto Protocol. With regard to the provisions of Art. 5.1 of the Kyoto Protocol, the project encompasses the following elements:

- Collaboration and cooperation of the different offices involved in data collection,
- Upgrading and updating of central GHG emissions data base,
- Setting up a simplified QA/QC system,
- Official consideration and approval of the data.

1.3. *Process for Inventory Preparation*

Figure 3 gives a schematic overview of the institutional setting of the process of inventory preparation within the NIS.

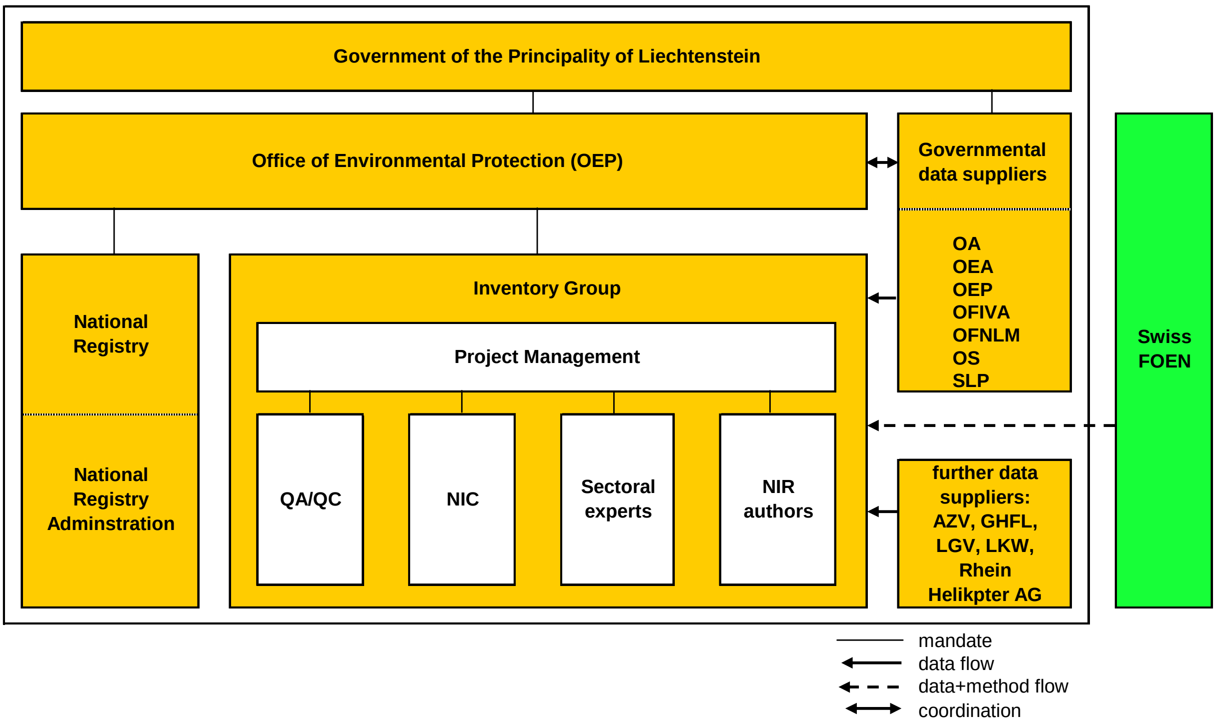

Figure 3 National Inventory System: Institutional setting.

The **Government of the Principality of Liechtenstein** bears the overall responsibility for the NIS. By Liechtenstein's Emission Trading Act (Emissionshandelsgesetz), the Office of

Environmental Protection (OEP) is in charge of establishing emission inventories and is therefore also responsible for all aspects concerning the establishing of the National Inventory System (NIS) under the Kyoto Protocol. The responsibility of the OEP for establishing the NIS is also described in the report of the Government to the parliament for ratifying the Kyoto Protocol[1]. The Government mandated the realisation of the NIS to its Office of Environmental Protection.

The **Office of Environmental Protection (OEP)** plays a major role in the National Inventory System. Its representative, the head of the OEP, is the project manager of the inventory group and the National Registry Administrator. He also coordinates in cooperation with the responsible head of the unit the data flow from the governmental data suppliers to the Inventory Group.

The **Inventory group** consists of the project manager, the responsible for the QA/QC activities, the National Inventory Compiler (NIC), represented by the head of the OEP and his replacement. Furthermore several external experts belong to the Inventory Group: Sectoral specialists for modelling the greenhouse gas emissions and removals and the NIR authors.

Among the **governmental data suppliers** there are

- Office of Economic Affairs (OEA)
- Office of Statistics (OS)
- Office of Forest, Nature and Land Management (OFNLM)
- Office of Agriculture (OA)
- Office of Land Use Planning (SLP)
- Office of Environmental Protection (OEP)

Further data suppliers are

- Co-operation for the storage of gas oil in the Principality of Liechtenstein Genossenschaft für Heizöl-Lagerhaltung im Fürstentum Liechtenstein (GHFL)
- Liechtenstein's Gas Utility / Liechtensteinische Gasversorgung (LGV)
- Electric power company / Liechtensteinische Kraftwerke (LKW)
- Abwasserzweckverband (AZV)
- Heliport Balzers (Rhein Helikopter AG and ROTEX HELICOPTER AG)

Swiss Federal Office for the Environment (FOEN)

The Swiss Federal Office for the Environment (FOEN) is the agency that has the lead within the Swiss federal administration regarding climate policy and its implementation. The FOEN and Liechtenstein's OEP cooperate in the inventory preparation. Due to the customs treaty of the two states, the import statistics in the Swiss overall energy statistics[2] also includes the fossil fuel consumption of the Principality of Liechtenstein. FOEN therefore corrects its fuel consumption data by subtracting Liechtenstein's fuel consumption from the data provided in the Swiss overall energy statistics. To that aim, OEP calculates its energy consumption and provides FOEN with the data. FOEN, on the other hand, makes a number of methods and emission factors available to OEP (mainly transportation, agriculture, LULUCF, synthetic

[1] Bericht und Antrag Nr. 76/2004 der Regierung an den Landtag

[2] Schweizerische Gesamtenergiestatistik 2007. Statistique globale Suisse de l'énergie 2007. Swiss Federal Office of Energy (SFOE 2008).

gases, solvents). Liechtenstein has benefited to a large extend from the methodological support by the inventory core group within the FOEN and its readiness to share very openly data and spreadsheet-tools. Its kind support is herewith highly appreciated.

Figure 4 illustrates in a simplified manner the data flow leading to the CRF tables required for reporting under the UNFCCC and under the Kyoto Protocol. For roles and responsibilities of the actors see Figure 3.

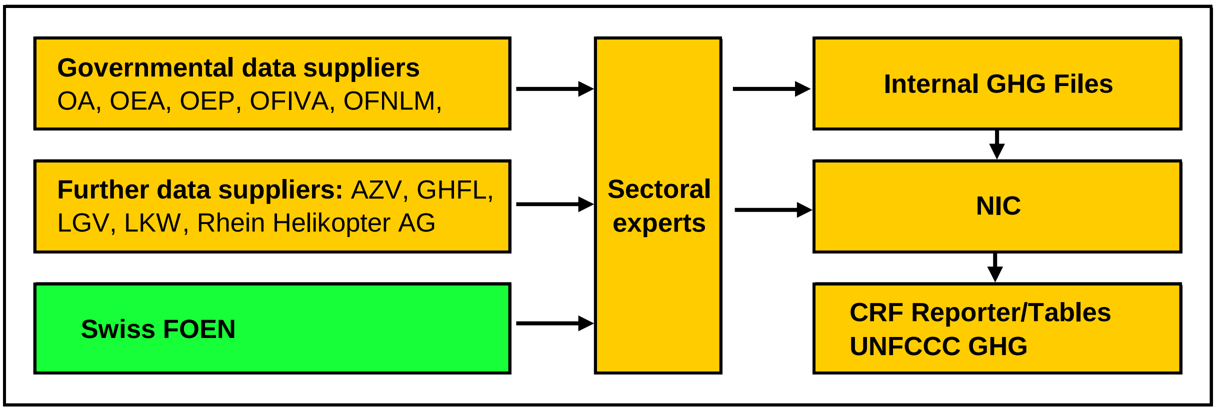

Figure 4 Data suppliers and data collection for setting up the UNFCCC GHG Inventory (see Glossary for abbreviations).

1.4. Methodologies

1.4.1. General Description

The emissions are calculated based on the standard methods and procedures of the Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (IPCC 1997a, 1997b, 1997c) and IPCC Good Practice Guidances (IPCC 2000, IPCC 2003) as adopted by the UNFCCC.

The emissions are modelled by using country specific activity data. Country specific emissions factors are applied if available. A number of default emission factors from IPCC are used. For a majority of emission sources, however, emission factors are adopted from the Swiss GHG inventory after checking their applicability. In those cases, the emission factors are reported as country specific. It is noteworthy that there is a very close relationship between Liechtenstein and Switzerland based on the Customs Union Treaty between the two countries (see Section 1.2). The Customs Union Treaty with Switzerland has a significant impact on environmental and fiscal strategies. Many Swiss environmental provisions and climate-protection regulations are also applicable in Liechtenstein or are implemented into Liechtenstein law on the basis of specific international treaty rules. In the following paragraph, a short summary of the methods used is given for every sector.

1 Energy

- Emissions from 1A Fuel Combustion Activities: Activity data is taken from the National Energy Statistics (including consistency modifications) and from census for the fuel sales of gasoline and diesel oil. The methods are country specific, the levels Tier 1 and Tier 2 are applied.
- Emissions from 1B Fugitive Emissions from Fuels: The Swiss method is applied corresponding country specific, Tier 3 level.

2 Industrial Processes

- HFC emissions from 2F1 Refrigeration and Air Conditioning Equipment are reported and are calculated with the rule of proportion applied on the Swiss emissions using country specific activity data as proxy for the conversion (e.g. no. of inhabitants).
- SF_6 emissions from 2F8 Electrical Equipment are reported based on country specific data.
- CO and NMVOC emissions from 2A5 Asphalt Roofing and 2A6 Road Paving with Asphalt. The emissions are estimated from the Swiss emissions using the no. of inhabitants as a proxy for the rough estimate of Liechtenstein's emissions.
- Other emissions from industrial processes (CO_2, CH_4, N_2O, PFCs) are not occurring.

3 Solvent and Other Product Use

- Emissions 3A–3D are estimated by country specific methods and emission factors: Swiss emissions are transformed using the number of Liechtenstein's inhabitants as a proxy for the rough estimate of Liechtenstein's emissions.

4 Agriculture

- Emissions are reported for 4A Enteric Fermentation, 4B Manure Management and 4D Agricultural Soils by applying Swiss methods (country specific).

5 LULUCF

- Emissions and removals are reported for 5A to 5F. The methods are adopted from Switzerland (country specific).

6 Waste

- Emissions are modelled by applying the following methods: 6A T2, 6B CS (CH_4) and D (N_2O), 6C T2 and 6D CS.

1.4.2. Specific Assumptions for the Year 2007

For the modelling of its emission, Liechtenstein uses several emission factors stemming from the Swiss GHG inventory. Important examples are the implied emission factors for 1A3b Road Transportation. Currently, the emissions 2007 of the Swiss inventory are not yet available in their final version, therefore the implied emission factors 2007 are not available either. For the time being, implied emission factors 2006 are used as a preliminary estimate for the implied emission factors 2007. The following sectors are concerned

- Energy: 1A3b
- Ind. Process: 2A5, 2A6
- Solvent and other Product Use: 3A, 3B, 3C, 3D
- Agriculture: 4A, 4B

For the subsequent submission in April 2010, the emissions 2007 will be recalculated for the above categories using the final Swiss emission factors 2007.

Greenhouse gas sources and sinks	CO_2		CH_4		N_2O	
Categories	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
1. Energy	CS,T1,T2	CS	CS,T1,T2,T3	CS,D	CS,T1,T2	CS,D
A. Fuel Combustion	CS,T1,T2	CS	CS,T1,T2	CS,D	CS,T1,T2	CS,D
1. Energy Industries	T2	CS	T2	CS	T2	CS,D
2. Manufacturing Industries and Construction	T2	CS	T2	CS	T2	D
3. Transport	T1	CS	T1	CS,D	T1	CS,D
4. Other Sectors	CS,T1,T2	CS	CS,T1,T2	CS	CS,T1,T2	CS,D
5. Other	T1	CS	T1	CS	T1	CS
B. Fugitive Emissions from Fuels	NA	NA	T3	CS	NA	NA
1. Solid Fuels	NA	NA	NA	NA	NA	NA
2. Oil and Natural Gas	NA	NA	T3	CS	NA	NA
2. Industrial Processes	NA	NA	NA	NA	NA	NA
A. Mineral Products	NA	NA	NA	NA	NA	NA
B. Chemical Industry	NA	NA	NA	NA	NA	NA
C. Metal Production	NA	NA	NA	NA	NA	NA
D. Other Production	NA	NA	NA	NA	NA	NA
E. Production of Halocarbons and SF_6						
F. Consumption of Halocarbons and SF_6						
G. Other	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	CS	CS			CS	CS
4. Agriculture			T2	CS,D	CS,T1b	D
A. Enteric Fermentation			T2	CS		
B. Manure Management			T2	D	CS	D
C. Rice Cultivation			NA	NA		
D. Agricultural Soils			NA	NA	CS,T1b	D
E. Prescribed Burning of Savannas			NA	NA	NA	NA
F. Field Burning of Agricultural Residues			NA	NA	NA	NA
G. Other			NA	NA	NA	NA
5. Land Use, Land-Use Change and Forestry	T2	CS	NA	NA	NA	NA
A. Forest Land	T2	CS	NA	NA	NA	NA
B. Cropland	T2	CS	NA	NA	NA	NA
C. Grassland	T2	CS	NA	NA	NA	NA
D. Wetlands	T2	CS	NA	NA	NA	NA
E. Settlements	T2	CS	NA	NA	NA	NA
F. Other Land	T2	CS	NA	NA	NA	NA
G. Other	NA	NA	NA	NA	NA	NA
6. Waste	T2	CS	CS,T2	CS	CS,D,T2	CS,D
A. Solid Waste Disposal on Land	NA	NA	T2	CS		
B. Waste-water Handling			CS	CS	D	D
C. Waste Incineration	T2	CS	T2	CS	T2	CS
D. Other	NA	NA	CS	CS	CS	CS

	HFCs		PFCs		SF_6	
2. Industrial Processes	CS	CS	NA	NA	CS	CS
F. Consumption of Halocarbons and SF_6	CS	CS	NA	NA	CS	CS

Table 3 Notation keys for applied methods and emission factors (see also CRF tables Summary3s1, Summary3s2).

1.4.3. Reference Approach for the Energy Sector

Liechtenstein has carried out the Reference Approach to estimate energy consumption and CO_2 emissions for the energy sector. The results are shown in Section.3.6

1.5. Key Categories

The key category analysis (KCA) is performed according to the IPCC Good Practice Guidance (IPCC 2000, chapter 7): A Tier 1 level and trend assessment is applied with the proposed threshold of 95%. The analysis is performed four times, for the base year 1990 and the latest year 2007, both years with and without LULUCF categories.

1.5.1. KCA without LULUCF categories

For 2007, among a total of 121 categories, 15 have been identified as key categories with an aggregated contribution of 95.2% of the national total emissions. 14 among the 15 are key categories due to the level assessment, 13 due to the trend assessment (see Table 4).

Of the 15 key categories, 11 are out of the energy sector, contributing 85.8% to total CO_2 equivalent emissions in 2007. The other key categories are from sectors Industrial Processes (1.8%), Solvent and Other Product Use (0.3%) and Agriculture (7.6%). There are six major key sources:

- 1A3b Energy, Fuel Combustion, Road Transportation, gasoline: CO_2, level contribution 22.9%,
- 1A4a Energy, Fuel Combustion, Other Sectors, Commercial/Institutional, liquid fuels: CO_2, level contribution 11.4%.
- 1A4a Energy, Fuel Combustion, Other Sectors, Commercial/Institutional, gaseous fuels: CO_2, level contribution 11.3%.
- 1A3b Energy, Fuel Combustion, Road Transportation, diesel: CO_2, level contribution 11.1%,
- 1A4b Energy, Fuel Combustion, Other Sectors, Residential, gaseous fuels: CO_2, level contribution 9.3%.
- 1A2 Energy, Fuel Combustion, Manufacturing Industries and Construction, gaseous fuels: CO_2, level contribution 9.0%.

Further details are shown in Table 4, and the complete Key Category Analysis is provided in Annex 1.

For the base year 1990, the level analysis is given in Table 5. There are 12 level key categories, which are also key categories in 2007. Gaseous fuels in 1A1 and 1A3b as well as consumption of halocarbons in 2F, which are all key categories with respect to level or trend 2007, are no level key categories in 1990.

Key Category Analysis 2007 (without LULUCF) IPCC Source Categories (and fuels if applicable)					Direct GHG	Base Year 1990 Estimate	Year t Estimate	Level Assessment	Trend Assessment	% Contribution in Trend	Result level assessment	Result trend assessment
Sorted by NFR code						[Gg CO2eq]	[Gg CO2eq]					
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO_2	0.12	2.44	1.00%	0.008942	1.7%	KC level	KC trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO_2	16.48	21.84	8.97%	0.016879	3.3%	KC level	KC trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO_2	18.74	8.97	3.68%	0.042251	8.2%	KC level	KC trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO_2	14.77	27.13	11.14%	0.044390	8.6%	KC level	KC trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	CO_2	0.00	2.71	1.11%	0.010504	2.0%	KC level	KC trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO_2	60.53	55.85	22.94%	0.032351	6.3%	KC level	KC trend
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO_2	8.70	27.40	11.25%	0.070348	13.7%	KC level	KC trend
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO_2	57.10	27.62	11.35%	0.127542	24.8%	KC level	KC trend
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO_2	2.51	22.54	9.26%	0.076974	15.0%	KC level	KC trend
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO_2	18.74	8.97	3.68%	0.042251	8.2%	KC level	KC trend
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO_2	2.36	3.33	1.37%	0.003196	0.6%	KC level	-
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			HFC	0.00	4.47	1.84%	0.017314	3.4%	KC level	KC trend
4A	4. Agriculture	A. Enteric Fermentation			CH_4	9.80	10.38	4.26%	0.000066	0.0%	KC level	-
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N_2O	5.75	5.66	2.33%	0.001704	0.3%	KC level	-
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N_2O	2.73	2.51	1.03%	0.001487	0.3%	KC level	-

Sorted by contribution in level												
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO_2	60.53	55.85	22.94%	0.032351	6.3%	KC level	KC trend
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO_2	57.10	27.62	11.35%	0.127542	24.8%	KC level	KC trend
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO_2	8.70	27.40	11.25%	0.070348	13.7%	KC level	KC trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO_2	14.77	27.13	11.14%	0.044390	8.6%	KC level	KC trend
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO_2	2.51	22.54	9.26%	0.076974	15.0%	KC level	KC trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO_2	16.48	21.84	8.97%	0.016879	3.3%	KC level	KC trend
4A	4. Agriculture	A. Enteric Fermentation			CH_4	9.80	10.38	4.26%	0.000066	0.0%	KC level	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO_2	18.74	8.97	3.68%	0.042251	8.2%	KC level	KC trend
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO_2	18.74	8.97	3.68%	0.042251	8.2%	KC level	KC trend
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N_2O	5.75	5.66	2.33%	0.001704	0.3%	KC level	-
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			HFC	0.00	4.47	1.84%	0.017314	3.4%	KC level	KC trend
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO_2	2.36	3.33	1.37%	0.003196	0.6%	KC level	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	CO_2	0.00	2.71	1.11%	0.010504	2.0%	KC level	KC trend
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N_2O	2.73	2.51	1.03%	0.001487	0.3%	KC level	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO_2	0.12	2.44	1.00%	0.008942	1.7%	KC level	KC trend

Table 4 List of Liechtenstein's 15 key categories 2007. Upper part sorted by NFR code (by category code), lower part sorted by contribution in level.

Key Category Analysis 1990 (without LULUCF) IPCC Source Categories (and fuels if applicable)					Direct GHG	Base Year 1990 Estimate	Level Assessment	Cumulative Total Column E-L	Result level assessment
Sorted by NFR code						[Gg CO2eq]			
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO_2	16.48	7.18%	74.75%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO_2	18.74	8.16%	59.41%	KC level
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO_2	14.77	6.43%	81.19%	KC level
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO_2	60.53	26.37%	26.37%	KC level
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO_2	8.70	3.79%	89.25%	KC level
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO_2	57.10	24.87%	51.24%	KC level
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO_2	2.51	1.09%	94.04%	KC level
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO_2	18.74	8.16%	67.57%	KC level
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO_2	2.36	1.03%	95.07%	KC level
4A	4. Agriculture	A. Enteric Fermentation			CH_4	9.80	4.27%	85.46%	KC level
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N_2O	5.75	2.51%	91.75%	KC level
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N_2O	2.73	1.19%	92.94%	KC level
Sorted by contribution in level									
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO_2	60.53	26.37%	26.37%	KC level
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO_2	57.10	24.87%	51.24%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO_2	18.74	8.16%	59.41%	KC level
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO_2	18.74	8.16%	67.57%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO_2	16.48	7.18%	74.75%	KC level
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO_2	14.77	6.43%	81.19%	KC level
4A	4. Agriculture	A. Enteric Fermentation			CH_4	9.80	4.27%	85.46%	KC level
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO_2	8.70	3.79%	89.25%	KC level
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N_2O	5.75	2.51%	91.75%	KC level
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N_2O	2.73	1.19%	92.94%	KC level
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO_2	2.51	1.09%	94.04%	KC level
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO_2	2.36	1.03%	95.07%	KC level

Table 5 List of Liechtenstein's 12 key categories in 1990. Upper part sorted by NFR code (by category code), lower part sorted by contribution in level.

1.5.2. Combined KCA without and with LULUCF categories

The key category analysis including LULUCF categories is also carried out for 1990 and 2007. The results are summarised in Table 6. According to IPCC Good Practice Guidance for LULUCF (IPCC 2003), Section 5.4.2, the set of key categories consists of all non-LULUCF key categories that result from the KCA without LULUCF combined with all LULUCF-key-categories that result from the KCA with LULUCF.

Key Category Analysis 2007 (including LULUCF) IPCC Source Categories (and fuels if applicable)					Direct GHG	Base Year 1990 Estimate	Year t Estimate	Level Assessment	Trend Assessment	% Contribution in Trend	Result level assessment	Result trend assessment
Sorted by NFR code						[Gg CO2eq]	[Gg CO2eq]					
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO_2	0.12	2.44	1.00%	0.008942	1.7%	KC level	KC trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO_2	16.48	21.84	8.97%	0.016879	3.3%	KC level	KC trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO_2	18.74	8.97	3.68%	0.042251	8.2%	KC level	KC trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO_2	14.77	27.13	11.14%	0.044390	8.6%	KC level	KC trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	CO_2	0.00	2.71	1.11%	0.010504	2.0%	KC level	KC trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO_2	60.53	55.85	22.94%	0.032351	6.3%	KC level	KC trend
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO_2	8.70	27.40	11.25%	0.070348	13.7%	KC level	KC trend
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO_2	57.10	27.62	11.35%	0.127542	24.8%	KC level	KC trend
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO_2	2.51	22.54	9.26%	0.076974	15.0%	KC level	KC trend
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO_2	18.74	8.97	3.68%	0.042251	8.2%	KC level	KC trend
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO_2	2.36	3.33	1.37%	0.003196	0.6%	KC level	-
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			HFC	0.00	4.47	1.84%	0.017314	3.4%	KC level	KC trend
4A	4. Agriculture	A. Enteric Fermentation			CH_4	9.80	10.38	4.26%	0.000066	0.0%	KC level	-
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N_2O	5.75	5.66	2.33%	0.001704	0.3%	KC level	-
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N_2O	2.73	2.51	1.03%	0.001487	0.3%	KC level	-
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CO_2	18.64	19.03	6.91%	0.002670	0.6%	KC level	KC trend
5B1	5. LULUCF	B. Cropland	1. Cropland remaining Cropland		CO_2	4.33	4.45	1.62%	0.000508	0.1%	KC level	-
5C1	5. LULUCF	C. Grassland	1. Grassland remaining Grassland		CO_2	2.13	1.80	0.65%	0.001595	0.3%	KC level	-
5C2	5. LULUCF	C. Grassland	2. Land converted to Grassland		CO_2	0.08	0.87	0.32%	0.002692	0.6%	-	KC trend
5E2	5. LULUCF	E. Settlements	2. Land converted to Settlements		CO_2	3.30	3.47	1.26%	0.000124	0.0%	KC level	-

Key Category Analysis 1990 (including LULUCF) IPCC Source Categories (and fuels if applicable)					Direct GHG	Base Year 1990 Estimate	Year t Estimate	Level Assessment	Cumulative Total Column E-L			
Sorted by NFR code						[Gg CO2eq]	[Gg CO2eq]					
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO_2	16.48	16.48	7.18%	74.75%		KC level	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO_2	18.74	18.74	8.16%	59.41%		KC level	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO_2	14.77	14.77	6.43%	81.19%		KC level	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO_2	60.53	60.53	26.37%	26.37%		KC level	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO_2	8.70	8.70	3.79%	89.25%		KC level	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO_2	57.10	57.10	24.87%	51.24%		KC level	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO_2	2.51	2.51	1.09%	94.04%		KC level	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO_2	18.74	18.74	8.16%	67.57%		KC level	
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO_2	2.36	2.36	1.03%	95.07%		KC level	
4A	4. Agriculture	A. Enteric Fermentation			CH_4	9.80	9.80	4.27%	85.46%		KC level	
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N_2O	5.75	5.75	2.51%	91.75%		KC level	
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N_2O	2.73	2.73	1.19%	92.94%		KC level	
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CO_2	18.64	18.64	7.20%	67.12%		KC level	
5B1	5. LULUCF	B. Cropland	1. Cropland remaining Cropland		CO_2	4.33	4.33	1.67%	90.23%		KC level	
5C1	5. LULUCF	C. Grassland	1. Grassland remaining Grassland		CO_2	2.13	2.13	0.82%	95.27%		KC level	
5E2	5. LULUCF	E. Settlements	2. Land converted to Settlements		CO_2	3.30	3.30	1.27%	91.51%		KC level	

Table 6 Liechtenstein's key categories in 2007 and in 1990combined without and with LULUCF categories.

In the KCA 2007 including LULUCF categories there are in total 135 categories. 22 of them are key categories. Five of the key categories are from the LULUCF sector. The largest category is 5A1 Forest Land remaining Forest Land; the other LULUCF key categories are of minor importance.

In the KCA including LULUCF categories for 1990, 16 categories appear as key categories. Four of the key categories are from the LULUCF sector. In contrast to the analysis for 2007 5C2 Land converted to Grassland drops from the list of key categories since its contribution is small.

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

1.6.1. Terms and objectives

According to the IPCC Good Practice Guidance (IPCC 2000) the major elements of a QA/QC system are:

- an inventory agency responsible for coordinating QA/QC activities;
- a QA/QC plan;
- QC procedures;
- QA review procedures;
- reporting, documentation, and archiving procedures.

The state of implementation of these quality elements is described in the following chapters. One has to note that Liechtenstein's QA/QC system accounts for the **specific circumstances of the Principality of Liechtenstein**: Due to the smallness of the State, not every process, data flow and arrangement does need to be established by a formal agreement due to short "distances" within the administration and due to a high degree of acquaintance between the persons involved. Therefore, the National System manages with little number of written documents.

Objectives of the quality system

The quality management shall enable the party to principally fulfil the requirements of the articles 3, 5 and 7 of the Kyoto Protocol. Specifically, it shall ensure and improve the quality of GHG inventory that means a continuous improvement **of transparency, consistency, comparability, completeness and confidence**. In detail, it serves

- for providing checks to ensure data integrity, correctness and completeness;
- to identify errors and omissions,
- to reduce the uncertainties of the emission estimates,
- to document and archive inventory material.

1.6.2. Responsible agency for coordinating QA/QC activities

The QA/QC activities are coordinated by the project manager of the GHG Inventory Group. The responsible person is Mr. Andreas Gstoehl, head of the unit Air Pollution Control, Noise and Climate (e-mail: Andreas.Gstoehl@aus.llv.li, phone: +423 236 61 86) in the Office of Environmental Protection (OEP). The QA/QC activities are organised within the Inventory Group, see National System represented in Figure 3.

Operational tasks are delegated to the lead NIR author. He distributes checklists to the NIC, to the sectoral experts, to the other NIR authors and to the project manager. They fill in the procedures that they carried out. The lists are then sent back to the project manager, who confirms the performance of the QA/QC activities. The activities are documented in the NIR (see Annex 8).

1.6.3. QA/QC plan

Table 7 illustrates the annual cycle of inventory planning and preparation including the time-lines for the performance of QC activities. The current inventory for the submission April 2009 proceeded due to the general schedule shown in the table below.

Issue	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Mai
Meeting of Inventory Group		x				x				x			
Meeting of Group Environment/Spatial Planning					x					x			
Considerataion of UNFCCC Syn.&Ass. II	x												
Data Collection				x	x	x	x	x	x				
Quality check of sectoral data							energy		other sectors				
Calculation of emissions/removals						x	x	x	x	x			
Generation of CRF tables								x	x	x			
Quality checks CRF tables									x	x			
Key Category Analysis incl. QC checks								x	x				
Uncertainty Analysis incl. QC checks								x	x	x			
Generation of NIR tables								x	x	x			
Compilation/Editing of NIR						x	x	x	x	x	x		
QC: Proofread of NIR (correctness, transparency etc.)								x	x	x			
QC: Fill in checklist									energy	other issues			
QA activities									int. review				
Official consideration and approval										x			
Submission to the UNFCCC secretariat											x	x	
Publication of NIR/CRF													x
Arciving, storage of GHG inventory documents	x	x										x	x

Table 7 Schedule for inventory planning and preparation. “external/internal review CH inventory”: QA activities for the Swiss GHG inventory serve as QA activities for Liechtenstein’s GHG inventory (see section QA activities below).

1.6.4. QC procedures

Quality control (QC) is defined by: “System of routine technical activities to measure and control the quality of the inventory as it is being developed.” (IPCC 2000).

Overall Activities

The following QC activities are carried out:

- The annual cycle for inventory preparation contains several meetings of the Inventory Group and several meetings of governmental and other data suppliers with the OEP. On these meetings the activities, responsibilities and schedule for the inventory preparation process are being organised and determined.
- Regular meetings of the group “Umwelt und Raum” (environment and spatial planning). The group is formed by the heads of the OEP, SLP, OFNLM and the minister for the environment. It prepares policy matters for the attention of the Government including climate affairs.
- The project manager, the sectoral experts, the national inventory compiler (NIC) and the NIR authors accomplish a number of QC activities:
    - The NIR authors check the emission results produced by the sectoral experts, for consistency of cross-cutting parameters, correctness of emissions aggregation,

completeness of the GHG inventory. They compare the methods used with IPCC Good Practice Guidance, check the correct compiling of the methods in the NIR, the correct transcription of CRF data into NIR data tables and figures, the consistency between data tables and text in the NIR, the completeness of references in the NIR, and are responsible for the correctness of the key source and the uncertainty analysis.

- The sectoral experts check the description of methods, numbers and figures in the NIR.
- The NIC checks the integrity of the database files, the consistency of time series, the correct and complete inputs into the CRF Reporter.
- Further staff members of the OEP carry out a proof reading of single sectors.
- The project manager executes an overall checking function for the GHG inventory and the NIR: He monitors the GHG emission modelling and the key category analysis. He checks the NIR for correctness, completeness, transparency and quality, checks for the complete archiving of documents, and the completeness of the CRF submission document.

It may be mentioned that the OEP enlarged its staff in the unit Climate Protection in the beginning of 2007 by two more collaborators. They are responsible for emission modelling, GHG inventory, implementation of the emission trading system, national registry, national allocation plan, Kyoto mechanisms (JI, CDM).

Documentation of the QC Activities

For the previous submission 2008, the QC activities had been documented for the first time by means of checklist. The lists are updated for the current submission and are shown in the Annex 8. The classification of the QC activities follows the IPCC GPG table 8.1 (IPCC 2000). The following persons are involved in the QC activities:

- Sectoral experts for energy, industrial processes etc.
- NIC
- NIR authors
- Project manager

Special attention of the QC activities for emissions has been directed to the key categories.

1.6.5. QA review procedures

Quality assurance (QA): System of activities that include a “system of review procedures conducted by personnel not directly involved in the inventory compilation development process, to verify that data quality objectives were met, ensure that the inventory represents the best possible estimate of emissions and sinks given the current state of scientific knowledge and data available, and support the effectiveness of the QC programme” (IPCC 2000).

Liechtenstein’s NIS quality management system follows a Plan-Do-Check-Act-Cycle (PDCA-cycle), which is a generally accepted model for pursuing a systematic quality performance according to international standards. This approach is in accordance with procedures described in decision 19/CMP.1 and in the IPCC Good Practice Guidance.

Liechtenstein carries out the following QA activities:

- Internal review: The draft NIR is passing through an internal review. The project manager, the project manager assistant, two specialised staff members of the climate unit, another staff member of the OEP and the NIC are proofreading the NIR or parts of it. They document their findings in checklists, which are sent back to the NIR authors (see Annex 8)
- The Swiss inventory management charges external experts for sectoral QA activities to review the Swiss GHG inventory. Since a number of Swiss methods and Swiss emission factors are used for the preparation of the Liechtenstein inventory, the results of the Swiss QA activities have to be checked and analysed by Liechtenstein's experts. Positive reviews may be interpreted as positive for Liechtenstein too, and problematic findings must not only be taken account for in Switzerland but also in Liechtenstein. Which sectors have already been reviewed for the Swiss GHG inventory?
    - In 2006, a consulting group (not involved in the GHG emission modelling) was mandated to review the two sectors Energy and Industrial Processes with respect to methods, activity data, emission factors, CRF tables, NIR chapter (Eicher and Pauli 2006). The results were documented in a review report and communicated to Liechtenstein's Inventory Group. The consequences for the main findings have been evaluated for Liechtenstein's GHG inventory and for the NIR for submission December 2006.
    - For the Swiss NIR, an internal review takes places annually shortly before the submission. Every chapter of the NIR is being proofread by specialists not involved in the emission modelling or in the NIR editing. The internal review is organised by the quality officer and the results are compiled by the same person that is also compiling Liechtenstein's NIR (lead author J. Heldstab, INFRAS). The results of the Swiss review are therefore communicated to Liechtenstein's Inventory Group. Where methods and results are concerned that are relevant for Liechtenstein too, the consequences were taken into account. This procedure has been performed in the three last and the current submissions (May and December 2006, May 2007, February 2008). It will also be repeated for future submissions.
- The applicability of Swiss methodologies and emission factors to Liechtenstein's GHG inventory is reviewed as well: Before Swiss methods are applied, they are discussed with the experts of Liechtenstein's administration. This process has taken place before the submission in December 2006 for the sectors Energy, Agriculture and Waste, for the sector LULUCF before the submission in February 2008.

1.6.6. Archiving procedures

The electronic files of Liechtenstein's GHG inventory are all saved by the backup system of Liechtenstein's administration.

Every computer belonging to the administration, including the computers of the Office of Environmental Protection, are connected to the central network. The data of the server systems, file-clusters and database servers, are being saved in a tape-library. Due to safety reasons, the tape-library is not in the computing centre but in a building of the National police: In case of a total lost of the computing centre, the data are still available.

There are several backups

- daily incremental saved up to one month (4 weeks)
- Weekly full backup saved up to two months
- Monthly full backup saved up to one year

The backup files are being initialised via scheduler of the master server. The data are written via network onto one of the LTO 2 Drives (tape). The master server manages the handling of the tapes. Backups are checked daily via Activity Monitor. If a backup is not carried out, it may be caught up manually. Since daily restores of user data is carried out, there is a guarantee for keeping the data readable.

For archiving reasons, the backup tapes are being doubled four times a year. The duplicates are not being overwritten during five years.

In addition to the administrational archiving system, the external experts of Acontec, who are mandated with the emission modelling and CRF generation, save all CRF and background tables yearly on CD ROM /DVD ROM. The disks are stored in a bank safe of the Liechtensteinische Landesbank (Liechtenstein's National Bank).

1.7. Uncertainty Evaluation

1.7.1. Data Used

Data on uncertainties is not provided explicitly for most key data sources. In this situation, the authors of the NIR chapters together with the involved experts generated first estimates of uncertainties based on IPCC Good Practice Guidance default values, uncertainty data from the Swiss NIR (FOEN 2008) and expert estimates.

All uncertainty figures are to be interpreted as corresponding to half of the 95% confidence interval. Distributions are assumed to be symmetric for Tier 1 analysis.

Uncertainties in the GWP-values were not taken into account in the inventory uncertainty estimates.

1.7.2. Uncertainty Estimates

For key categories individual uncertainties are used. For non-key categories the NIR provides qualitative estimates of uncertainties. The terms used are high, medium and low data quality. In order to extend the quantitative uncertainty analysis to every non-key category the default values presented in Table 8 are used. They are motivated by the comparison of uncertainty analyses of several countries carried out by Keizer et al. (2007), as presented at the 2nd Internat. Workshop on Uncertainty in Greenhouse Gas Inventories (Vienna 27-28 Sep 2007), and by Table A1-1 of IPCC Guidelines, Vol. 1, Annex 1, Managing uncertainties (IPCC 1996).

Gas	Uncertainty category	Relative uncertainty
CO_2	low	2%
	medium	10%
	high	40%
CH_4	low	15%
	medium	30%
	high	60%
N_2O	low	40%
	medium	80%
	high	150%
HFC	medium	20%
PFC	medium	20%
SF_6	medium	20%

Table 8 Semi-quantitative uncertainties (2 σ) for non-key categories.

1.7.3. Results for Tier 1 Uncertainty Evaluation

A quantitative uncertainty analysis has been carried out following IPCC Good Practice Guidance Tier 1 methodology (IPCC 2000, p. 6.13ff.).First, uncertainties of activity data and emission factors are estimated separately. The combined uncertainty for each source is then calculated using a Rule B approximation (IPCC 2000 p. 6.12). Finally, the Rule A approximation is used to obtain the overall uncertainty in national emissions and the trend in national emissions between the base year and the current year.

The results of the Tier 1 uncertainty analysis for GHG emissions from key categories in Liechtenstein are summarised in Table 9.

Details on the uncertainty estimates of specific sources are provided in the sub-sections on "Uncertainties and Time-Series Consistency" in each of the chapters on source categories below.

The resulting Tier 1 uncertainty in the national total annual emissions in CO_2 equivalents is estimated to be about 5.95% for the level 2007. Trend uncertainty is 7.68%. This result is significantly lower compared to the previous submission (11.1% level, 18.1% trend uncertainty, see OEP 2008). A first reason is that there is a decrease in the activity data for Liquid fuels. The main reason, however, is that for liquid fuels, the uncertainties have been estimated in this submission for four fuel types separately instead of estimating the uncertainty for the aggregate liquid fuel consumption as in previous submissions. The change is made, because methods to determine fuel consumption and associated uncertainties differ for each of the fuel types.

The overall uncertainty is still determined by the rather high activity data uncertainty of liquid fuels. This is due to the fact that Liechtenstein, forming a customs and monetary union with Switzerland, has no own customs statistics of imports of oil products, and activity data has to be based on soundings with suppliers, being of heterogeneous quality.

The uncertainty analysis is carried out without the LULUCF sector. As soon as Switzerland will provide information on the uncertainty of its LULUCF categories, it will be assessed whether the uncertainties may be applied to Liechtenstein's situation (the activity data – areas - are supposed to be quite exact, whereas no information is available yet about the uncertainty of the carbon factors).

Please note that the current results of the Tier 1 uncertainty analysis for GHG emissions from key sources in Liechtenstein do not (fully) take into account the following factors that may further increase uncertainties:

- Correlations that exist between source categories that have not been considered,
- Uncertainties due to the assumption of constant parameters, e.g. of constant net calorific values for fuels for the entire period since 1990,
- Uncertainties due to methodological shortcomings, such as differences between sold fuels and actually combusted fuels (stock-changes in residential tanks) for liquid fossil fuels,
- For uncertainties of non-key categories, only a simplified uncertainty assessment has been made.

IPCC GPG Table 6.1
Tier 1 Uncertainty Calculation and Reporting

A	B	C	D	E	F	G	H	I	J	K	L	M
IPCC Source category	Gas	Base year emissions 1990	Year 2007 emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combinded uncertainty as % of total national emission in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data	Calc/Input						
		Gg CO2 equivalent	Gg CO2 equivalent	%	%	%	%	%	%	%	%	%
1. CO2 emissions from Fuel Combustion												
1A 1. Energy A. Fuel Combustion Gaseous fuels	CO2	27.81	76.93	5.0	4.6	6.8	2.147	0.2064	0.3351	0.95	2.37	2.55
1A 1. Energy A. Fuel Combustion Gas oil and LPG	CO2	94.58	45.56	20.0	0.61	20.0	3.744	-0.2376	0.1985	-0.15	5.61	5.62
1A 1. Energy A. Fuel Combustion Gasoline	CO2	60.53	55.85	10.0	1.36	10.1	2.315	-0.0363	0.2433	-0.05	3.44	3.44
1A 1. Energy A. Fuel Combustion Diesel	CO2	18.43	31.92	15.0	0.47	15.0	1.968	0.0538	0.1391	0.03	2.95	2.95
1A 1. Energy A. Fuel Combustion Jet Kerosene	CO2	0.08	0.13	15.0	1.16	15.0	0.008	0.0002	0.0006	0.00	0.01	0.01
1A 1. Energy A. Fuel Combustion Solid fuels	CO2	0.09	0.01	20.0	5.0	20.6	0.001	-0.0004	0.0001	0.00	0.00	0.00
Total CO2 Emissions Fuel Combustion	CO2	201.53	210.41									

A	B	C	D	E	F	G	H	I	J	K	L	M
		Gg CO2 equivalent	Gg CO2 equivalent	%	%	%	%	%	%	%	%	%
2. Emissions which are not CO2 emissions from Fuel Combustion												
Key Sources												
2F 2. Industrial Proc. F. Consumption of Halocarbons and SF6	HFC	0.00	4.47		13.8	13.8	0.254	0.0195	0.0195	0.27	0.00	0.27
4A 4. Agriculture A. Enteric Fermentation	CH4	9.80	10.38	6.4	17.2	18.3	0.782	-0.0001	0.0452	0.00	0.41	0.41
4D1 4. Agriculture D. Agricultural Soils; Direct Soil Emissions	N2O	5.75	5.66		76.5	76.5	1.779	-0.0019	0.0247	-0.15	0.00	0.15
4D3 4. Agriculture D. Agricultural Soils; Indirect Emissions	N2O	2.73	2.51		159.1	159.1	1.643	-0.0017	0.0110	-0.27	0.00	0.27
Non Key Sources												
Rest of sources	all	9.74	10.04		24.1	24.1	0.996	-0.0012	0.0438	-0.03	0.00	0.03
Total other Key Sources and rest of sources		28.02	33.07									

A	B	C	D				H					M
		Gg CO2 equivalent	Gg CO2 equivalent									
3. Total (combined uncertainty of 1. and 2.)												
Total Emissions	all	229.55	243.48									
Total Uncertainties						Overall uncertainty in the year (%)	**5.95**				Trend uncertainty (%)	**7.68**

Table 9 Tier 1 Uncertainty calculation and reporting for sources in Liechtenstein, 2007 (IPCC 2000, Table 6.1).

Table 6.1 (CONTINUED)
Tier 1 Uncertainty Calculation and Reporting

A (continued)				B	N	O	P	Q
IPCC Source category				Gas	Emission factor quality indicator IPCC **D**efault, **M**easurement based, national **R**eferenced data	Activity data quality indicator IPCC **D**efault, **M**easurement based, national **R**eferenced data	Expert judgement reference numbers	Reference to section in NIR
1A	1. Energy	A. Fuel Combustion	Gaseous fuels	CO2	M	D		Section 3.2.3
1A	1. Energy	A. Fuel Combustion	Gas oil and LPG	CO2	M	R		Section 3.2.3
1A	1. Energy	A. Fuel Combustion	Gasoline	CO2	M	R		Section 3.2.3
1A	1. Energy	A. Fuel Combustion	Diesel	CO2	M	R		Section 3.2.3
1A	1. Energy	A. Fuel Combustion	Jet Kerosene	CO2	M	R		Section 3.2.3
1A	1. Energy	A. Fuel Combustion	Solid fuels	CO2	D	D, R		Section 3.2.3
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6		HFC	R	R		Section 4.7.3
4A	4. Agriculture	A. Enteric Fermentation		CH4	R	R		Section 6.2.3
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions		N2O	D	R		Section 6.5.3
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions		N2O	D	D		Section 6.5.3
	Rest of sources			All	R	R		Exp. est.

Table 10 Further information on the Tier 1 uncertainty calculation and reporting for sources in Liechtenstein, 2007 (IPCC 2000, Table 6.1 continued).

1.7.4. Results of Tier 2 Uncertainty Evaluation (Monte Carlo)

The principle of Monte Carlo analysis is to select random values for emission factor and activity data from within their individual probability distributions, and to calculate the corresponding emission values. This procedure is repeated until an adequately stable result has been found. The results of all iterations yield the overall emission probability distribution.

In the present analysis, Monte Carlo simulations were performed to estimate uncertainties both in emissions and in emission trends, at the source category level as well as for the inventory as a whole (excluding LULUCF). The simulations were run with the commercial software package Crystal Ball (® Decisioneering). This tool generates random numbers within user-defined probability ranges and probability distributions. As a result, selected statistics are produced for the forecast variables.

a) Uncertainty in emissions

As a first step, for key categories, the shape and extent of the probability distributions were derived for the activity data and emission factors, based on measured data, literature or expert judgement. The mean value of the probability distributions was set equal to the value of the GHG inventory. In most cases, normal distributions were assumed. However, for two key categories with a high level of uncertainty (4D1 agricultural soils, direct emissions N_2O and 4D3 agricultural soils, indirect emissions N_2O), normal distribution would allow negative emissions. For these cases, log-normal distributions were used (cf. Annex A1.2.2). The log-normal distribution is positively skewed and produces only positive values, while the upper bound of emissions may be poorly known.

As a second step, emissions were calculated as emission factor multiplied by the corresponding activity data. For those cases where the activity data or emission factor for a specific source category were not available as well as for all non key categories, emissions were modelled directly, with the mean value set equal to the value of the GHG inventory and an adequate probability distribution of the emissions.

The Monte Carlo simulation then provided information on the simulated distribution, on the 2.5 and 97.5 percentiles of emissions, on the uncertainty of the national total emission in 2007 and in the base year 1990 as well as on the trend uncertainty 1990–2007.

b) Dependent Uncertainties

Correlations may have a significant effect on the overall inventory uncertainty. The more the source categories are differentiated the more correlations become important. For the Liechtenstein inventory, the differentiation is on a relatively low level: The most important energy sector is only split into fuel types for the purpose of Monte Carlo simulation but not into sub-categories. Therefore only correlations between the fuel types have to be considered for the level uncertainty, especially correlations between gasoline and diesel consumption. A detailed description of the assumptions for the present analysis and the respective correlation coefficients can be found in Annex A7. For consistency reasons, Crystal Ball software adjusted a few of the correlation coefficients by an average of 0.10.

c) Uncertainty in Emission Trends

The trend is defined as the difference between the base year and the year of interest (year t, 2007). Hence for estimation of the uncertainty in the emission trends, the Monte Carlo simulation was run for the year 2007 and for the base year 1990. The trend was then derived for the source categories as well as for the total emissions. It was assumed that

- the uncertainties for the base year are equal to the uncertainties of 2007 and that the probability distributions of the 1990 data are of equal shape as the distributions derived for 2007,
- the activity data of 1990 are positively correlated with the activity data of 2007 (correlation coefficients are set to 0.5)
- and that the emission factors of the two years are assumed to be positively correlated with correlation coefficient set to 1.0.

For a more sophisticated analysis, the uncertainties of the base year will have to be considered more closely and set larger for a couple of activity data. This improvement will have to be realised for a later submission.

d) Results

Uncertainties of national total 2007 and of trend 1990–2007

The Monte Carlo simulations reveal a level uncertainty of 6.0% and a trend uncertainty of 8.9%. The distributions of the total emissions for 2007 and 1990 are nearly symmetric. Due to the higher emissions in 2007, it is shifted towards higher mean emissions (cf. Figure 5). The uncertainty estimates as derived from the Monte Carlo simulations are shown in Table 11.

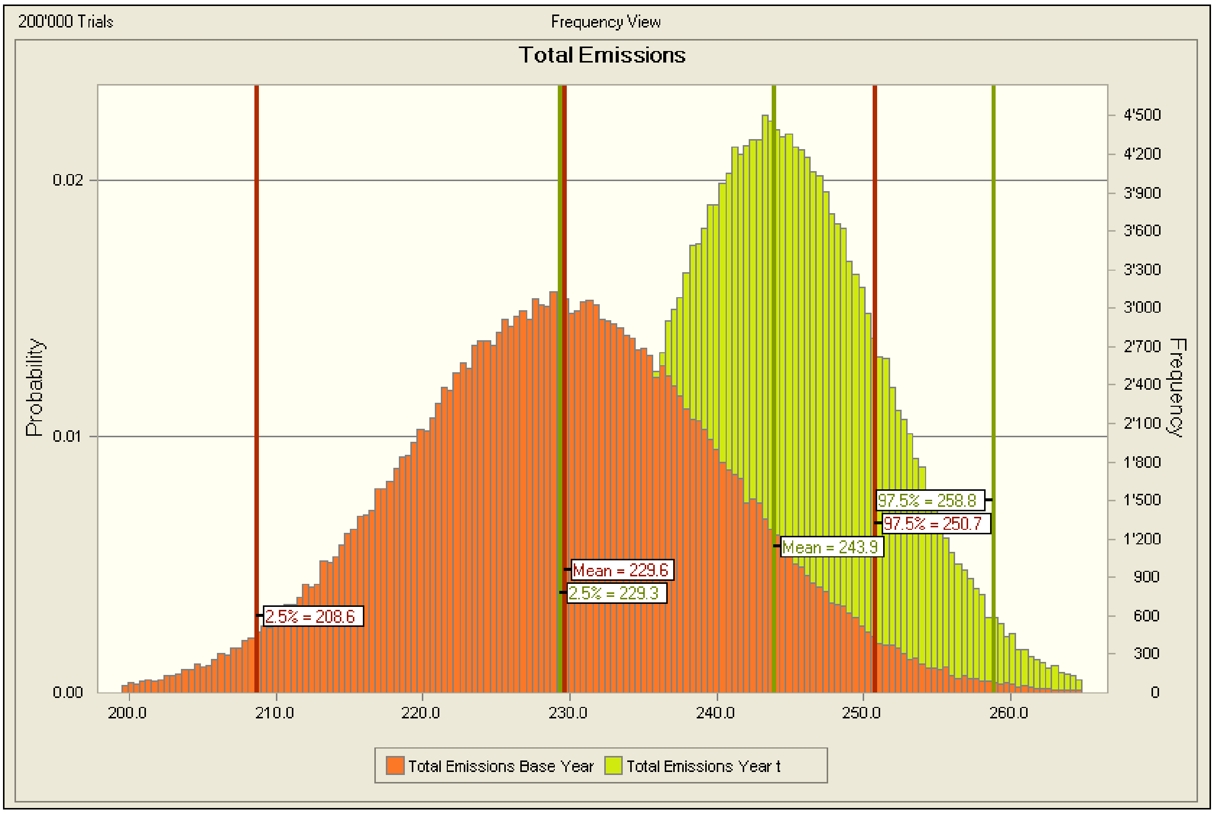

Figure 5 Probability distributions of total emissions for the base year 1990 (in red) and year t=2007 (in green). On the x-axis, the total emissions reported in the inventory (without LULUCF) are given in Gg CO_2 equivalent. The number of Monte Carlo runs is 200'000. The vertical lines show simulated mean values (*Mean*) and the *2.5%* and *97.5%* percentile values.
Note that mean and percentile values correspond to the simulated values and differ slightly from the reported inventory values. For the transformation, see Table 140 in Annex A7.

Main results of the Monte Carlo simulation

Level uncertainty of national total emissions in 2007

The total uncertainty of the 2007 Liechtenstein emissions is **6,05%** (14.7 Gg CO_2 equivalent) of the total GHG emissions (243.5 Gg CO_2 equivalent excluding LULUCF).

The 95% confidence interval is almost symmetric and lies between **94.0% and 106.1%** of the Swiss total GHG emissions. The end points are: 229.0 Gg (=243.5 Gg–14.5 Gg) and 258.4 Gg (=243.5 Gg+15.0 Gg).

Trend uncertainty of national total emissions 1990–2007

The change in total emissions between 1990 and 2007 is +6.1%. With a probability of 95%, the change lies within the range **of -2.7% to +15.0%, corresponding to a trend uncertainty of 8.9%.**

A				B	C	D	E	F	G	H	I	J
IPPC Source Category				Gas	Base year (1990) emissions	Year t (2006) emissions	Uncertainty in year t emissions as % of emissions in the category		Uncertainty introduced on national total in year t	% change in emissions between year t and base year	Range of likely % change between year t and base year	
					(Gg CO2 equivalent)	(Gg CO2 equivalent)	% below (2.5 percentile)	% above (97.5 percentile)	(%)	(%)	% below (2.5 percentile)	% above (97.5 percentile)
1. CO2 emissions from Fuel Combustion												
1A	1. Energy	A. Fuel Combustion	Gaseous fuels	CO2	27.8	76.9	93	107	2.1	177	163	191
1A	1. Energy	A. Fuel Combustion	Gas oil and LPG	CO2	94.6	45.6	80	120	3.7	-52	-69	-35
1A	1. Energy	A. Fuel Combustion	Gasoline	CO2	60.5	55.8	90	110	2.3	-8	-17	2
1A	1. Energy	A. Fuel Combustion	Diesel	CO2	18.4	31.9	85	115	1.9	73	51	95
1A	1. Energy	A. Fuel Combustion	Jet Kerosene	CO2	0.08	0.13	85	115	0.0	77	55	100
1A	1. Energy	A. Fuel Combustion	Solid fuels	CO2	0.09	0.01	80	120	0.0	-86	-105	-68
2. Emissions which are not CO2 emissions from Fuel Combustion												
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6		HFC	0.00	4.5	86	114	0.2	53'245'125	46'017'556	60'445'379
4A	4. Agriculture	A. Enteric Fermentation		CH4	9.8	10.4	82	118	0.8	6	-20	32
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions		N2O	5.8	5.7	25	175	1.7	-2	-110	107
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions		N2O	2.7	2.5	100	256	1.3	-8	-234	207
Other					9.7	10.0	*	*	*	*	*	*
Total					229.6	243.5	94.0	106.1	6.05	6.01	-2.7	15.0

Table 11 Tier 2 uncertainty results for sources in Liechtenstein 2007 (IPCC 2000, Table 6.2). In this table, uncertainties of the key categories are reported. For the non-key categories, see Table 142 in Annex A7.

1.7.5. Comparison of Tier 1 and Tier 2 Results

In the GHG inventory, some of the uncertainties may become large and their statistical distribution may clearly deviate from normal distributions. Tier 1 uncertainty analysis is based on simple error propagation, which assumes only small and normally distributed uncertainties. The application of the Tier 1 method is therefore not the optimal instrument for determining the uncertainties of a GHG inventory. The more appropriate choice is the Monte Carlo simulation, which is designed for uncertainties of any shape, for any size of uncertainties, any correlated figures and which is recommended by the IPCC Good Practice Guidance (IPCC 2000) as the Tier 2 method. The results of the Monte Carlo simulation are therefore considered to provide a more realistic picture of the uncertainties than the results of the Tier 1 method.

Tier 2 uncertainty analysis produces an overall level uncertainty of 6.05% for 2007 emissions. This value is somewhat larger then the result of Tier 1 uncertainty analysis (5.95%). The correct treating of large uncertainties, the existence of correlations and the lognormal distributions for agricultural sources do all together increase the uncertainty slightly. As mentioned in Section 1.7.3, the fact of splitting the activity data of 1A Fuel Combustion into fuel types is a much more dominant change in the application of the uncertainty analysis than the methodological change from Tier 1 to Tier 2 analysis.

The trend uncertainty of Tier 2 analysis is 8.9% and is therefore somewhat larger than in Tier 1 analysis, 7.7%. Although the positive correlations for activity data and emission factors between of the base year and the year 2007 tend to lower the trend uncertainty (as may be seen from equation A1.8 of IPCC Good Practice Guidance IPCC 2000 with $r > 0$), Tier 2 trend uncertainty is nevertheless larger than Tier 1 trend uncertainty. This may be explained by the methodological differences between Tier 1 and Tier 2 uncertainty analysis. Due to IPCC (2000), chapter 6.3, Tier 1 analysis uses Type A and Type B sensitivity to calculate the trend uncertainty, whereas Tier 2 simulates simple differences between the base year and year t but accounting for correlations between activity data and emission factors.

Again, the difference between Tier 1 and Tier 2 analysis is very small compared to the effect of splitting the fuels in the activity data of 1A Fuel Combustion. Without splitting, the trend uncertainty raises up to 18%. With splitting, the trend uncertainty drops down to 7.7% (Tier 1) and 8.9% (Tier 2).

1.8. Completeness Assessment

Liechtenstein’s current GHG inventory is complete for all Kyoto gases. The emissions of precursors (NO_x, CO, NMVOC, SO_2) are in general not estimated and not reported (not mandatory). However, CO and NMVOC emissions from source category 2 Industrial Processes and 3 Solvent and Other Product Use have been estimated in a preliminary way based on Swiss data.

2. Trends in Greenhouse Gas Emissions and Removals

This chapter gives an overview of Liechtenstein's GHG emissions and removals as well as their trends in the period 1990–2007.

2.1. Aggregated Greenhouse Gas Emissions 2007

In 2007, Liechtenstein emitted 243.5 Gg (kilotonnes) CO_2 equivalent, or 6.88 tonnes CO_2 equivalent per capita (CO_2 only: 5.97 tonnes per capita) to the atmosphere not including emissions and removals from Land Use, Land-Use Change and Forestry (LULUCF). The largest contributor gas is CO_2, and the most important sources of emissions are fuel combustion activities in the Energy sector. Table 12 shows the emissions for individual gases and sectors in Liechtenstein for the year 2007. Fuel combustion within the Energy sector was by far the largest source of emissions of CO_2 in 2007. Emissions of CH_4 and N_2O originated mainly from Agriculture, and the synthetic gas emissions stemmed by definition from Industrial Processes.

Emissions 2007	**CO_2**	**CH_4**	**N_2O**	**HFCs**	**PFCs**	**SF_6**	**Total**
	CO_2 equivalent (Gg)						
1 Energy	210.4	1.9	1.1				**213.3**
2 Industrial Processes	NO	NO	NO	4.5	NA,NO	0.1	**4.6**
3 Solvent and other Product Use	0.9		0.2				**1.1**
4 Agriculture		12.1	10.5				**22.6**
6 Waste	0.0	0.7	1.1				**1.9**
Total (excluding LULUCF)	**211.3**	**14.7**	**12.9**	**4.5**	**0.0**	**0.1**	**243.5**
5 LULUCF	-6.6	NO	NO				**-6.6**
Total (including LULUCF)	204.7	14.7	12.9	4.5	0.0	0.1	**236.9**
International Bunkers	*0.8*	*0.0*	*0.0*				***0.8***

Table 12 Summary of Liechtenstein's GHG emissions by gas and sector in CO_2 equivalent (Gg), 2007.

A breakdown of Liechtenstein's total emissions by gas is shown in Figure 6 below. Figure 7 is a bar chart of contributions to GHG emissions by gas and sector.

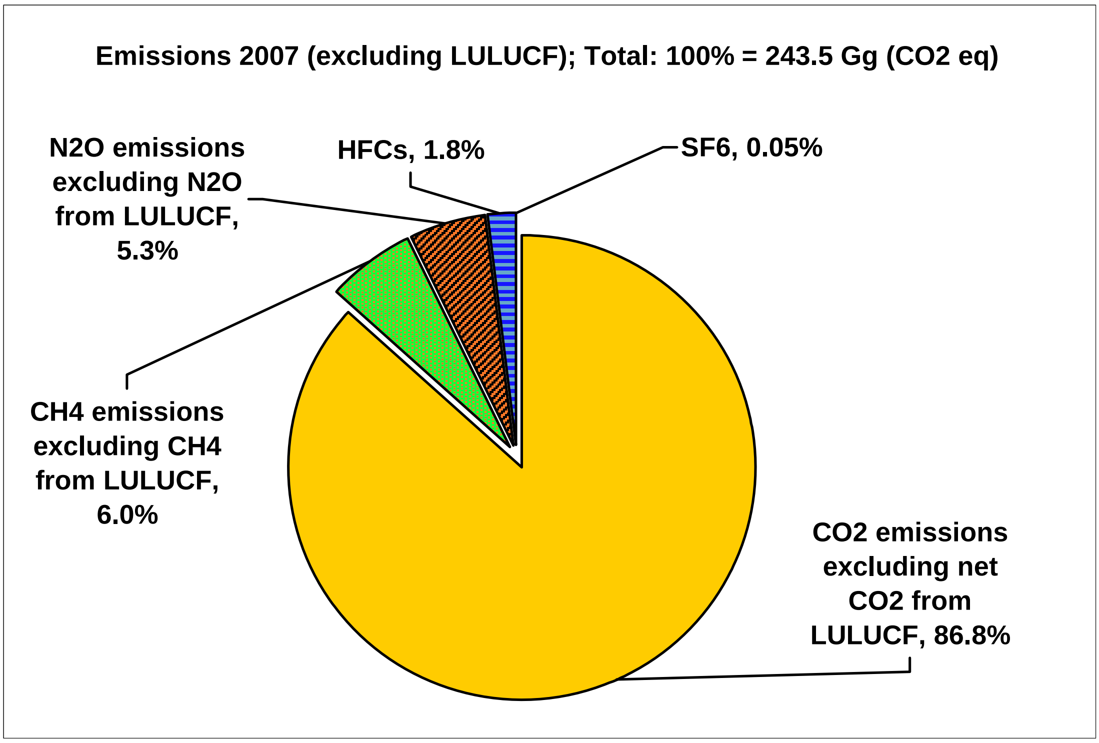

Figure 6 Liechtenstein's GHG emissions by gas excluding LULUCF in 2007.

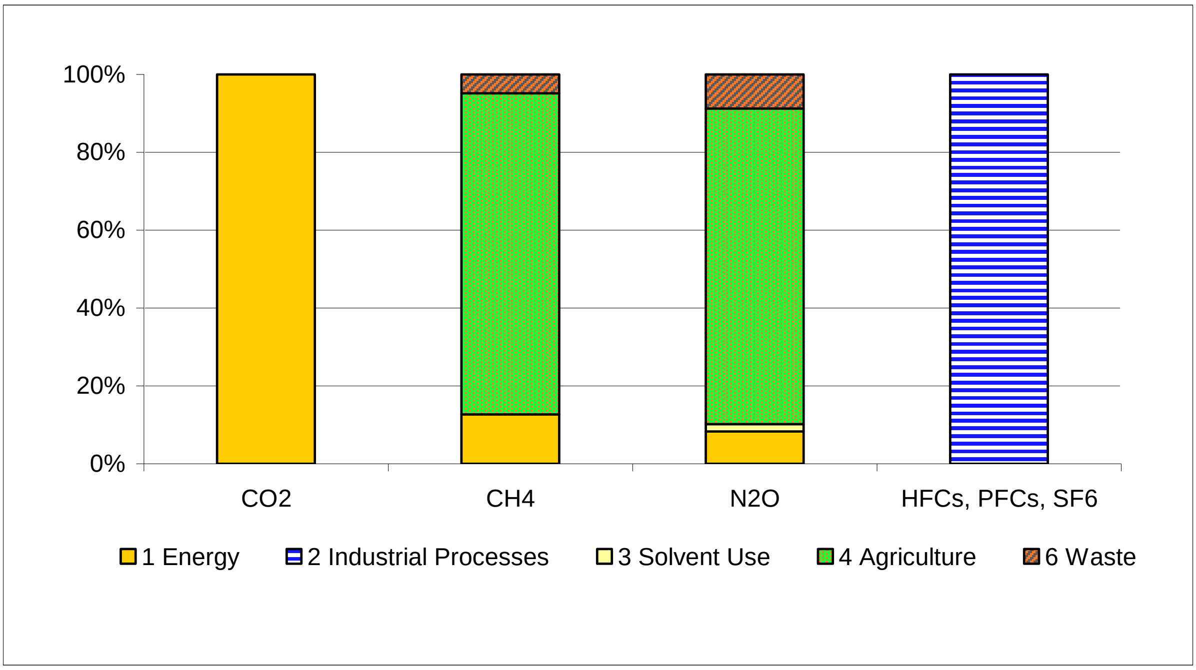

Figure 7 Relative contributions of the individual sectors (excluding LULUCF) to GHG emissions in 2007.

2.2. Emission Trends by Gas

Emission trends 1990–2007 by gas are summarised in the Table 13 and in Figure 8.

Greenhouse Gas Emissions	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)									
CO_2 emissions including net CO_2 from LULUCF	194.7	202.4	203.3	211.6	197.6	200.9	203.0	218.9	230.2	229.4
CO_2 emissions excluding net CO_2 from LULUCF	203.1	210.8	211.7	220.0	206.1	209.4	211.6	223.8	235.1	234.3
CH_4 emissions including CH_4 from LULUCF	13.4	13.2	13.1	12.4	12.6	12.6	12.7	12.6	12.6	12.5
CH_4 emissions excluding CH_4 from LULUCF	13.4	13.2	13.1	12.4	12.6	12.6	12.7	12.6	12.6	12.5
N_2O emissions including N_2O from LULUCF	13.1	13.3	13.4	13.0	13.0	13.2	13.0	13.0	12.8	12.8
N_2O emissions excluding N_2O from LULUCF	13.1	13.3	13.4	13.0	13.0	13.2	12.9	13.0	12.8	12.7
HFCs	0.0	0.0	0.0	0.1	0.1	0.4	0.7	1.0	1.4	1.8
PFCs	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
SF_6	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.0	0.0	0.0	0.0
Total (including LULUCF)	**221.2**	**229.0**	**229.8**	**237.0**	**223.3**	**227.1**	**229.4**	**245.5**	**257.0**	**256.4**
Total (excluding LULUCF)	**229.6**	**237.3**	**238.2**	**245.5**	**231.7**	**235.5**	**237.9**	**250.4**	**261.9**	**261.3**

Greenhouse Gas Emissions	2000	2001	2002	2003	2004	2005	2006	2007	*1990-2007*
	CO_2 equivalent (Gg)								*%*
CO_2 emissions including net CO_2 from LULUCF	222.6	220.7	225.6	233.5	233.7	233.4	235.1	204.7	*5.1*
CO_2 emissions excluding net CO_2 from LULUCF	227.5	225.6	230.6	240.0	240.2	240.0	241.6	211.3	*4.0*
CH_4 emissions including CH_4 from LULUCF	12.3	13.0	13.1	13.3	13.5	14.0	14.4	14.7	*9.7*
CH_4 emissions excluding CH_4 from LULUCF	12.3	13.0	13.1	13.3	13.5	14.0	14.4	14.7	*9.7*
N_2O emissions including N_2O from LULUCF	12.5	12.7	12.5	12.5	12.6	12.7	12.8	12.9	*-1.4*
N_2O emissions excluding N_2O from LULUCF	12.5	12.7	12.5	12.5	12.5	12.6	12.8	12.9	*-1.4*
HFCs	2.3	3.0	3.2	3.7	4.2	4.2	4.2	4.5	---
PFCs	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	---
SF_6	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	---
Total (including LULUCF)	**249.8**	**249.4**	**254.5**	**263.1**	**263.9**	**264.3**	**266.5**	**236.9**	***7.1***
Total (excluding LULUCF)	**254.7**	**254.3**	**259.4**	**269.6**	**270.4**	**270.8**	**273.0**	**243.5**	***6.1***

Table 13 Summary of Liechtenstein's GHG emissions in CO_2 equivalent (Gg) by gas, 1990–2007. The column on the far right (digits in italics) shows the percent change in emissions in 2007 as compared to the base year 1990.

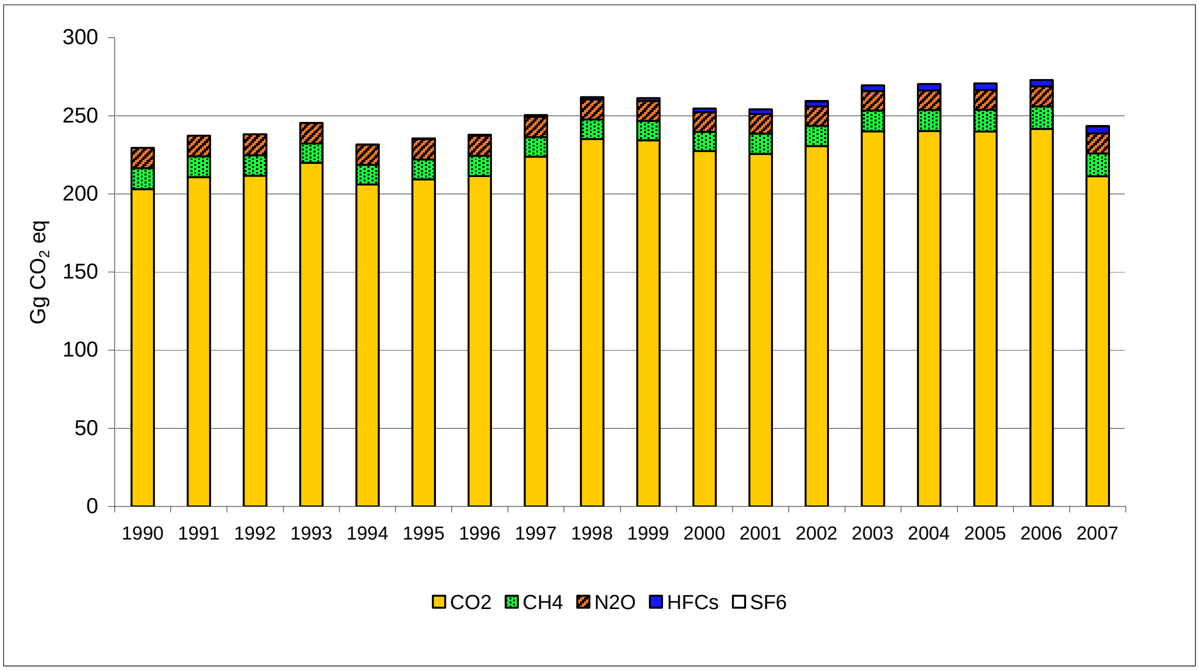

Figure 8 Trend of Liechtenstein's greenhouse gas emissions by gases1990–2007. CO_2, CH_4 and N_2O correspond to the respective total emissions excluding LULUCF.

The emission trends for the individual gases are as follows:

- Total emissions excluding LULUCF Removals/Emissions increased from 1990 to 2007 by 6.1%.
- Total emissions including LULUCF increased more strongly by 7.1%.
- The CO_2 emissions excluding net CO_2 emissions from LULUCF increased from 1990 to 2007 by 5.1%. It contributes the largest share of emissions, accounting for about 88.5% of the total emissions in 2007. This share fluctuated between 86.8% and 89.8% in the period 1990–2007.
- The CO_2 emissions excluding net CO_2 emissions from LULUCF show a very significant decrease from 2006 to 2007 (the explanation is provided by the analysis of the sources; see next paragraph below at 1A4 Other Sectors).
- CH_4 emissions excluding CH_4 from LULUCF showed an increase of 9.7%, which is the result of an increase in the sectors energy and waste. Its contribution to the total national emissions is 6.0% in 2007, which is slightly lower than in 1990, where the number was 5.8%.
- N_2O emissions excluding N_2O from LULUCF have decreased by 1.4% due to reduced input of mineral fertilizers and due to a reduction of organic soils. Its contribution to the total national emissions decreased from 5.7% in 1990 to 5.3% in 2007.
- HFC emissions (mainly from 2F1 Refrigeration and Air Conditioning Equipment) increased due to their role as substitutes for CFCs. SF_6 emissions stem from electrical transformation stations and plays a minor role for the total of synthetic gases. PFC emissions are not occurring. The share of synthetic gases increased from 0.0% (1990) to 1.8% (2007).

2.3. Emission Trends by Sources and Sinks

Table 14 shows emission trends for all major source and sink categories. As the largest share of emissions originated from the energy sector, the table also shows the contributions of the energy sub-sectors (1A1-1A5, 1B).

Source and Sink Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)									
1 Energy	**203.5**	**211.5**	**212.6**	**221.1**	**207.2**	**210.7**	**212.9**	**225.4**	**236.8**	**236.0**
1A1 Energy Industries	0.2	0.8	1.9	1.9	1.8	2.0	2.5	2.5	2.9	2.9
1A2 Manufacturing Industries and Construction	35.3	34.2	34.2	36.0	34.2	34.4	34.3	35.9	38.2	37.6
1A3 Transport	76.4	89.7	89.1	87.0	79.6	81.7	82.9	86.6	86.2	91.9
1A4 Other Sectors	88.9	83.4	84.2	93.3	88.8	89.9	90.3	97.3	105.9	99.8
1A5 Other (Offroad)	2.4	2.9	3.0	2.4	2.3	2.2	2.3	2.6	3.0	3.1
1B Fugitive emissions from oil and natural gas	0.3	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.7
2 Industrial Processes	**0.0**	**0.0**	**0.0**	**0.1**	**0.1**	**0.4**	**0.7**	**1.0**	**1.4**	**1.8**
3 Solvent and Other Product Use	**2.0**	**1.9**	**1.8**	**1.7**	**1.7**	**1.6**	**1.5**	**1.4**	**1.4**	**1.3**
4 Agriculture	**22.5**	**22.5**	**22.3**	**21.1**	**21.1**	**21.3**	**21.1**	**21.0**	**20.8**	**20.5**
6 Waste	**1.6**	**1.5**	**1.5**	**1.5**	**1.6**	**1.5**	**1.6**	**1.6**	**1.6**	**1.6**
Total (excluding LULUCF)	**229.6**	**237.3**	**238.2**	**245.5**	**231.7**	**235.5**	**237.9**	**250.4**	**261.9**	**261.3**
5 Land Use, Land-Use Change and Forestry	-8.3	-8.4	-8.4	-8.4	-8.5	-8.5	-8.5	-4.9	-4.9	-4.9
Total (including LULUCF)	221.2	229.0	229.8	237.0	223.3	227.1	229.4	245.5	257.0	256.4

Source and Sink Categories	2000	2001	2002	2003	2004	2005	2006	2007	*1990-2007*
	CO_2 equivalent (Gg)								*%*
1 Energy	**229.5**	**227.4**	**232.3**	**241.9**	**242.1**	**241.9**	**243.6**	**213.3**	***4.9***
1A1 Energy Industries	2.7	2.9	2.5	2.8	2.9	3.1	2.8	2.5	*1354*
1A2 Manufacturing Industries and Construction	34.3	34.6	35.7	38.3	37.4	36.2	37.4	30.9	*-12.5*
1A3 Transport	95.9	92.2	87.7	87.3	86.0	85.5	82.5	86.6	*13.4*
1A4 Other Sectors	92.8	94.4	102.9	109.2	111.9	112.6	116.2	88.8	*0.0*
1A5 Other (Offroad)	3.0	2.6	2.8	3.5	3.1	3.5	3.7	3.4	*41.0*
1B Fugitive emissions from oil and natural gas	0.7	0.8	0.8	0.9	0.9	1.0	1.1	1.1	*233.5*
2 Industrial Processes	**2.4**	**3.0**	**3.3**	**3.7**	**4.2**	**4.2**	**4.2**	**4.6**	**---**
3 Solvent and Other Product Use	**1.3**	**1.2**	**1.2**	**1.2**	**1.1**	**1.1**	**1.1**	**1.1**	***-44.4***
4 Agriculture	**19.8**	**21.0**	**20.9**	**21.1**	**21.2**	**21.6**	**22.3**	**22.6**	***0.2***
6 Waste	**1.7**	**1.6**	**1.8**	**1.8**	**1.8**	**1.9**	**1.8**	**1.9**	***19.2***
Total (excluding LULUCF)	**254.7**	**254.3**	**259.4**	**269.6**	**270.4**	**270.8**	**273.0**	**243.5**	***6.1***
5 Land Use, Land-Use Change and Forestry	-4.9	-4.9	-4.9	-6.5	-6.5	-6.5	-6.5	-6.6	*-21.1*
Total (including LULUCF)	249.8	249.4	254.5	263.1	263.9	264.3	266.5	236.9	*7.1*

Table 14 Summary of Liechtenstein's GHG emissions by source and sink categories in CO_2 equivalent (Gg), 1990–2007. The column on the far right (digits in italics) shows the percent change in emissions in 2007 as compared to the base year 1990.

Figure 9 is a graphical representation of Table 14 data. For the development of the sub-sectors of sector 1 Energy see Chapter 3.

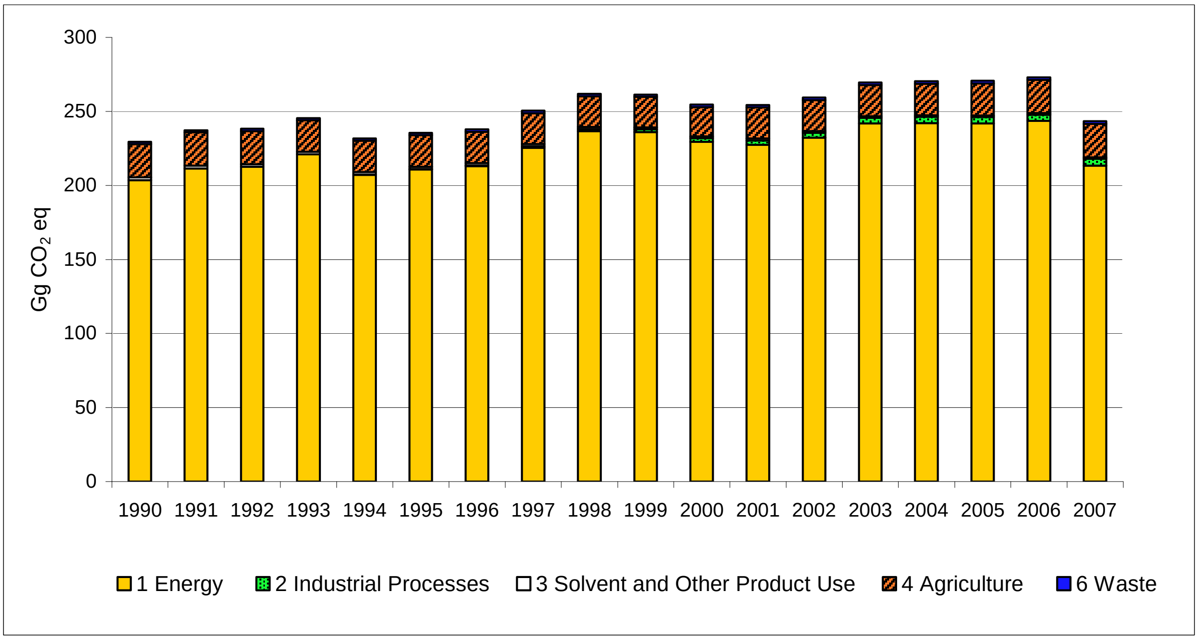

Figure 9 Trend of Liechtenstein's greenhouse gas emissions by main source categories in CO_2 equivalent (Gg), 1990–2007 (excl. net CO_2 from LULUCF).

The following emission trends in the sectors are found:

- 1 Energy: 87.6% of Liechtenstein's GHG emissions stem from the energy sector. The sub-sectors show different trends between 1990 and 2007.
  - 1A1: The consumption of natural gas in co-generation plants has enormously increased by a factor of 20. Accompanied by an extension of the gas-grid, natural gas has replaced gas oil as the main heating fuel in buildings.
  - 1A2: The consumption of natural gas by industries has increased whereas gas oil has decreased. In the total there results a net decrease of 12.5%.
  - 1A3: In line with a general increase of the road-vehicle kilometres of all vehicle categories, the fuel consumption and the emissions are increasing (13.4%).
  - 1A4: Inhabitants have increased by 22% whereas employment has increased by 40% in the period 1990-2007, which is reflected in a similar increase of energy consumption and GHG emissions by 30.7% until 2006 with several fluctuations caused by warm and cold winter periods. From 2006 to 2007 a pronounced jump downwards of almost one forth is observed. There are two hypotheses that may explain the decrease: A very high price for gas oil in the corresponding period, which gave an incentive for people to reduce fuel consumption and which also caused people to hold off the filling of their oil tanks and – simultaneously – warm winter months at the beginning and at the end of 2007, which is documented by a reduction of 5% to 10% in the heating degree days of Liechtenstein in 2007. (A similar, albeit less significant, phenomenon may be observed in Switzerland, where the prices for gas oil and the climate are similar to Liechtenstein). Holding off the filling of the residential fuel tanks would mean that to some extent instead of buying new fuel, stocks in private residential fuel tanks were depleted. A calculation based on consumption data without taking account of those residential stock changes, as it is currently the case for Liechtenstein, may therefore underestimate actual emissions in 2007. Similarly, actual emissions may be overestimated in following years, when residential tanks might be refilled. Next year's fuel consumption data will probably show which of the reasons explain the decrease in fuel consumption from 2006 to 2007.

- 1A5: The emissions reported under this category are all kind of vehicles from construction sites. The general construction activities have increased in Liechtenstein with a subsequent, fluctuating increase of diesel consumption and emissions (41.0%).
- 1B: In parallel with the built-up of Liechtenstein's gas supply network since 1990, the fugitive emissions have strongly increased over the period 1990-2007 (233%).

- 2 Industrial Processes: Due to the lack of heavy industry in the (small!) state Liechtenstein, only synthetic gases contribute to sector 2. The increasing trend is determined by HFC emissions from 2F1 Refrigeration and Air Conditioning Equipment (substitutes for CFCs).
- 3 Solvent and other product use: Emissions have strongly decreased due to reduction measures for NMVOCs resulting from legal restrictions and the introduction of the VOC levy (-44.4%).
- 4 Agriculture: The emissions show a minimum around 2000 due to decreasing and increasing animal numbers. In 2007 the emissions reached more or less the same amount as in 1990 (increase of 0.2%).
- 5 LULUCF: Figure 10 shows the net removals (negative emissions) by sources and sinks from LULUCF categories in Liechtenstein. Increase and decrease of living biomass in forests are the dominant categories. The conversion rates of forest land, which are derived from aerial photographs in three years (1984, 1996, 2002), differ significantly. They result in a time series similar to a step-like function. Other categories of land-use changes and soils have a much smaller influence on the net removals.

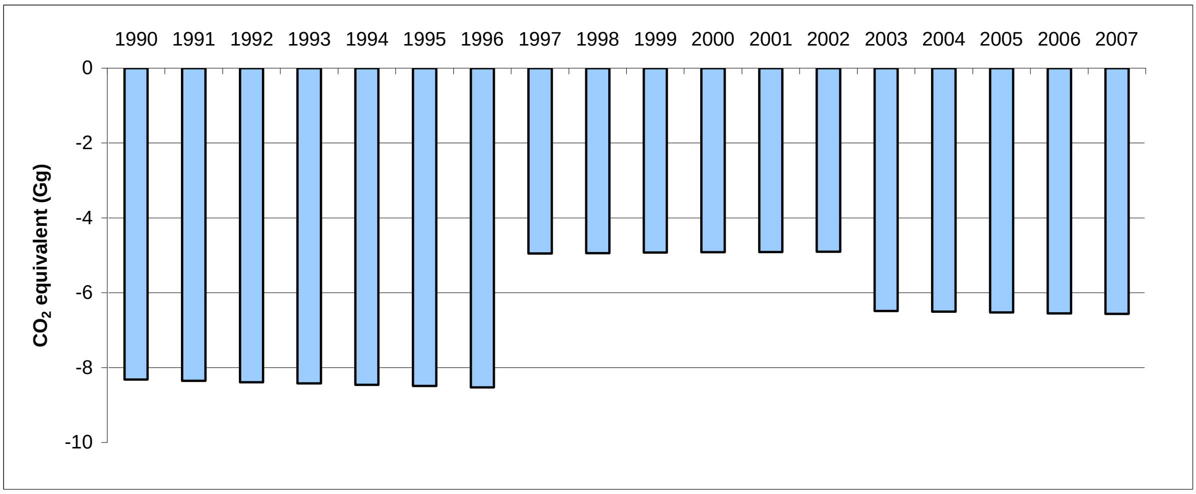

Figure 10 Net removals of CO_2 from LULUCF for 1990–2007.

- 6 Waste: In Liechtenstein only few emissions from the sector “Waste” are occurring, because all municipal solid waste is exported to a Swiss incineration plant. The increasing trend of the emissions (19.2%) remaining in Liechtenstein is determined by increasing composting activities and a slight increase in emissions from waste water handling.

2.4. Emission Trends for Indirect Greenhouse Gases and SO_2

The emissions of the indirect greenhouse gases are not yet reported for Liechtenstein.

3. Energy

3.1. *Overview*

3.1.1. Greenhouse Gas Emissions

This chapter contains information about the greenhouse gas emissions of sector 1 Energy. In Liechtenstein, the energy sector is the most relevant greenhouse gas source. In 2007, it emitted 213.3 Gg CO_2 equivalents which correspond to 87.6% of total emissions (243.5 Gg, without LULUCF). The emissions of the time period 1990–2007 are depicted in Figure 11.

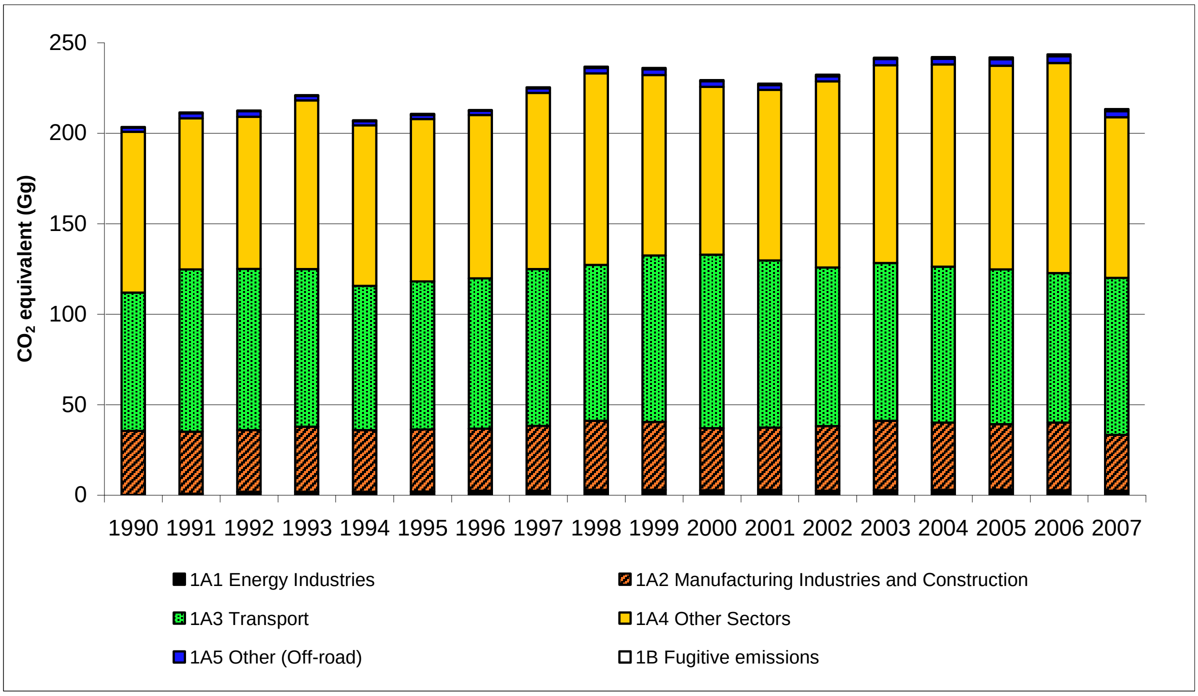

Figure 11 Liechtenstein's GHG emissions of the energy sector 1990–2007.

The following Table 15 summarises the emissions of the individual gases 1990–2007

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)									
CO_2	201.5	209.3	210.3	218.7	204.8	208.2	210.4	222.7	234.1	233.3
CH_4	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.3
N_2O	0.9	1.1	1.2	1.3	1.3	1.5	1.4	1.5	1.5	1.5
Sum	**203.5**	**211.5**	**212.6**	**221.1**	**207.2**	**210.7**	**212.9**	**225.4**	**236.8**	**236.0**

Gas	2000	2001	2002	2003	2004	2005	2006	2007	*1990-2007*
	CO2 equivalent (Gg)								%
CO_2	226.5	224.6	229.6	239.1	239.3	239.1	240.7	210.4	*4.4*
CH_4	1.4	1.3	1.4	1.5	1.6	1.7	1.8	1.9	*77.3*
N_2O	1.6	1.5	1.3	1.3	1.2	1.2	1.1	1.1	*19.7*
Sum	**229.5**	**227.4**	**232.3**	**241.9**	**242.1**	**241.9**	**243.6**	**213.3**	***4.9***

Table 15 GHG emissions of source category "1 Energy" in Liechtenstein by gas in CO_2 equivalent (Gg), 1990–2007 and the relative increase 1990–2007 (last column).

Table 16 shows more details of the emissions of sector 1 Energy in 2007. The table includes emissions from international bunkers (aviation) as well as biomass which are both not accounted for in the Kyoto Protocol.

Emissions 2007	**CO_2**	**CH_4**	**N_2O**	**Total**	
Sources	**CO_2 equivalent (Gg)**				***%***
1 Energy	**210.4**	**1.87**	**1.07**	**213.3**	***100.0***
1A Fuel Combustion	**210.4**	**0.80**	**1.07**	**212.3**	***99.5***
1A1 Energy Industries	2.4	0.03	0.08	**2.5**	***1.2***
1A2 Manufacturing Industries and Construction	30.8	0.05	0.03	**30.9**	***14.5***
1A3 Transport	85.8	0.16	0.64	**86.6**	***40.6***
1A4 Other Sectors	88.0	0.56	0.27	**88.8**	***41.6***
1A5 Other	3.3	0.00	0.04	**3.4**	***1.6***
1B Fugitive Emissions from Fuels	**NA,NO**	**1.07**	**NA,NO**	**1.1**	***0.5***
International Bunkers	0.8	0.0	0.0	**0.0**	***NE,NO***
CO_2 Emissions from Biomass	15.7	0.0	0.0	**15.7**	***---***

Table 16 Summary of sector Energy, emissions in 2007 in Gg CO_2 equivalent (rounded values).

The most obvious features of the energy emissions may be characterised as follows:

- For the total emissions of the energy sector, an increase of 4.9% may be observed between 1990 and 2007. The increase of 19.7% between 1990 and 2006 has therefore been markedly cut down due to the sharp decrease of fuel sales between 2006 and 2007.
- The three sub-categories 1A2, 1A3 and 1A4 dominate the emissions of 1 Energy and cover together 96.7% of its emissions:
  - 1A2 Manufacturing Industries and Construction contribute 14.5% of the emissions.
  - 1A3 Transport is responsible for 40.6% of the emissions.
  - 1A4 Other Sectors (commercial/institutional, residential) is the largest source with 41.6% of the emissions.
  - 1A1 Energy Industries, 1A5 Other (Off-road) and 1B Fugitive Emissions only play a minor role. In 2007, they cover 1.2%, 1.6% 0.5%, respectively, of the total emissions of 1 Energy.
- The only bunker emissions occurring stem from a helicopter basis in Balzers, Liechtenstein. Only few flights are domestic, most of them are business flights to Switzerland and Austria, producing bunker emissions. The emissions are 0.76 Gg CO_2 eq.
- CO_2 emissions from biomass add up to 15.7 Gg. It includes wood burning (heating) and the burning of gas from sewage treatment (heating, power).
- The far most important gas emitted from source category 1 Energy is CO_2. It accounts for 99.0% of the category in 1990 and for 98.6% in 2007.
- In 2007, CH_4 emissions contributed 0.88% to the total emissions of the energy sector. The increasing trend since 1990 (77%) is the result of the extended consumption of natural gas and the subsequent increase of fugitive emissions of methane (increase by a factor of 2.3). As well, the CH_4 emissions of 1A4 have increased by a factor of 1.9 in

the same period. The emissions from road transportation have actually decreased by one third mainly due to the growing number of gasoline passenger cars with catalytic converters.

- N_2O contributed 0.44% (1990) and 0.50% (2007) to the total emissions of the energy sector. The changes in N_2O emissions may be explained by changes in the emission of passenger cars due to catalytic converters.

The Liechtenstein greenhouse gas inventory identifies 15 key sources (see Chapter 1.5), 11 of which belong to the energy sector. These are depicted in Figure 12. Most dominant are the CO_2 emissions from 1A3b Transport (gasoline).

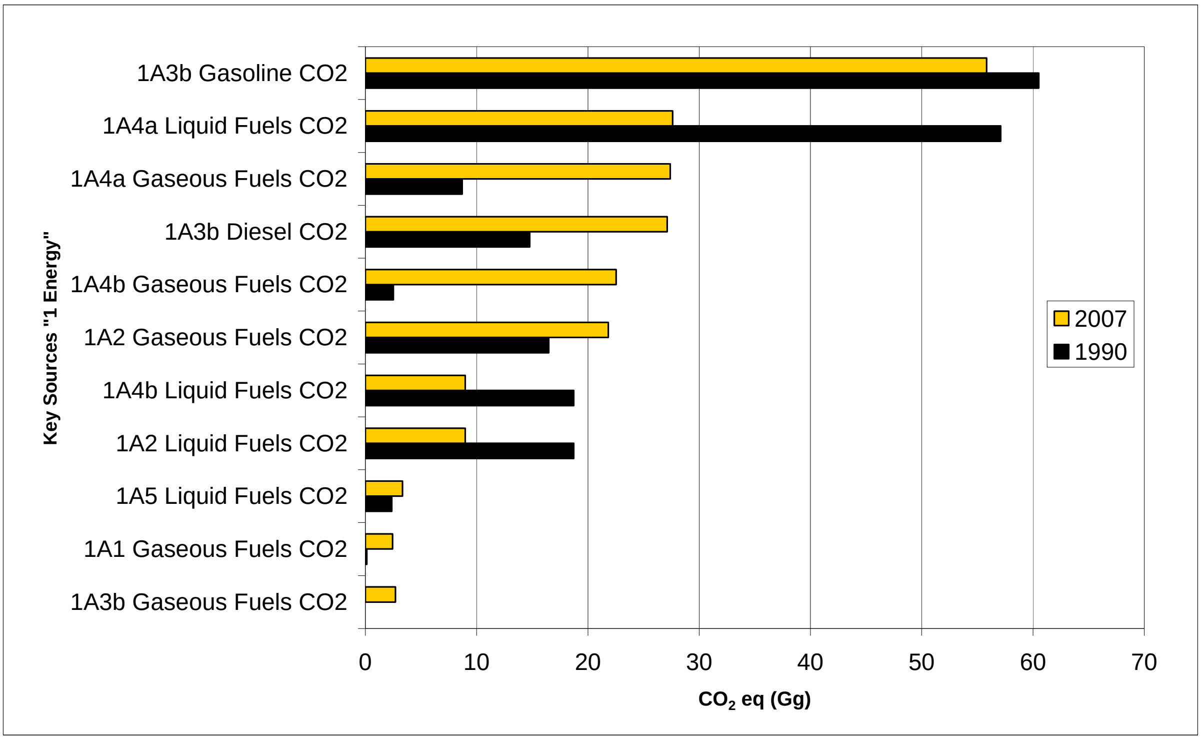

Figure 12 Key sources in the Liechtenstein GHG inventory pertaining to the energy sector.

3.1.2. CO_2 Emission Factors and Net Calorific Values

The CO_2 emission factors and the net calorific values (NCV) used for the calculation of the emissions of Sector 1 Energy are shown in Table 17.

Fuel	CO2 Emission Factor 1990-2007			Net calorific values (NCV)	
	t CO_2 / TJ	t CO_2 / t	t CO_2 / volume	**GJ / t**	**GJ / volume**
Hard Coal	94.0	2.47	---	26.3	---
Gas Oil	73.7	3.14	2.65t / 1000 lt	42.6	36.0 / 1000 lt
Residual Fuel Oil	77.0	3.17	3.01t / 1000 lt	41.2	39.1 / 1000 lt
Natural Gas	55.0	2.56	2.00t / 1000 Nm^3	46.5	36.3 / 1000 Nm^3
Gasoline	73.9	3.14	2.34t / 1000 lt	42.5	31.7 / 1000 lt
Diesel Oil	73.6	3.15	2.61t / 1000 lt	42.8	35.5 / 1000 lt
Propane/Butane (LPG)	65.5	---	---	46.0	---
Jet Kerosene	73.2	3.15	2.52t / 1000 lt	43.0	34.4 / 1000 lt
Lignite	104.0	2.09	---	20.1	---
Biofuel (vegetable oil)	89.0	3.35	---	37.6	34.6 / 1000 lt

Table 17 CO_2 emission factors and net calorific values (NCV) for fuels. The values are assumed to be constant over the period 1990-2007. The value for natural gas also holds for CNG (compressed natural gas).

3.1.3. Energy Statistics (Activity Data)

a) National Energy Statistics and Modifications

In general, the data is taken from Liechtenstein's energy statistics (OEA 2008). A more detailed analysis revealed that the data from the national energy statistics included some inconsistencies and could not simply be copied, but had to be revised in an adequate way as will be explained in the following sections. The revised data is summarised in Table 18.

Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	TJ									
Gasoline	819	916	957	947	878	903	909	954	896	940
Diesel	250	339	288	261	230	230	242	252	311	347
Gas Oil	1'272	1'116	1'077	1'189	1'095	1'065	988	1'125	1'208	1'060
Natural Gas	506	614	688	742	754	824	943	914	1'008	1'084
LPG	13.3	8.1	15.5	12.1	9.5	8.1	9.8	7.0	7.2	5.8
Hard Coal	0.97	0.92	1.10	1.00	0.71	0.68	0.50	0.53	0.55	0.29
Kerosene (domestic)	1.03	1.03	1.03	1.03	1.03	1.03	1.04	1.05	1.06	1.07
Sum	**2'862**	**2'995**	**3'027**	**3'154**	**2'969**	**3'032**	**3'093**	**3'253**	**3'431**	**3'439**
1990=100%	100%	105%	106%	110%	104%	106%	108%	114%	120%	120%
Kerosene (bunker)	5.84	5.84	5.84	5.84	5.84	5.84	6.00	6.16	6.33	6.49
Biomass										
Wood	44.7	30.9	44.6	40.5	51.1	37.7	35.0	42.5	47.5	52.2
Sewage gas	15.6	16.3	17.3	17.3	18.7	17.0	18.1	18.4	20.0	21.5
Biofuel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum biomass	60.2	47.2	61.8	57.7	69.8	54.7	53.1	60.9	67.5	73.7

Fuel	2000	2001	2002	2003	2004	2005	2006	2007
	TJ							
Gasoline	1'040	1'007	920	879	851	823	752	756
Diesel	298	267	284	330	339	364	395	434
Gas Oil	931	885	1'001	1'061	1'030	986	1'026	608
Natural Gas	1'067	1'181	1'210	1'294	1'368	1'427	1'454	1'399
LPG	5.5	3.9	4.2	4.6	4.1	3.7	5.5	11.0
Hard Coal	0.63	0.34	0.32	0.34	0.26	0.24	0.16	0.13
Kerosene (domestic)	1.08	1.09	1.14	1.19	0.85	1.15	1.85	1.83
Sum	**3'342**	**3'345**	**3'421**	**3'571**	**3'593**	**3'605**	**3'634**	**3'210**
1990=100%	117%	117%	120%	125%	126%	126%	127%	112%
Kerosene (bunker)	6.66	6.82	6.12	6.74	4.82	6.52	10.47	10.36
Biomass								
Wood	91.5	56.0	58.6	77.4	84.7	93.8	107.1	142.7
Sewage gas	21.7	20.9	20.0	20.7	21.6	20.8	22.5	24.3
Biofuel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1
Sum biomass	113.2	76.9	78.6	98.2	106.3	114.6	129.6	168.1

Table 18 Time series of Liechtenstein's fuel consumption due to the sales principle, including bunker fuel consumption (kerosene only) and biomass. Data sources: OEA (2008), OEP (2006b, 2006c, 2008a), Rhein Helikopter (2006, 2007, 2008).

The following modifications on the original energy statistics data have been carried out:

Gas oil: The "consumption" of gas oil in Liechtenstein's energy statistics reflects the amount of gas oil supplied annually to customers in Liechtenstein by oil transport companies. These customers include (i) final consumers as well as (ii) *Liechtenstein's main storage facility* for gas oil, located in Schaan. Gas oil supplied to final consumers in Liechtenstein stems both from sources in Switzerland as well as from Liechtenstein's storage. In order to avoid double counting, the amount of gas oil supplied to the storage facility has to be subtracted from the overall amount of gas oil supplied as provided by the energy statistics.

Therefore, data on the amount of gas oil supplied to Liechtenstein's storage facility has been collected from the Co-operation for the Storage of Gas Oil in the Principality of Liechtenstein (GHFL 2007, GHFL 2008). Actual consumption of gas oil in Liechtenstein has been calculated based on the total amount supplied according to national energy statistics minus supply to the stock (see Table 19).

Source	Total supply Energy Statistics	Supplied to stoc GHFL 2008	Consumption 1 Calculated	Assumed densit OEA-LIE	Consumption Calculated	Actual density FOEN 2008	Consumption 2 Calculated	Consumption Calculated
Year	Gas oil [t]	Gas oil [t]	Gas oil [t]	Gas oil [t/m3]	Gas oil [m3]	Gas oil [t/m3]	Gas oil [t]	Gas oil [TJ]
1990	35'484	5'813	29'671	0.840	35'323	0.845	29'848	1'272
1991	29'240	3'207	26'033	0.840	30'991	0.845	26'188	1'116
1992	26'083	961	25'122	0.840	29'907	0.845	25'271	1'077
1993	28'531	792	27'739	0.840	33'023	0.845	27'904	1'189
1994	26'931	1'380	25'551	0.840	30'418	0.845	25'704	1'095
1995	25'004	159	24'845	0.840	29'578	0.845	24'993	1'065
1996	23'053	0	23'053	0.840	27'444	0.845	23'190	988
1997	26'443	200	26'243	0.840	31'241	0.845	26'399	1'125
1998	28'701	520	28'181	0.840	33'549	0.845	28'349	1'208
1999	24'774	45	24'729	0.840	29'439	0.845	24'876	1'060
2000	21'931	216	21'715	0.840	25'851	0.845	21'844	931
2001	21'098	435	20'663	0.840	24'599	0.845	20'786	885
2002	24'218	859	23'359	0.840	27'808	0.845	23'498	1'001
2003	24'871	116	24'755	0.840	29'471	0.845	24'903	1'061
2004	24'036	0	24'036	0.840	28'614	0.845	24'179	1'030
2005	23'100	98	23'002	0.840	27'383	0.845	23'139	986
2006	24'231	278	23'953	0.840	28'516	0.845	24'096	1'026
2007	14'549	352	14'197	0.840	16'902	0.845	14'282	608

Table 19 Total supply of gas oil as provided by Liechtenstein's energy statistics and fraction of supply that is supplied to Liechtenstein's stock (and may be further supplied to final consumers). Gas oil *consumption 1* is the difference of total supply minus supply to stock
(*Consumption 1 = Total supply - Supplied to stock*).
This consumption is then corrected for actual density, resulting in *consumption 2*. The latter is then used for Liechtenstein's GHG Inventory. (*Consumption 2 = Consumption 1 * 0.845 / 0.840*).

Gas oil supply is measured in volume units (litres, m^3) and later reported to the office of the environment in mass units (t). This conversion is made with a (rounded) density of 0.84*0* t/m^3, whereas the more correct density is 0.845 t/m^3 (FOEN 2008) Therefore, the *Consumption 1* is corrected accordingly, resulting in *Consumption 2*, as is shown in Table 19. Using a net calorific value of 42.6 GJ/t (FOEN 2008), the actual consumption in energy units results as used in Liechtenstein's GHG inventory. See also Table 136.

Natural gas: Natural gas consumption as published in the energy statistics (OEA 2008) is based on net natural gas imports. The amount of natural gas that leaks from the distribution network (reported under 1B2b) and is not burned at the final consumer's combustion system, is subtracted from the net imports in order to determine final consumption in 1A.

Gasoline / Diesel oil: Due to the census carried out by the Office of Economic Affairs (OEA), the fuel consumption had large uncertainties. A number of distributors of gasoline and diesel annually report the amount of gasoline and diesel provided to domestic gasoline stations. Since not all distributors are known (they may come from any Swiss place and may differ every year), the census may not provide a complete statistics. Therefore, in 2000, the Office of Environmental Protection started a second census by direct questioning of all public gasoline stations. The results of this new census may be considered as a complete overview of all gasoline and diesel oil sold to passenger cars (including also "tank tourism"[3]), but it covers only the years 2000-2007. For the years 1990-1999 (diesel: 1990-2001 see below), the data compiled by OEA were collected in their original units (mass and volume units were used) and transformed into energy units by using the following densities and NCV.

[3] Like in Switzerland, gasoline stations sell relevant amounts of gasoline to foreign car owners due to fuel price differences between Liechtenstein/Switzerland (same prices) and Austria, Germany (higher gasoline prices). This amount of fuel is mainly consumed abroad (Therefore called "tank tourism"), but the whole amount must be reported as national under 1A3b Road transportation. For diesel oil, a similar tourism holds but inverse (import), because diesel oil is cheaper in Austria and Germany.

Parameter	unit	Gasoline	Diesel oil	Biodiesel
Density	kg/litre	0.745	0.830	0.920
NCV	GJ/t	42.5	42.8	37.6

Table 20 Values .used for the entire period 1990-2007 (OEP 2006c, FOEN 2008). See also Table 17 and Table 136

For gasoline consumption, in 1990 the value of the energy statistics is used. For the years 1991-1999, a 3-years-mean is carried out (e.g. 1991: arithmetic mean of 1990, 1991, 1992). From 2000 to 2007, the values of the second census are used. The result of this modification is shown in Table 18 in row gasoline (OEP 2008a).

For diesel oil the amount sold at gasoline station does not yet cover the whole amount consumed.

- There are private diesel stations, which are not part of the OEP census of public accessible gasoline stations. The holders of these private stations are mainly transport companies with heavy duty vehicles, construction companies with construction vehicles and farmers with agricultural machinery/vehicles. Because the diesel oil containers are subject to registration, the holders of these private diesel stations are known to the OEP. Based on these registration data, the OEP in 2002 started a further census of the diesel consumption by these private stations (OEP 2006c, OEP 2008a).
- Finally, the agriculture part is known by another information channel:
    - Until 2005: Farmers declared their purchase of diesel fuel and claimed refund of the fuel tax at the General Directorate of Swiss Customs, which was the collecting and refunding institution of fuel taxes for fuel purchase in Switzerland and Liechtenstein, and which provided the OEP with the information about the amount declared annually by Liechtenstein's farmers. For simplification reasons, Switzerland has given up the refunding system.
    - Since 2005: The OEP collects the consumption data directly at all the farmers by questionnaire. For the first time this was carried out in winter 2007 to collect the consumption data 2005, which was also available from the former method practised by the General Directorate of Swiss Customs. This allowed a quality control check. Since the difference was only 1%[4] (OEP 2006c), both methods may be characterised as of equal and very high quality. The census is now being repeated annually.
- The OEP census for diesel oil therefore encompasses three parts: diesel oil of public gasoline stations (in improved census since 2000), diesel oil consumption of private stations (in census since 2002) and diesel oil consumption by farmers (data available for all years since 1990). The sum of these three parts, as available since 2002, is the total of diesel oil consumption.

For diesel oil, in 1990, the value is taken from the energy statistics. For the years 1991-2001, a 3-years-mean is carried out (e.g. 1991: arithmetic mean of 1990, 1991, 1992), because of low data quality. From 2002 to 2007, the values of the OEP census are used, because for these years data of high quality is available. The result of this modification is shown in Table 18 in line "diesel".

Kerosene: The fuel sales at the single helicopter base have been reported in detail (domestic, international/bunker) for 2001, 2002, 2005, 2006, 2007 and less detailed for 1995

[4] Consumption due to General Directorate of Swiss Customs 514'759 litres of diesel oil, due to questionnaire: 520'618 litres. Difference 5859 litres (1.1%). Data source OEP 2007a.

(Rhein Helikopter 2006, 2007, 2008). For the other years in the reporting period, adequate assumptions were made (see Section 3.2.2.c)

Bunker (kerosene, civil aviation): See Section 3.4.

Biomass: See Section 3.5.

b) Energy Statistics and Contribution to the IPCC Source Categories

b1) Gas oil

No data on the specific contribution of Source Categories 1A2, 1A4a and 1A4b to total gas oil consumption in 1A Fuel Combustion Activities is currently available. Therefore, the following rough estimated shares based on expert judgement are assumed for all years from 1990 to 2007:

Source category		**Share in consumption of gas oil (1990-2007)**
1A2	Manufaturing Industries and Contruction	20%
1A4a	Other Sectors - Commercial/Institutional	60%
1A4b	Other Sectors - Residential	20%
Total 1A		100%

Table 21 Estimated share of source categories in total consumption of gas oil in 1A Fuel Combustion Activities.

b2) Natural gas

The data on total consumption of natural gas in Liechtenstein is provided by the gas utility (LGV 2008) and published in the national energy statistics (OEA 2008). It refers to the net import.

For the partition of natural gas consumption between the different combustion activities in 1A, only limited data is available. Even though the gas utility publishes statistics of natural gas consumption of different groups of its customers, the definition of these groups is not fully in line with IPCC source categories and appears also somewhat arbitrary. The following tentative attribution is used:

IPCC Source Category		**Corresponding category in NG statistics**	
		(English)	*(German)*
1A1a	Public Electricity and Heat Production	Co-generation	Blockheizkraftwerke
1A2	Manufacturing Industries and Construction	Industry	Industrie
1A3b	Road Transportation	Fuel for transportation	Treibstoff
1A4a	Other Sectors - Commercial/Institutional	Services	Gewerbe/Dienstleistungen und Öffentliche Hand
1A4b	Other Sectors - Residential	Residential/Households	Wohnungen/Haushalt

Table 22 Tentative correspondence between IPCC source categories and categories in Liechtenstein's natural gas (NG) consumption statistics.

b3) Gasoline

The whole amount of gasoline sold is attributed to 1A3b Road Transportation.

b4) Diesel oil

The diesel consumption, which stems from three different data sources, is attributed to the source categories according to the following assumptions (private diesel tanks: see Section

a. National Energy Statistics and Modifications above).

Shares of diesel sales Data source	**1A3b Road Transportation**	**1A4c Other Sect./Agriculture**	**1A5b Other/Mobile**	**Sum**
Questioning gasoline stations	100%	0%	0%	100%
Diesel "tanks"	70%	0%	30%	100%
"Oberzolldirektion"	0%	100%	0%	100%

Table 23 Data sources for the diesel consumption and its attribution to IPCC source categories for the period 1990-2007 (Acontec 2006).

Note

Please note that for the Swiss greenhouse gas inventory, the data for source category 1A Fuel Combustion from the Swiss Overall Energy Statistics is corrected for the fuel consumption in Liechtenstein (FOEN 2008). In the Swiss GHG Inventory, the fuel consumption in Liechtenstein is subtracted from the fuel consumption from the Swiss Overall Energy Statistics (that includes Liechtenstein's consumption). Therefore, a potential overestimation (underestimation) of fuel consumption in Liechtenstein is fully compensated by a related underestimation (overestimation) of fuel consumption in Switzerland.

3.2. Source Category 1A – Fuel Combustion Activities

3.2.1. Source Category Description

a) Energy Industries (1A1)

Key categories 1A1
CO_2 from the combustion of Gaseous Fuels in Energy Industries (1A1) is a key category regarding level and trend.

According to IPCC guidelines, source category 1A1 “Energy Industries” comprises emissions from fuels combusted by fuel extraction and energy producing industries.

In Liechtenstein, fuel extraction is not occurring and 1A1 includes only emissions from the production of heat and/or electricity for sale to the public. Producers in industry producing heat and/or electricity for their own use are included in category 1A2 “Manufacturing Industries and Construction”. Waste incineration plants do not exist in Liechtenstein, municipal solid waste is exported to Switzerland for incineration.

1A1	Source	Specification	Data Source
1A1 a	Public Electricity and Heat Production	This source consists of natural gas or biogas[5] fuelled public co-generation units.	AD: Energy Statistics 2007 (OEA 2008) EF: SAEFL 2005
1A1 b	Petroleum Refining	Not occurring	-
1A1 c	Manufacture of Solid Fuels and Other Energy Industries	Not occurring	-

Table 24 Specification of source category 1A1 “Energy Industries” (AD: activity data; EF: emission factors)

In Liechtenstein, over 80% of electricity consumption is imported and less than 20% is produced domestically (see Table 25).

	(MWh)	
Total consumption Liechtenstein 2007	379'013	100%
Power generation in Liechtenstein 2007	72'273	19%
Hydro power	68'360	
Natural gas co-generation	2'632	
Biogas co-generation	980	
Photovoltaic	301	
Imports	306'740	81%

Table 25 Electricity consumption, generation and imports in Liechtenstein in 2007. Data source Energy Statistics 2007 (OEA 2008).

Domestic power generation is dominated by hydroelectric power plants (see Figure 13). Other power sources are (fossil and bio fueled) combined heat and power generation, and power generation from photovoltaic plants.

[5] Biogas from sewage sludge in waste water treatment.

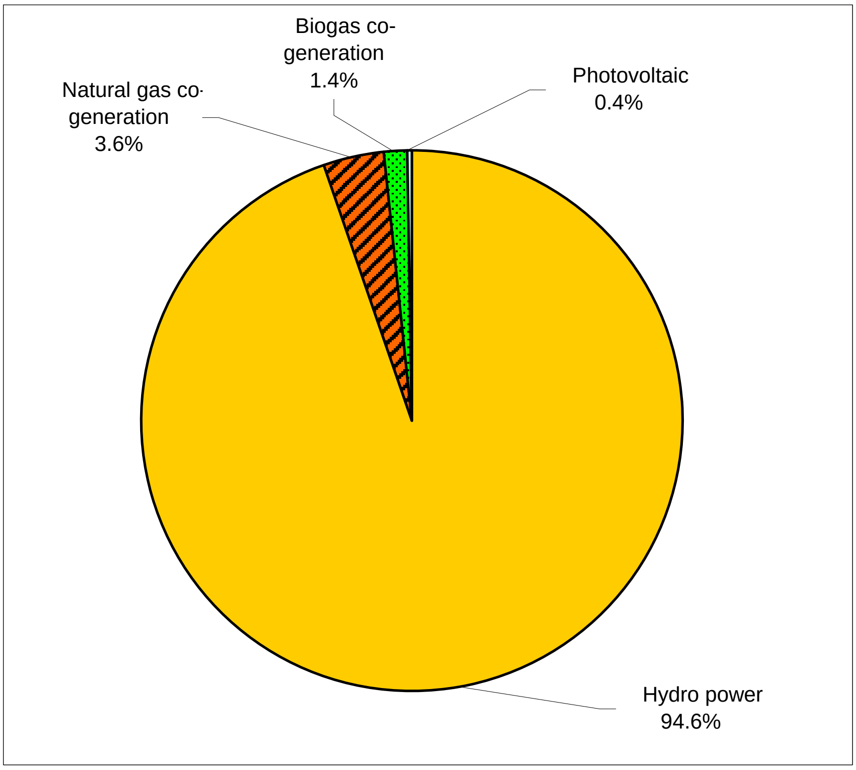

Figure 13 Structure of power generation in Liechtenstein 2007. Data source: Energy Statistics (OEA 2008).

Overall, renewable sources account for over 96% of domestic power generation in Liechtenstein.

b) Manufacturing Industries and Construction (1A2)

Key categories 1A2
CO_2 from the combustion of Gaseous Fuels and Liquid Fuels in Manufacturing Industries and Construction (1A2) is a key category regarding both level and trend.

The source category 1A2 "Manufacturing Industries and Construction" comprises all emissions from the combustion of fuels in stationary boilers, gas turbines and engines within manufacturing industries and construction. This includes industrial auto-production of heat and electricity. Not included are combustion installations in the commercial/institutional and the residential sector as well as in agriculture/forestry. These are included in category 1A4 ("Other Sectors").

Iron and Steel, Nonferrous Metals industry, Chemicals and Pulp and Paper production are not occurring in Liechtenstein.

Because data needed for the disaggregation of fuel consumption between the categories 1A2e to 1A2f is not available, all emissions related to Manufacturing Industries and Construction are reported under 1A2f Other.

1A2	Source	Specification	Data Source
1A2 a	Iron and Steel	Not occurring.	-
1A2 b	Non-ferrous Metals	Not occurring.	-
1A2 c	Chemicals	Not occurring.	-
1A2 d	Pulp, Paper and Print	Not occurring.	-
1A2 e	Food Processing, Beverages and Tobacco	Included in 1A2f.	-
1A2 f	Other (Combustion Installations in Industries)	Category 1A2 f contains all emissions related to 1A2.	AD: Energy Statistics (OEA 2008) EF: EMIS, SAEFL 2000a

Table 26 Specification of source category 1A2 “Manufacturing Industries and Construction” (AD: activity data; EF: emission factors)

c) Transport (1A3)

Key categories 1A3b
CO_2 from the combustion of gasoline (level and trend)
CO_2 from the combustion of diesel (level and trend)
CO_2 from the combustion of gaseous fuels (trend)

The source contains road transport and national civil aviation. Civil aviation in fact is only a very small contribution resulting from one only helicopter base in Liechtenstein. Railway is not producing emissions (see below), navigation and other transportation are not occurring. Further off-road transportation is included in category 1A4 Other Sectors (off-road transport in agriculture and forestry) and in 1A5 Other (off-road, e.g. construction).

1A3	Transport	Specification	Data Source
1A3a	Civil Aviation (National)	Helicopters only	AD: Rhein Helikopter AG 2006-2008 Acontec 2006 EF: FOEN 2008, IPCC 1997c
1A3b	Road Transportation	Light and heavy motor vehicles, coaches, two-wheelers	AD: OEA 2008, OEP 2006c, EF: NIR CH (FOEN 2008), IPCC 1997c
1A3c	Railways	Fully electrified system, no electricity infeed, no diesel locomotives, shunting yards	---
1A3d-e	Navigation, military aviation	Not occurring	---

Table 27 Specification of Liechtenstein's source category 1A3 “Transport” (AD: activity data; EF: emission factors).

d) Other Sectors (1A4 – Commercial/Institutional, Residential, Agriculture/ Forestry)

Key categories 1A4a, 1A4b
CO_2 from the combustion of gaseous and liquid fuels in the Commercial/Institutional Sector (1A4a) and in the Residential Sector (1A4b) are key categories regarding both level and trend.

Source category 1A4 “Other sectors” comprises emissions from fuels combusted in commercial and institutional buildings, and in households, as well as emissions from fuel combustion for grass drying and off-road machinery in agriculture.

1A4	Source	Specification	Data Source
1A4 a	Commercial/ Institutional	Emission from fuel combustion in commercial and institutional buildings	AD: Energy Statistics (OEA 2008) EF: EMIS, SAEFL 2000a; SFOE 2001
1A4 b	Residential	Emissions from fuel combustion in households	AD: Energy Statistics (OEA 2008) EF: EMIS, SAEFL 2000a; SFOE 2001
1A4 c	Agriculture/ Forestry/ Fishing	Comprises fuel combustion for agricultural machinery.	AD: Energy Statistics (OEA 2008) EF: EMIS, SAEFL 2000a; SFOE 2001; INFRAS 2008

Table 28 Specification of source category 1A4 “Other sectors” (AD: activity data; EF: emission factors).

e) Other – Off-road: Construction, Hobby, Industry and Military (1A5)

Key source 1A5b
CO_2 from the combustion of liquid fuels in 1A5 Other – Off-road is a key source regarding level.

In Liechtenstein, the sub-sources are defined according to the next table. The IPCC category structure distinguishes stationary (1A5a) and mobile (1A5b) sources. In Liechtenstein, the main sources are construction and industrial vehicles. All emissions are therefore reported under 1A5b Mobile. 1A5a Stationary sources are not reported. Should some of them occur in reality, their emissions would not be neglected but would appear under 1A5b since the emission of the total amount of fuel sold is included in the modelling.

1A5b	Off-road	Specification	Data Source
	Construction	Construction vehicles and machinery	EF: INFRAS 2008 AD: OEP 2008a
	Industry	Industrial off-road vehicles and machinery	

Table 29 Specification of Liechtenstein's source category 1A5b “Other, Mobile” (off-road).

3.2.2. Methodological Issues

General Issues

National and Reference Approach

The Reference Approach uses Tier 1 methods for the different source categories of the energy sector, whereas the National (Sectoral) Approach uses specific methods for the different source categories. For the Inventory of the Framework Convention and the Kyoto Protocol the Sectoral Approach is used. The Reference Approach is only used for controlling purposes (quality control).

Emission factors

Due to the close relations with Switzerland, similar economic structures, the same liquid/gaseous fuels and a similar vehicle fleet composition, a large number of emission factors, especially for CO_2, are taken from the Swiss greenhouse gas inventory.

Oxidation Factors

For the calculation of CO_2 emissions, an oxidation factor of 100% is assumed for all fossil fuel combustion processes (including coal), because technical standards for combustion installations in Liechtenstein are relatively high. Coal plays a negligible role in Liechtenstein (coal related CO_2 emissions were 0.012 Gg in 2007).

a) Energy Industries (1A1)

Key categories 1A1
CO_2 from the combustion of Gaseous Fuels in Energy Industries (1A1) is a key category regarding both level and trend.

In Liechtenstein, Energy Industries (source category 1A1) consists solely of natural gas and biogas fuelled public co-generation units in Public Electricity and Heat Production in 1A1a.

Petroleum Refining (1A1b) and Manufacture of Solid Fuels and Other Energy Industries (1A1c) do not occur.

Public Electricity and Heat Production (1A1a)

Methodology

For fuel combustion in Public Electricity and Heat Production (1A1a) a Tier 2 method is used. Aggregated fuel consumption data from the energy statistics is used to calculate emissions. These sources are characterised by rather similar industrial combustion processes and the same emission factors are applied throughout these sources. Emissions of GHG are calculated by multiplying fuel consumption (in TJ) by emission factors.

Emission Factors

The emission factors for CO_2 and CH_4 for co-generation are country specific and representative for engines used in Switzerland and Liechtenstein (lean fuel-air-ratio). They have been taken from Switzerland (SAEFL 2005). For the N_2O emissions the default emission factors from IPCC 1997c have been used.
Biomass: Country specific emission factors for biogas from wastewater treatment plants are taken from SAEFL 2005. The emission factor of biogenic CO_2 has been adapted to take into account CO_2 being present in the biogas as a product of fermentation already prior to combustion.[6]

The following table presents the emission factors used in 1A1a:

Source/fuel	**CO_2 t/TJ**	**CO_2 bio. t/TJ**	**CH_4 kg/TJ**	**N_2O kg/TJ**
1A1a Public Electricity/Heat				
Natural gas	55	NO	25	0.1
Biomass (biogas from WWTP)	NO	100.5	6	11

Table 30 Emission Factors for 1A1a Public Electricity and Heat Production in Energy Industries for all years 1990 - 2007 (public co-generation).

Activity Data

Activity data on natural gas consumption (in TJ) for Public Electricity and Heat Production (1A1a) is extracted from the energy statistics.

Source/fuel	**Unit**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
1A1a Public Electricity/Heat Fuel Consumption											
Natural gas	TJ	2.16	14.04	32.40	33.48	31.32	35.64	44.64	43.56	50.40	50.40
Biomass	TJ	15.57	16.32	17.28	17.28	18.75	16.98	18.12	18.44	19.96	21.49

Source/fuel	**Unit**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
1A1a Public Electricity/Heat Fuel Consumption									
Natural gas	TJ	47.52	50.40	43.20	48.60	50.76	54.00	48.96	44.28
Biomass	TJ	21.70	20.87	20.00	20.73	21.64	20.82	22.54	24.26

Table 31 Activity data for natural gas and biomass consumption in 1A1a Public Electricity/Heat Production.

The table above documents the increase of Gaseous Fuel consumption by a factor of over 21 from 1990 to 2007. This increase is the reason for category 1A1 Gaseous Fuels being a key category regarding trend.

Activity data on biogas consumption from waste water treatment plants are provided by plant operators (for data see section 8.3.1).[7]

[6] The CO_2 emission factor of 100.5 t biogenic CO_2 / TJ biogas is based on the assumtion that 35% of the volume of the biogas is CO_2 and 65% CH_4.

[7] Acivita data for biogas is provided in m^3. A density of 1.2 kg/m^3 and a lower calorific value of 19.2 MJ/kg is used to calculate the energy content.

b) Manufacturing Industries and Construction (1A2)

Key categories 1A2
CO_2 from the combustion of Gaseous Fuels and Liquid Fuels in Manufacturing Industries and Construction (1A2) is a key category regarding both level and trend.

Methodology

For fuel combustion in Manufacturing Industries and Construction (1A2) a Tier 2 method is used.

A top-down method based on aggregated fuel consumption data from the energy statistics is used to calculate CO_2 emissions of 1A2f. All emissions from 1A2 are reported under 1A2f. The sources are characterised by rather similar industrial combustion processes and assumingly homogenous emission factors, where a top-down approach is feasible. Identical emission factors for each fuel type are applied throughout these sources. The unit of emission factors refers to fuel consumption (in TJ).

Emissions of GHG are calculated by multiplying levels of activity by emission factors.

An oxidation factor of 100% is assumed for all combustion processes and fuels (see sub-section on oxidation factors in the beginning of Section 3.2.2).

Emission factors

The emission factors for CO_2 are country specific and are based on measurements and analysis of fuel samples carried out by the Swiss Federal Laboratories for Materials Testing and Research EMPA (carbon emission factor documented in SFOE 2001, Table 45, p. 51).

Emission factors for CH_4, and N_2O are based on comprehensive life cycle analysis of industrial boilers in Switzerland, documented in SAEFL 2000a (pp. 14-27). For the N_2O emissions the default emission factors from IPCC 1997c have been used.

The following table presents the emission factors used for the sources in category 1A2f:

Source/fuel	CO_2 t/TJ	CH_4 kg/TJ	N_2O kg/TJ	NO_x kg/TJ
1A2 f Other				
Gas oil	73.7	1.0	0.6	NE
Gas	55.0	6.0	0.1	NE

Table 32 Emission factors for sources in 1A2f for all years 1990 - 2007.

Activity data

Activity data on fuel consumption (TJ) are based on aggregated fuel consumption data from the energy statistics (see Section 3.1.3).

The resulting disaggregated fuel consumption data for 1990 to 2007 is provided in the table below

Source	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1A2f Other	TJ	554	545	546	572	546	550	555	574	611	610
Gas oil	TJ	254	223	215	238	219	213	198	225	242	212
Natural gas	TJ	300	322	331	334	327	338	358	349	369	398

Source	Unit	2000	2001	2002	2003	2004	2005	2006	2007
1A2f Other	TJ	559	566	578	622	608	589	609	519
Gas oil	TJ	186	177	200	212	206	197	205	122
Natural gas	TJ	373	389	378	410	402	392	404	397

Table 33 Activity data fuel consumption in 1A2f Manufacturing Industries and Construction 1990 to 2007.

Table 33 documents the increase of Natural Gas consumption for manufacturing industries by 33% from 1990 to 2007 as well as the net decrease of gas oil consumption by 52% over the period. This shift in fuel mix is the reason for CO_2 emissions from the use of Gaseous, and Liquid Fuels in category 1A2 being key categories regarding trend. The sharp decrease 2006-2007 for gas oil will be discussed below under source category 1A4.

c) Transport (1A3)

Key categories 1A3b
CO_2 from the combustion of gasoline (level and trend)
CO_2 from the combustion of diesel (level and trend)
CO_2 from the combustion of gaseous fuels (trend)

In Liechtenstein, 1A3 Transport mainly consists of sub-category 1A3b Road Transportation and a minor contribution of 1A3a Civil Aviation.

Aviation (1A3a)

Methodology

The emissions are estimated based on the fuel consumption, flying hours and the fleet composition of Liechtenstein's single helicopter base.

It must be noted, that these emissions are also reported in the Swiss GHG inventory. Since Switzerland and Liechtenstein form a customs union, all imports of kerosene appear in the Swiss overall energy statistics. The Swiss Federal Office of Civil Aviation (FOCA) carries out an extended Tier 3a method to determine the domestic (and bunker) emissions of civil aviation. Within this calculation, all fuel consumption of helicopters is accounted for. The helicopter basis in Balzers/Liechtenstein is included in this modelling scheme. All resulting emissions from helicopters are reported in the Swiss inventory as domestic emissions. The amount of emissions from the Balzers helicopter basis is very small compared to the total of Swiss helicopter emissions. Therefore, Switzerland disclaimed to subtract the small contribution of emissions from its inventory. Nevertheless, for Liechtenstein these emissions are not negligible. They are calculated using a Tier 1 method.

Emission Factors

Emission factors	**CO_2** t/TJ	**CH_4** kg/TJ	**N_2O** kg/TJ
1A3a Civil aviation/ helicopters	73.2	0.5	2.3
data source	FOEN 2008	IPCC 1996	IPCC 1996

Table 34 Emission factors used for estimating emissions of helicopters. The values are used for the entire time series 1990-2007.

Activity Data

The two operating companies of the helicopter base provided the fuel consumption for 1995, 2001–2007 as well as detailed flying hours, shares of domestic and international flights as well as specific consumption of the helicopter fleet for 2001–2002 (Rhein Helikopter 2006, 2007, 2008). The fleet consists of

Company Rhein-Helikopter AG: Helikopter AS 350 B-3 Ecureuil, 180 litre/hour
Rotex Helicopter AG: Helikopter Kamax K 1200, 320 litres/hour

From the shares of domestic flights in 2001 (14%) and in 2002 (16%), a mean share of 15% was adopted for all other years in the period 1990–2000, 2003–2007. The consumption 1990–1994, which is not available any more, is assumed to be constant and equal to 1995. The consumption for 1996–2000 was linearly interpolated between 1995 and 2001.

Kerosene	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	TJ									
1A3a Civ. Aviation (domestic)	1.03	1.03	1.03	1.03	1.03	1.03	1.04	1.05	1.06	1.07

Kerosene	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
	TJ							
1A3a Civ. Aviation (domestic)	1.08	1.09	1.14	1.19	0.85	1.15	1.85	1.83

Table 35 Activity data for civil aviation: Kerosene consumption 1990-2007 in TJ (only domestic consumption without bunker).

Road Transportation (1A3b)

Key categories 1A3b
CO_2 from the combustion of gasoline (level and trend)
CO_2 from the combustion of diesel (level and trend)
CO_2 from the combustion of gaseous fuels (trend)

Methodology

The emissions are calculated with a Tier 1 method (top-down) as suggested by IPCC Good Practice Guidance using Swiss emission factors. The CO_2 emission factors are derived from the carbon content of fuels (see Table 17). For CH_4 and N_2O, the implied emission factors of the Swiss greenhouse gas inventory are applied. The activity data corresponds to the amounts of gasoline and diesel fuel sold in Liechtenstein (sales principle). These numbers are taken from the national energy statistics modified as mentioned in Chapter 3.1.3. For Liechtenstein, "tank tourism" is a very important feature of the gasoline sales, since the prices in the neighbouring Austria are much higher than in Liechtenstein and Switzerland (which both have the same price due to the Customs Union Treaty) and since an enormous number of Austrian and German people are working in Liechtenstein (35'365 inhabitants, 16'242 commuters, where 8'283 are non-Swiss commuters) and buying their gasoline in Liechtenstein (OEA 2008b). The method of reporting the fuel sold at all gasoline stations in the country guarantees that indeed the sales principle is applied and not a territorial principle as might be the case by applying a traffic model, which, for Liechtenstein, would considerably underestimate the fuel sold.

Emission Factors

The emission factors for gasoline and diesel oil are adopted from Switzerland:

- CO_2 for gasoline, diesel oil and natural gas: The emission factors are taken from Table 17. They are kept constant over the whole time period 1990–2007 as it is practiced in Switzerland.
- CO_2 for biofuel: The fuel is produced in Liechtenstein by a single producer. The fuel is based on recycling of waste vegetable oil consisting of canola mainly. A small fraction of fossil diesel oil is added to the vegetable fuel. The fossil fraction is contained in the diesel sold and has therefore not to be accounted again (otherwise double counting), whereas the biogenic fraction is not reported under 1A3b but under Memo items "biomass". An emission factor of 89 t/TJ is assumed (ANGHGI 1996)
- CH_4, N_2O for gasoline and diesel oil: The implied emission factors of the Swiss CRF Table1.A(a)s3 (rows 1A3b Road Transportation Gasoline / Diesel oil) are used for the period 1990–2006. For 2007, the Swiss values 2006 have been used according to the assumptions of Chp. 1.4.2. The fleet composition of the two countries are very similar, the CO_2 emissions of light motor vehicles (passenger cars, light duty vehicles, motorcycles) and heavy motor vehicles (heavy duty vehicles, buses, coaches) are similar in Liechtenstein and Switzerland. A quantitative analysis based on the traffic models of Switzerland (INFRAS 2004, Annex A5) and of Liechtenstein (OEP 2002, Table 7, p. 16) shows: The contribution of light motor vehicles to the CO_2 emissions of the total (light and heavy motor vehicles) is 80% in Liechtenstein and 85% in Switzerland. Note that these results are derived on the territorial principle. From the viewpoint of sales principle, both numbers would be higher due to tank tourism, but in Liechtenstein, the increase would be stronger since tank tourism is more pronounced in Liechtenstein than in Switzerland. It may therefore be expected that the two numbers 80% and 85% would even be closer together. This comparison may serve as an argument for the applicability of Swiss implied emission factors for Liechtenstein.
- For 2007, the implied emission factors of Switzerland are not yet available. For the provisional emission modelling, the factors 2007 are set equal to the factors of 2006. The annual variation in the implied emission factors may reach some percents. But since the emission factors for CO_2 remain unchanged, the deviation of the emission total of source category 1A3b is very small: The recalculation for 2006 shows a difference due to recalculation of -0.06% between latest and previous submission. Anyway, the emissions 2007 will be recalculated for the submission 2010.
- CH_4, N_2O for natural gas: There are no implied emission factors available in the Swiss CRF. Therefore, the IPCC default emission factors for CH_4 and N_2O are applied.
- CH_4, N_2O for biofuel: There are no implied emission factors available in the Swiss CRF. In lieu of reviewed emission factors for biofuels, the Swiss implied emission factors for fossil diesel are used.

Gas	unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Gasoline																			
CO_2	t/TJ	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9
CH_4	kg/TJ	28.3	25.2	22.1	19.7	17.4	15.6	14.0	12.8	11.6	10.7	9.75	8.97	8.18	7.58	7.11	6.62	6.26	6.26
N_2O	kg/TJ	1.86	2.26	2.66	2.96	3.24	3.74	3.63	3.64	3.59	3.49	3.34	3.15	2.91	2.67	2.46	2.25	2.04	2.04
Diesel																			
CO_2	t/TJ	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6
CH_4	kg/TJ	1.99	1.95	1.86	1.75	1.65	1.58	1.49	1.41	1.34	1.26	1.17	1.03	0.92	0.87	0.76	0.73	0.70	0.70
N_2O	kg/TJ	0.75	0.75	0.74	0.71	0.71	0.71	0.72	0.80	0.87	0.94	1.04	1.12	1.18	1.25	1.30	1.36	1.41	1.41
Gaseous fuels																			
CO_2	t/TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	55.0	55.0	55.0	55.0	55.0	55.0	55.0
CH_4	kg/TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	49.9	50.0	49.9	50.1	50.0	50.0	50.0
N_2O	kg/TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Biofuel																			
CO_2	t/TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	(89)
CH_4	kg/TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.7
N_2O	kg/TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	1.41

Table 36 Emission factors for road transport. The values for gasoline and diesel oil are adopted from the Swiss GHG inventory (implied emission factors from CRF Table1.A(a)s3, NIR CH, FOEN 2008). For gaseous fuels, IPCC default values are used (IPCC 1997c). Swiss factors for 2007 are not available yet. For the emission modelling, they are provisionally set equal to the factors 2006. For biofuel (waste vegetable oil), the CO_2 emission factor is given in brackets since it is of biogenic origin.

The following paragraph gives a couple of explanations to the origin of the Swiss emission factors for road transportation:

Swiss emission factors (excerpt from NIR CH, chp. 3.2.2.c, FOEN 2008):

The emission factors for CO_2 are country specific and based on measurements and analyses of fuel samples. Emission factors for the further gases are derived from “emission functions” which are determined from measurements of a large number of driving patterns within an international measurement program of Switzerland together with Austria, Germany and the Netherlands. The method has been developed in 1990-1995 and has been extended and updated in 2000 and 2004. The latest version is presented and documented on the website http://www.hbefa.net/. Several reports may be downloaded from there:

- *Documentation of the general emission factor methodology, INFRAS et al. 2004c (in German),*
- *Emission Factors for Passenger Cars and Light Duty Vehicles Switzerland, Germany, Austria, INFRAS 2004a (in English),*
- *Update of the Emission Factors for Heavy Duty Vehicles, Hausberger et al. 2002 (in English),*
- *Update of the Emission Factors for Two-wheelers, RWTÜV 2003 (in German)*

The resulting emission factors are published on CD ROM (“Handbook of emission factors for Road Transport”, INFRAS 2004b). The underlying database contains a dynamic fleet compositions model simulating the release of new exhaust technologies and the dying out of old technologies. Corrective factors are provided to account for future technologies. Further details are shown in Annex 2.6 of FOEN 2008.

The CO_2 factors are constant over the whole period 1990–2006. Changes in the carbon content of the fuels have not been considered so far due to (approximately) constant fuel qualities. For the other gases, more or less pronounced decreases of the emission factors occur due to new emission regulations and subsequent new exhaust technologies (mandatory use of catalytic converters for gasoline cars and lower limits for sulphur content in diesel fuels). Early models of catalytic converters have been substantial sources of N_2O, leading to an emission increase until 1998. Recent converter technologies have overcome this problem resulting in a decrease of the (mean) emission factor. It should be noted that the N_2O emission factors are much smaller than the IPCC default values. The factors used in

Switzerland are taken from a recent Dutch measurement programme (Gense and Vermeulen 2002, Gense and Vermeulen 2000a, Riemersma et al. 2003).

It may be added that

- CO_2 emission factors 2007 are the same as for 1990–2006
- cold start and evaporative emissions are included in the Swiss modelling scheme.

Activity Data

The amount of gasoline and diesel fuel sold in Liechtenstein serves as the activity data for the calculation of the CO_2 emissions. For gasoline, the numbers are identical with Table 18 line "gasoline". For diesel, around 85% of the value for “diesel” in the national statistics of Table 18 is consumed in 1A3b Road Transportation, the remaining amount in 1A5b (construction) and 1A4c Other Sectors, agricultural machinery (see also Table 42). For gaseous fuels, the amount reported by gasoline stations is used.

Fuel	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	TJ									
Gasoline	819	916	957	947	878	903	909	954	896	940
Diesel	201	282	231	211	182	184	195	199	253	287
Natural Gas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Biofuel	0	0	0	0	0	0	0	0	0	0
Sum	1'020	1'198	1'188	1'159	1'060	1'087	1'104	1'152	1'149	1'226
	100%	118%	116%	114%	104%	107%	108%	113%	113%	120%

Fuel	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
	TJ							
Gasoline	1'040	1'007	920	879	851	823	752	756
Diesel	240	214	229	264	277	298	326	369
Natural Gas	NO	14	31	32	31	32	36	49
Biofuel	0	0	0	0	0	0	0	1
Sum	1'279	1'235	1'179	1'175	1'159	1'153	1'114	1'175
	125%	121%	116%	115%	114%	113%	109%	115%

Table 37 Activity data for 1A3b Road Transportation.

The share of gasoline has decreased from 80% in 1990 to 64% in 2007. In the same period, the consumption of diesel has increased from 20% to 31%, natural gas from 0% to 4%. The consumption of biofuel has only started in 2007.

In the study OEP (2002) the territorial fuel consumption was estimated based on kilometres travelled. This approach is substantiated by a model which uses input data from transport statistics and traffic counting. The CO_2 emissions are more than 40% lower in the base year and 30% lower in 2004 than the emissions reported in the GHG inventory. The differences between this result and the statistics of fuel sales are explained by fuelling of Austrian cars due to lower gasoline prices in Liechtenstein. (Moreover, the differences show the importance of collecting sales numbers as activity data for Liechtenstein and not using data derived from the territorial principle.)

Railways (1A3c)

There is a railway line crossing the country, where Austrian and Swiss railways are passing. Liechtenstein has no own railway. The railway line is owned and maintained by the Austrian

Federal Railway. The line in Liechtenstein is fully electrified. There are no diesel sales to railway locomotives, therefore there are no emissions occurring, which are relevant for the GHG inventory.

Navigation (1A3d)

Navigation is not occurring in Liechtenstein, because there are no lakes, and the river Rhine is not navigable within Liechtenstein. Therefore, there are no emissions occurring.

d) Other Sectors (Commercial, Residential, Agriculture, Forestry; 1A4)

Key categories 1A4a, 1A4b
CO_2 from the combustion of gaseous and liquid fuels in the Commercial/Institutional Sector (1A4a) and in the Residential Sector (1A4b) are key categories regarding both level and trend.

“Other Sectors” (source category 1A4) comprises

- “Commercial/ Institutional” (1A4a)
- “Residential” (1A4b)
- “Agriculture/Forestry/Fisheries” (1A4c)

Commercial/ Institutional (1A4a) and Residential (1A4b)

Methodology

For Fuel Combustion in Commercial and Institutional Buildings (1A4a) and in Households (1A4b), a Tier 2 method is used. A top-down method based on aggregated fuel consumption data from the energy statistics is used to calculate emissions. These sources are characterised by rather similar combustion processes and the same emission factors are assumed for 1A4a and 1A4b. Emissions of GHG are calculated by multiplying levels of activity by emission factors. An oxidation factor of 100% is assumed for all combustion processes and fuels (see sub-section on oxidation factors in the beginning of Section 3.2.2).

Emission Factors

The emission factors for CO_2 are country specific and are based on measurements and analysis of fuel samples carried out by the Swiss Federal Laboratories for Materials Testing and Research EMPA (carbon emission factor documented in SFOE 2001, Table 45, p. 51; net calorific values on p. 61. See also Annex A2.1 of the NIR in hand).

The coal emission factor for CO_2 is a mixed emission factor that results as a weighted average of the hard coal and lignite emission factors in Switzerland (FOEN 2007), where similar conditions prevail.

Emission factors for CH_4 are country specific and are based on comprehensive life cycle analysis of combustion boilers in the residential, commercial institutional and agricultural sectors, documented in SAEFL 2000a (pp. 42-56) and SAEFL 2005. For the N_2O emissions the default emission factors from IPCC 1997c have been used.

The country specific emission factor for CH_4 emissions from Liquefied Petroleum Gas (LPG) is from UBA 2004.

All emission factors for biomass are country specific and are based on SAEFL 2000a (pp. 26ff).

Since the fraction of stationary engines in total fuel consumption is rather small, emission factors for combustion boilers are used for all sources and fuels considered (see also Section 3.2.6 on planned improvements).

Table 38 presents the emission factors used in 1A4a and 1A4b:

Source/fuel	**CO_2 t/TJ**	**CO_2 bio. t/TJ**	**CH_4 kg/TJ**	**N_2O kg/TJ**
1A4 a+b Other Sectors: Commercial/Institutional and Residential				
Gas oil	73.7		1	0.6
LPG	65.5		2.5	0.1
Coal	94.0		300	1.6
Natural gas	55.00		6	0.1
Biomass (1A4a)		92	8	1.6
Biomass (1A4b)[8]		92	350	1.6

Table 38 Emission Factors for 1A4a and 1A4b: Commercial/Institutional and Residential in “Other Sectors” for all years 1990 - 2007.

Activity Data

Activity data on fuel consumption (TJ) are based on aggregated fuel consumption data from the energy statistics. A description of the modifications and the disaggregation of data from energy statistics is provided in Section 3.1.

The resulting disaggregated fuel consumption data from 1990–2007 is provided in Table 39.

[8] The CH_4 emission factor of 350 kg/TJ in 1A4b Residential is an average value over emission factors for open fireplaces (700 kg /TJ), old closed stoves (450 kg/TJ), modern closed stoves (130 kg/TJ), and modern closed stoves with ventilation (70 kg/TJ).

Source/Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1A4a Commercial/Institutional	TJ	961	892	893	979	943	933	942	1'005	1'100	1'020
Gas oil	TJ	763	669	646	713	657	639	593	675	725	636
LPG	TJ	13.3	8.1	15.5	12.1	9.5	8.1	9.8	7.0	7.2	5.8
Natural gas	TJ	158	196	204	229	246	264	319	298	340	347
Coal	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Biomass	TJ	27	19	27	24	31	23	21	25	29	31
1A4b Residential	TJ	319	319	354	401	390	416	434	466	510	522
Gas oil	TJ	254	223	215	238	219	213	198	225	242	212
Natural gas	TJ	46	82	120	146	150	188	222	224	248	289
Coal	TJ	1.0	0.9	1.1	1.0	0.7	0.7	0.5	0.5	0.6	0.3
Biomass	TJ	18	12	18	16	20	15	14	17	19	21

Source/Fuel	Unit	2000	2001	2002	2003	2004	2005	2006	2007
1A4a Commercial/Institutional	TJ	976	963	1'057	1'123	1'151	1'168	1'219	960
Gas oil	TJ	558	531	601	637	618	591	616	365
LPG	TJ	5.5	3.9	4.2	4.6	4.1	3.7	5.5	11.0
Natural gas	TJ	357	394	417	435	478	516	533	498
Coal	TJ	NO	NO	NO	NO	NO	NO	NO	NO
Biomass	TJ	55	34	35	46	51	56	64	86
1A4b Residential	TJ	513	533	565	612	647	667	679	589
Gas oil	TJ	186	177	200	212	206	197	205	122
Natural gas	TJ	290	334	341	369	407	432	431	410
Coal	TJ	0.6	0.3	0.3	0.3	0.3	0.2	0.2	0.1
Biomass	TJ	37	22	23	31	34	38	43	57

Table 39 Activity data in 1A4a Commercial/Institutional and 1A4b Residential.

The table above documents the increase of natural gas consumption by a factor of more than three (1A4a) and by a factor of almost nine (1A4b) from 1990 to 2007 with the build-up of Liechtenstein's gas supply network. Gas oil consumption decreased by -52% in both categories 1A4a and 1A4b over the same period. This shift in fuel mix is the reason for CO_2 emissions from the use of gaseous and liquid fuels in category 1A4a/b being key categories regarding trend.

The significant decrease of gas oil consumption between 2006 and 2007 may be due to two reasons, as explained in chapter 2.3: high prices of fossil fuels and warm winters. The former might lead to stock changes in residential fuel tanks, which would entail an underestimation of actual emissions in 2007 and an overestimation in subsequent years, when stocks might be refilled. Next year's fuel consumption data will probably show which of the reasons explain the decrease in fuel consumption from 2006 to 2007.

Agriculture/Forestry (1A4c)

Methodology

For source category 1A4c, a Tier 1 method is used. Emissions stem from fuel combustion in agricultural machinery. Implied emission factors from a Swiss off-road study are used. The activity data follows from the information provided by the General Directorate of Swiss Customs (refunding institution of fuel taxes until 2005) and by OEP census, data 2007 (OEP 2008a). For details, see above in Section 3.1.3 a), paragraph Gasoline/Diesel oil.

Emission Factors

Emission factors for the use of diesel in off-road machinery are country specific and are taken from INFRAS 2008 (diesel engines).

Activity Data

Off-road machinery: Activity data (diesel consumption) is shown in Table 40.

Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	TJ									
Diesel	17.7	18.1	17.8	17.2	17.3	16.8	16.5	18.5	17.4	18.8

Fuel	2000	2001	2002	2003	2004	2005	2006	2007
	TJ							
Diesel	17.7	18.4	18.5	19.9	20.5	18.5	19.2	19.9

Table 40 Activity data in 1A4c Agriculture/Forestry.

e) Other – Off-road: Construction, Industry (1A5b)

Key source 1A5b
CO_2 from the combustion of liquid fuels in 1A5 Other – Off-road is a key source regarding level.

Methodology

For source category 1A5, a Tier 1 method is used. Due to Table 23, among private diesel tanks non-agriculture, the amount of 30% of the consumption is attributed to 1A5b Other/Mobile (off-road) activity: Construction vehicles and machinery; Industrial off-road vehicles and machinery. Emission factors are taken from the latest Swiss off-road study (INFRAS 2008).

Emission Factors

The emission factors are country specific and are based on a query on the new Swiss off-road database for construction machinery (INFRAS 2008). They correspond to implied emission factors: The total of emissions of the whole fleet of construction vehicles was divided by the fuel consumption (in TJ). For the application in the Liechtenstein inventory, it is assumed, that the fleet composition is similar to the Swiss fleet composition (vehicle category, size class, age distribution).

Gas	unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
liquid fuels											
CO2	t/TJ	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6
CH4	kg/TJ	0.72	0.73	0.73	0.73	0.73	0.74	0.73	0.73	0.73	0.73
N2O	kg/TJ	2.98	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99

Gas	unit	2000	2001	2002	2003	2004	2005	2006	2007
liquid fuels									
CO2	t/TJ	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6
CH4	kg/TJ	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
N2O	kg/TJ	2.99	2.99	2.99	2.99	2.98	2.98	2.98	2.98

Table 41 Emission factors used for 1A5b Other – Off-road / mobile sources. Data are based on revised Swiss off-road database (INFRAS 2008).

Note that the update of the Swiss off-road database (INFRAS 2008) implied an update of Liechtenstein's emission factors with notable differences for CH_4 and N_2O, which results in a recalculation of the whole time series 1990-2006, affecting thereby the base year 1990 (increase of 0.01 Gg CO_2 eq in the latest compared to the previous version, see Sec.3.2.5).

Activity Data

The activity data includes the consumption of diesel oil as mentioned in the paragraph "Methodology" above and Section 3.1.3 a), paragraph Gasoline/Diesel oil.

Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	TJ									
Diesel	32.1	38.8	39.6	32.7	30.7	29.7	30.4	34.3	39.8	42.1

Fuel	2000	2001	2002	2003	2004	2005	2006	2007
	TJ							
Diesel	40.3	34.4	37.2	46.3	41.1	47.5	49.2	45.3

Table 42 Activity data (diesel oil consumption) for 1A5b Other – Off-road / mobile sources.

3.2.3. Uncertainties and Time-Series Consistency

a) Uncertainties

Uncertainty in aggregated fuel consumption activity data (1A Fuel Combustion)

Liechtenstein and Switzerland form a customs and monetary union governed by a customs treaty. Therefore, no customs statistics exist that would provide reliable data on (liquid and solid) fuels imports into Liechtenstein.

The level of disaggregation that has been chosen for the key category analysis provides a rather fine disaggregation of combustion related CO_2 emissions in Sector 1 Energy. E.g. the key category analysis distinguishes between Emissions from Commercial/Institutional (1A4a), Residential (1A4b), and Agriculture/Forestry (1A4c).

However, the data on fuel consumption originates at the aggregated level of sales data. It is only later disaggregated using simple expert judgement leading to the consumption in different branches (see Section 3.1.3). In order to avoid errors that are introduced in the process of disaggregation, but do not apply to the aggregated emissions on the national level, the analysis of uncertainties for CO_2 emissions from fuel combustion is carried out on the level of aggregated total national emissions (1A) for Gaseous, Liquid and Solid fuels. For liquid fuels, the uncertainties have been estimated in this submission for four fuel types separately instead of estimating the uncertainty for the aggregate liquid fuel consumption as in previous submissions. The change is made, because methods to determine fuel consumption and associated uncertainties differ for each of the fuel types (see also Sect. 1.7.3 and Sect. 3.1.3).

Details of uncertainty analysis of activity data (fuel consumption) in 1A are based on expert judgement. The dominant contributor to overall uncertainty is liquid fuel consumption. Because customs statistics of imports of oil products do not exist, this data is based on surveys with oil suppliers carried out earlier by OEA and in recent years by OEP. The methodology and completeness of the surveys has been improved over the years. Therefore it is assumed that the uncertainty in activity data for liquid fuels around 1990 is rather high, whereas recent data is of medium uncertainty. Comparing the different liquid fuels, the uncertainty for gasoline is lowest, because activity data is based on surveys at all filling stations in Liechtenstein, and the uncertainty is estimated to be 10%. Diesel consumption is also based on surveys at filling stations, but small unknown quantities may be imported directly from construction companies and farmers, and uncertainty is estimated to be 15%. The uncertainty for gas oil and LPG consumption is estimated to be highest among liquid fuels, because fuel is provided by direct delivery to homes by several companies, which is more difficult to monitor, and uncertainty is estimated to be 20%. Uncertainty for jet kerosene is estimated to be 15%. The total of kerosene reported may be known more precisely, but the split into domestic and international is quite uncertain.

Uncertainty in CO_2 emission factors in fuel combustion (1A)

Liechtenstein and Switzerland form a customs and monetary union governed by a customs treaty. E.g. all Gas oil is supplied by Swiss suppliers and no taxation accrues at the borders for the import to Liechtenstein. It may therefore be assumed that fuel has the same properties as the fuels sold on the Swiss market. Therefore, the emission factors and their uncertainties have been taken from Switzerland, and are documented in the Swiss NIR (FOEN 2008).

Table 43 below provides the results of the quantitative Tier 1 analysis (following Good Practice Guidance; IPCC 2000, p. 6.13ff) estimating uncertainties of CO_2 emissions from fuel combustion activities.

A		B	C	D	E	F	G	H	I	J	K	L	M
IPCC Source category		Gas	Base year emissions 1990	Year 2007 emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total CO2 combustion emission in year t	Type A sensitivity (CO2 from combustion)	Type B sensitivity (CO2 from combustion)	Uncertainty in trend in national emissions introduced by emission factor uncertainty (CO2 from combustion)	Uncertainty in trend in national emissions introduced by activity data uncertainty (CO2 from combustion)	Uncertainty introduced into the trend in total CO2 combustion emissions
			Gg CO2 equivalent	Gg CO2 equivalent	%	%	%	%	%	%	%	%	%
1A	Gaseous fuels	CO2	27.81	76.93	5.0	4.6	6.8	2.484	0.2373	0.3817	1.09	2.70	2.91
1A	Gas oil and LPG	CO2	94.58	45.56	20.0	0.61	20.01	4.333	-0.2627	0.2261	-0.16	6.39	6.40
1A	Gasoline	CO2	60.53	55.85	10.0	1.36	10.09	2.679	-0.0364	0.2771	-0.05	3.92	3.92
1A	Diesel	CO2	18.43	31.92	15.0	0.47	15.01	2.277	0.0628	0.1584	0.03	3.36	3.36
1A	Jet Kerosene	CO2	0.08	0.13	15.0	1.16	15.04	0.010	0.0003	0.0007	0.00	0.01	0.01
1A	Solid fuels	CO2	0.09	0.01	20.0	5.0	20.6	0.001	-0.0004	0.0001	0.00	0.00	0.00
1A	Other fuels	CO2	NA,NO	NA,NO									
Total CO2 Emissions Fuel			201.53	210.41									
Overall uncertainty CO2 combustion emissions in the year (%):								6.11	CO2 combustion emissions trend uncertainty (%):				8.72

Table 43 Results from Tier 1 uncertainty calculation and reporting for CO2 emissions in 1A Fuel Combustion.

The analysis results in an overall uncertainty of the CO_2 emissions from 1A Fuel Combustion of 6.11% for the year 2007 and in a trend uncertainty for the period 1990 to 2007 of 8.72%.

The overall uncertainty is determined by the rather high activity data uncertainty of liquid fuels.

Qualitative estimate of uncertainties of non-key category emissions in 1A Fuel Combustion

Non-CO_2 emissions in Energy Industries (1A1), Manufacturing Industries and Construction (1A2) and Other Sectors (Commercial, Residential, Agriculture, Forestry; 1A4):
Uncertainty in emissions of non-CO_2 gases is estimated to be medium.

Non-CO_2 emissions in 1A3 and 1A5
Uncertainty in emissions of non-CO_2 gases is estimated to be high.

b) Consistency and Completeness in 1A Fuel Combustion

Consistency:
The method for the calculation of GHG emissions is the same for the years 1990 to 2007; time series is consistent

Completeness:
The emissions for the full time series 1990–2007 have been calculated and reported. The data on emissions of the six Kyoto gases (CO_2, CH_4, N_2O, HFC, PFC, SF_6) are therefore complete. The precursor emissions from Energy have not been estimated.

3.2.4. Source-Specific QA/QC and Verification

QC activities have been performed due to Section 1.6. They are documented in the checklist in Annex 2. Special attention has been focused on the update of the activity data i.e. on the energy sales data. They were checked independently by two NIR authors and by the OEP specialist.

3.2.5. Source-Specific Recalculations

The implied emission factors for 2006 have been updated due to the Swiss emission factors (FOEN 2008). The update affects CH_4 and N_2O emissions of the categories 1A3b Road Transportation, 1A4c Other Sectors, Agriculture/Forestry and 1A5b Other / off-road.

- 1A3b: CH_4 and N_2O emission factors are decreasing in the actual period due to technological improvements. The updated factors 2006 are therefore some percent lower than the factor used for 2006 in the previous submission. The emissions 2006 have thus been recalculated.
- The Swiss off-road database has been updated (INFRAS 2008). It is used for Switzerland's emission modelling of most off-road source (except aviation). Liechtenstein adopts implied emission factors for construction vehicles and machinery; Industrial off-road vehicles and machinery. Updated emissions of CH_4 and N_2O implied adaptations for Liechtenstein's emission factors used for the sectors 1A4c Agriculture/Forestry and 1A5b Other (off-road). A recalculation with the updated emission factors for the complete time series 1990-2006 has been carried out. CH_4 and N_2O emissions increase by ca. 60% and 40% respectively. The base year 1990 is affected too and shows an increase of source category 1A5b of 0.008 Gg CO_2 eq in the latest compared to the previous version. For source category 1A4c, the increase is 0.003 Gg CO_2 eq in 1990.

In 1A4a, CH_4 and N_2O implied emission factors for liquid fuels were corrected. In the last submission, an error had been made concerning the emission factor of LPG; as most of the liquid fuel is gas oil and not LPG, the correction has only a minor influence on the implied emission factors for liquid fuels. A recalculation was made for the time series; the base year 1990 was not affected.

3.2.6. Source-Specific Planned Improvements

There are no source-specific planned improvements.

3.3. Source Category 1B – Fugitive Emissions from Fuels

3.3.1. Source Category Description

Source category 1B “Fugitive Emissions from Fuels” is **not a key category.**

Fugitive emissions arise from the production, processing, transmission, storage and use of fuels. According to IPCC guidelines, emissions from flaring at oil and gas production facilities are included while emissions from vehicles are not included in 1B.

Source Category 1B “Fugitive Emissions from Fuels” comprises the following sub-categories:

- Solid fuels (1B1)
- Oil and Natural Gas (1B2)

a) Solid fuels (1B1)

Coal mining is not occurring in Liechtenstein.

b) Oil and Natural Gas (1B2)

1B2	Source	Specification	Data Source
1B2 a	Oil	Refining of oil is not occurring	-
1B2 b	Natural Gas	Emissions from gas pipelines	AD: LGV 2008 EF: FOEN 2008
1B2 c	Venting / Flaring	Not occurring	-

Table 44 Specification of source category 1B2 “Fugitive Emissions from Oil and Natural Gas” (AD: activity data; EF: emission factors)

3.3.2. Methodological Issues

a) Oil and Natural Gas (1B2)

Methodology

For source 1B2b Natural Gas, the emissions of CH_4 leakages from gas pipelines are calculated with a Tier 3 method, adapted from the Swiss NIR (FOEN 2008). The method considers the length, type and pressure of the gas pipelines. The distribution network components (regulators, shut off fittings and gas meters), the losses from maintenance and extension as well as the end user losses are taken into account. NMVOC leakages are not estimated.

Emission factors

The emission factors for gas distribution losses (source 1B2b) depend on the type and pressure of the natural gas pipeline (see Table 45; sources cited in FOEN 2008: Battelle 1994, Xinmin 2004). The CH_4-emissions due to gas meters are considered with an emission factor of 5.11 m^3 CH_4 per gas meter and year.

1B2 Fugitive Emissions from Oil and Natural Gas [m^3/h/km]	**< 100 mbar**	**1- 5 bar**	**> 5 bar**
Steel cath.	-	-	0.0284
HDPE (Polyethylene)	0.0080	0.0024 (0.00062)	-

Table 45 CH_4-Emission Factors for 1B2 "Fugitive Emissions from Oil and Natural Gas" in 2007 (Battelle 1994, Xinmin 2004). For HDPE (Polyethylene) 1-5 bar, the first value shows the assumption for 1993 and previous years while the second value (in brackets) shows the value for 2001 and following years. Data between 1993 and 2001 are linearly interpolated between the two values.

Activity data

The activity data such as length and type of pipes in the distribution network for the calculation of methane leaks have been extracted from the annual reports of Liechtenstein's Gas Utility (LGV 2008).

Source/Fuel	**Unit**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
1B2 Fugitive Emissions from Oil and Natural Gas											
Steel cath. > 5 bar	km	26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.3
HDPE (Polyethylene) < 100 mbar	km	67.0	84.3	96.5	109.0	122.4	135.9	147.6	162.7	179.3	192.0
HDPE (Polyethylene) 1-5 bar	km	28.5	28.5	28.3	28.5	29.2	29.5	29.8	30.0	34.1	35.8
Connections	No.	479	698	890	1'060	1'221	1'398	1'584	1'782	1'984	2'195

Source/Fuel	**Unit**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
1B2 Fugitive Emissions from Oil and Natural Gas									
Steel cath. > 5 bar	km	26.3	26.3	26.6	26.6	26.6	26.6	26.6	26.6
HDPE (Polyethylene) < 100 mbar	km	206.0	218.7	238.5	252.0	264.9	276.3	289.1	297.6
HDPE (Polyethylene) 1-5 bar	km	37.3	37.4	36.0	38.9	45.3	45.6	49.3	49.7
Connections	No.	2'460	2'657	2'863	3'067	3'271	3'464	3'659	3'801

Table 46 Activity Data for 1B2 "Fugitive Emissions from Oil and Natural Gas": length of pipes and number of connections to customers

3.3.3. Uncertainties and Time-Series Consistency

Uncertainty in fugitive CH_4 emissions from natural gas pipelines in 1B2
Following Good Practice Guidance (IPCC 2000: p. 2.92) overall uncertainty of bottom-up inventories of fugitive methane losses from gas activities are expected to result in errors of 25-50%. From this a conservative uncertainty of 50% is estimated for Liechtenstein.

The time series is consistent.

3.3.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out.

3.3.5. Source-Specific Recalculations

No recalculations have been carried out.

3.3.6. Source-Specific Planned Improvements

The current 1B2 methane emission calculation is based on data on natural gas quality from Switzerland (FOEN 2008). For future submissions, the use of more country specific data from Liechtenstein's natural gas utility will be considered.

3.4. Source Category International Bunker Fuels

For Liechtenstein, the only source of international bunker emissions is civil aviation (one helicopter-base). Total emissions of civil aviation are calculated as described in Section 3.2.2.c) with Tier 1 method. The share of consumption for international flights is provided by the two operating companies of the helicopter base Rhein-Helikopter AG and Rotex Helicopter AG for 2001 (84%) and 2002 (86%) (Rhein Helikopter 2006). For all other years, the mean (85%) is used. Marine bunker emissions are not occurring.

Kerosene	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	TJ									
international (bunker)	5.84	5.84	5.84	5.84	5.84	5.84	6.00	6.16	6.33	6.49
domestic (1A3a)	1.03	1.03	1.03	1.03	1.03	1.03	1.04	1.05	1.06	1.07
total	6.87	6.87	6.87	6.87	6.87	6.87	7.04	7.21	7.39	7.56

domestic (1A3a)

Kerosene	2000	2001	2002	2003	2004	2005	2006	2007
	TJ							
international (bunker)	6.66	6.82	6.12	6.74	4.82	6.52	10.47	10.36
domestic (1A3a)	1.08	1.09	1.14	1.19	0.85	1.15	1.85	1.83
total	7.74	7.91	7.26	7.93	5.68	7.67	12.32	12.18

Table 47 Kerosene (civil aviation) due to sales principle: International flights (bunker, memo item), domestic flights (reported under 1A3a) and total. Data source: Rhein Helikopter (2006, 2007, 2008).

3.5. CO_2 Emissions from Biomass

A description of the methodology for calculating CO_2 emissions from the combustion of biomass and the consumption of biofuel is included in the relevant Chapters 3.2.2c./d (Energy) and 8 (Waste).

3.6. Comparison of Sectoral Approach with Reference Approach

The apparent consumption, the net carbon emissions and the effective CO_2 emissions are calculated for the Reference Approach as prescribed in the CRF tables 1A(b)–1A(d). Data is taken from the energy statistics as described in 3.1.3. The Reference Approach covers the CO_2 emissions of all imported fuels.

The following table and the figure show the differences between the Reference and the Sectoral (National) Approaches 1990–2007. Energy consumption and CO_2 emissions agree very well for all years. The largest difference occurs in 1998 with 0.48% and 0.33% respectively. On an average, the energy consumption in the Reference Approach is 5 TJ higher than in the Sectoral Approach. The CO_2 emissions in the Reference Approach exceed those of the Sectoral Approach by 0.1 Gg on an average.

Difference between Reference and Sectoral Approach										
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	percent (%)									
Energy Consumption	0.17	0.24	0.42	0.14	0.04	0.05	0.08	0.05	0.48	0.08
CO_2 Emissions	0.06	0.12	0.27	0.04	-0.03	-0.02	0.01	-0.02	0.33	0.01

	2000	2001	2002	2003	2004	2005	2006	2007
	percent (%)							
Energy Consumption	0.04	0.06	0.05	0.21	0.12	0.10	0.21	0.31
CO_2 Emissions	-0.02	0.00	-0.02	0.12	0.05	0.03	0.12	0.21

Table 48 Differences in energy consumption and CO_2 emissions between the Reference and the Sectoral (National) Approach. The difference is calculated according to [(RA-SA)/SA] 100% with RA = Reference Approach, SA = Sectoral (National) Approach.

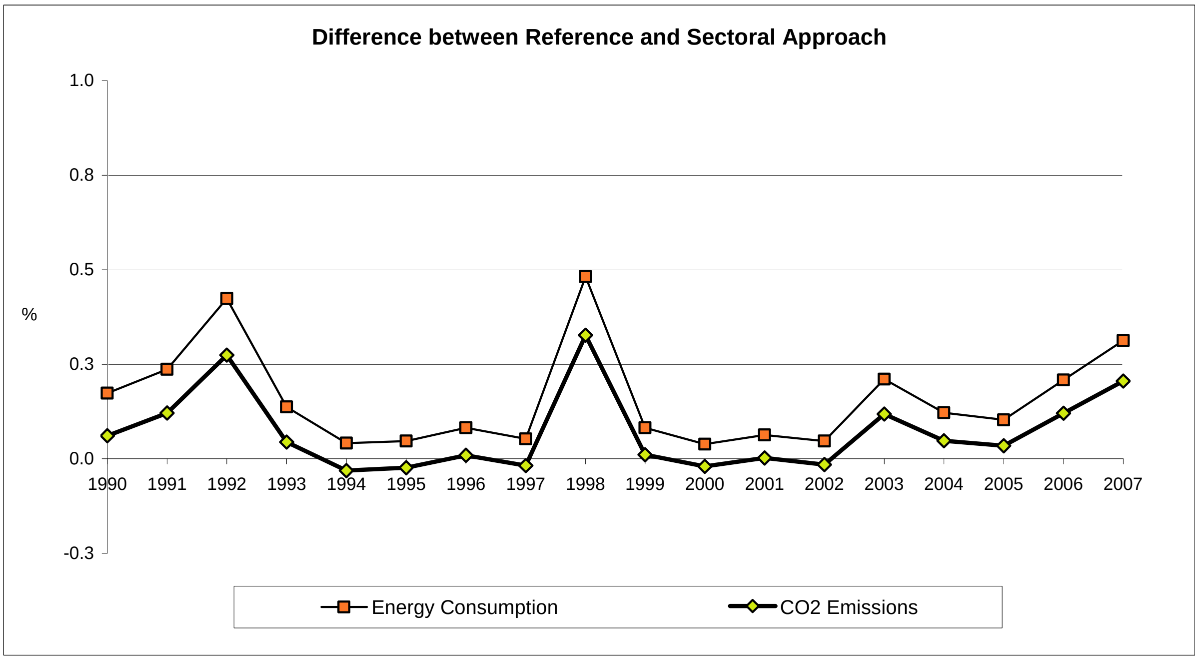

Figure 14 Time series for the differences between Reference and Sectoral Approach. Numbers are taken from the table above.

The oxidations factor is consequently set to 1.0 due to the following reason: combustion installations in Liechtenstein have very good combustion properties; combined emissions of CO and unburnt VOC lie in the range of only 0.1 to 0.3 percent of CO_2 emissions for oil and gas combustion. Also for coal an oxidation factor of 1.0 was used for conservative reasons and due to the negligible quantity consumed, which results in an emission of 0.015 Gg CO_2.

Conversion factors (TJ/unit) and carbon emission factors (t C /TJ) in CRF table1.A(b) have been taken from Table 17 and are therefore identical to the ones used for the Sectoral Approach.

4. Industrial Processes

4.1. Overview

According to IPCC guidelines, emissions within this sector comprise greenhouse gas emissions as by-products from industrial processes and also emissions of synthetic greenhouse gases during production, use and disposal. (Emissions from fuel combustion in industry are reported under sector 1 Energy.)

Only few IPCC source categories among the sector Industrial Processes occur in Liechtenstein. Sources in the categories 2B, 2C, 2D, 2E and 2G are not occurring at all. Emissions are reported from categories 2A Mineral Products and 2F Consumption of Halocarbons and SF_6. HFC emissions are estimated from refrigeration and air conditioning equipment as well as some SF_6 emissions from electrical equipment. The emissions have increased from 1990 to 2007, as shown in Table 49. PFC emissions are not occurring in Liechtenstein.

Gas	Category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	2A Mineral Products	**Gg**									
CO	2A5, 2A5	0.020	0.020	0.019	0.019	0.019	0.018	0.018	0.018	0.018	0.018
NMVOC	2A6	0.028	0.027	0.025	0.024	0.023	0.021	0.020	0.019	0.019	0.019
	2F Consumption of Halocarbons and SF6	**Gg CO_2 eq**									
HFC	2F1, 2F4	8.E-06	1.E-03	0.01	0.05	0.14	0.38	0.66	1.04	1.39	1.82
PFC		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
SF6	2F8	NO	NO	NO	NO	NO	NO	0.00	1.0E-08	1.0E-08	4.1E-08
Sum	**2F**	**8.E-06**	**1.E-03**	**0.01**	**0.05**	**0.14**	**0.38**	**0.66**	**1.04**	**1.39**	**1.82**

Gas	Category	2000	2001	2002	2003	2004	2005	2006	2007
	2A Mineral Products	**Gg**							
CO	2A5, 2A5	0.018	0.018	0.017	0.016	0.014	0.013	0.013	0.013
NMVOC	2A6	0.018	0.016	0.015	0.014	0.014	0.014	0.014	0.014
	2F Consumption of Halocarbons and SF6	**Gg CO_2 eq**							
HFC	2F1, 2F4	2.34	2.97	3.23	3.66	4.16	4.16	4.16	4.47
PFC		NO	NO	NO	NO	NO	NO	NO	NO
SF6	2F8	7.8E-07	1.5E-06	2.2E-06	2.2E-06	2.4E-06	2.4E-06	2.2E-06	5.0E-06
Sum	**2F**	**2.34**	**2.97**	**3.23**	**3.66**	**4.16**	**4.16**	**4.16**	**4.47**

Table 49 GHG emissions of source category 2 “Industrial Processes” 1990–2007 by gases in CO_2 equivalent (Gg).

The most obvious features of the emissions from industrial processes may be characterised as follows: The most relevant emissions in sector 2 are those of HFCs. HFC use started to be relevant from 1992 when they were introduced as substitutes for CFCs. Since then, HFC use experienced a steep growth from 0.009 Gg CO_2 eq in 1992 up to 4.47 Gg CO_2 eq in 2007. Nevertheless, the HFC emissions contribute in 2007 only 1.8% to the emission total.

4.2. Source Category 2A – Mineral Products

4.2.1. Source Category Description

Source category 2A "Mineral Products" is **not a key category.**

Details on source category 2A “Mineral Products” are provided in the table below:

2A	Source	Specification	Data Source
2A1	Cement Production	Not occurring in Liechtenstein.	-
2A2	Lime Production	Not occurring in Liechtenstein.	-
2A3	Limestone and Dolomite Use	Not occurring in Liechtenstein.	-
2A4	Soda Ash Production and Use	Not occurring in Liechtenstein.	-
2A5	Asphalt Roofing		AD: OEA 2008b EF: FOEN 2008
2A6	Road Paving with Asphalt		AD: OEA 2008b EF: FOEN 2008
2A7	Other	Not occurring in Liechtenstein.	-

Table 50 Specification of source category 2A “Mineral Products”

4.2.2. Methodological Issues

a) Asphalt Roofing (2A5) and Road Paving with Asphalt (2A6)

Methodology

For the determination of CO and NMVOC emissions from Asphalt Roofing and NMVOC emissions from Road Paving with Asphalt data availability in Liechtenstein is very limited.

In order to establish rough estimates of emissions for Liechtenstein, the specific emissions per inhabitant in Switzerland[9] (from FOEN 2008) are used as a proxy:

Emissions of CO and NMVOC from 2A5 and 2A6 in Liechtenstein are the product of *the specific emissions per inhabitant in Switzerland* times *the number of inhabitants in Liechtenstein*.

This allows for a first preliminary estimate of emissions. The rationale behind this simple approach is that the general characteristics of Liechtenstein and Switzerland determining emissions are roughly similar.

Emission Factors

Emission factors for CO and NMVOC, the specific emissions per inhabitant, are calculated by dividing the emissions from Asphalt Roofing (2A5) and Road Paving with Asphalt (2A6) from the Swiss national inventory (FOEN 2008) by the number of inhabitants in Switzerland, as given below. [10]

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[9] The emission estimates for 2A5 Asphalt Roofing in the *Swiss* national inventory (FOEN 2008) are based on emission factors of 42g (1998-2006) NMVOC per square meter of roofing fabric. A total of 15 mio. Square meters of roofing fabric is estimated to have been used in Switzerland in 2005 (source EMIS).
The emission estimates for 2A6 Road Paving with Asphalt in the *Swiss* national inventory (FOEN 2007) are based on emission factors of 100g NMVOC per ton of "Mischgut" (bitumous material) used for preparatory works of road surface ("Voranstrich") and 360 g NMVOC per ton of "Mischgut" (bitumous material) used for the implementation of new asphalt cover on streets ("Belagsarbeiten"). A total of 5 mio. tons of "Mischgut" (bitumous material) have been used in Switzerland in 2005 (source EMIS).

[10] This approach is used for all years but the latest (2007). Here, for Liechtenstein the specific emissions of Switzerland of the previous year (2006) are used, because the Swiss National Inventory

Activity Data

The activity data consist in the number of inhabitants in Liechtenstein as provided in the Table below.

Inhabitants	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Liechtenstein	**29'032**	**29'386**	**29'868**	**30'310**	**30'629**	**30'923**	**31'143**	**31'320**	**32'015**	**32'426**
Switzerland	6'796'000	6'880'000	6'943'000	6'989'000	7'037'000	7'081'000	7'105'000	7'113'000	7'132'000	7'167'000
Liechtenstein/Switzerland	0.427%	0.427%	0.430%	0.434%	0.435%	0.437%	0.438%	0.440%	0.449%	0.452%

Inhabitants	2000	2001	2002	2003	2004	2005	2006	2007
Liechtenstein	**32'863**	**33'525**	**33'863**	**34'294**	**34'600**	**34'905**	**35'168**	**35'365**
Switzerland	7'209'000	7'260'000	7'349'000	7'364'100	7'418'400	7'459'128	7'508'739	7'593'494
Liechtenstein/Switzerland	0.456%	0.462%	0.461%	0.466%	0.466%	0.468%	0.468%	0.468%

Table 51 Inhabitants in Liechtenstein 1990 – 2007 (OEA 2008b) and inhabitants in Switzerland (SFSO 2008).[11]

4.2.3. Uncertainties and Time-Series Consistency

A preliminary uncertainty assessment results in low confidence in emission estimates.

The time series is consistent.

4.2.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out.

4.2.5. Source-Specific Recalculations

No recalculations have been carried out.

4.2.6. Source-Specific Planned Improvements

It is planned to update and recalculate proxy data of the Swiss population to increase consistency with the Swiss NIR.

4.3. Source Category 2B – Chemical Industry

4.3.1. Source Category Description

Source Category 2B Chemical Industry is **not a key category.**

Details on source category 2B "Chemical Industry" are provided in the table below:

is published only after the drafting of Liechtensteins NIR. For the next submission, the emission factors used for Liechtenstein will be updated according to the latest Swiss NIR.

[11] Please note that the number of inhabitants in Switzerland 2007 is used, because the provisional value for the specific emissions for the latest year (2007) is based on the Swiss value for the emissions of the year before (2006) and the Swiss value for the population of the latest year (2007). It is planned to use the Swiss population of the year before instead of the population of the latest year in future submissions. See also footnote [10].

2B	Source	Specification
2B1	Ammonia Production	Not occurring in Liechtenstein
2B2	Nitric Acid Production	Not occurring in Liechtenstein
2B3	Adipic Acid Production	Not occurring in Liechtenstein
2B4	Carbide Production	Not occurring in Liechtenstein
2B5	Other (Emissions from the production of Organic Chemicals (Ethylene, PVC, Formaldehyde, Acetic Acid))	Not occurring in Liechtenstein

Table 52 Specification of source category 2B “Chemical Industry”

GHG emissions from source category 2B are not occurring in Liechtenstein.

4.4. Source Category 2C – Metal Production

4.4.1. Source Category Description

Source category 2C "Metal Production" is **not a key category.**

Details on source category 2C “Metal Production” are provided in the table below:

2C	Source	Specification
2C1	Iron and Steel Production	Not occurring in Liechtenstein
2C2	Ferroalloys Production	Not occurring in Liechtenstein
2C3	Aluminium Production	Not occurring in Liechtenstein
2C4	Use of SF_6 in Aluminium and Magnesium Foundries	Not occurring in Liechtenstein
2C5	Other	Not occurring in Liechtenstein

Table 53 Specification of source category 2C “Metal Production”.

GHG emissions from source category 2C are not occurring in Liechtenstein.

4.5. Source Category 2D – Other Production

Source category 2D "Other Production" is **not a key category.**

GHG emissions from source category 2D are not occurring in Liechtenstein.

4.6. *Source Category 2E – Production of Halocarbons and SF_6*

Source category 2E "Production of Halocarbons and SF_6" is **not a key category.**

There is no production of HFC, PFC or SF_6 in Liechtenstein. GHG emissions from source category 2E are not occurring in Liechtenstein.

4.7. *Source Category 2F – Consumption of Halocarbons and SF_6*

4.7.1. Source Category Description

Key category 2F
HFC from source category 2F "Consumption of halocarbons and SF6" is a key category regarding level and trend (see Table 4)

Source category 2F comprises HFC and SF_6 emissions from consumption of the applications listed below. Other applications are not occurring in Liechtenstein. PFC emissions from this source category are not occurring within Liechtenstein.

2F	Source	Specification	Data Source
2F1	Refrigeration and Air Conditioning Equipment	Emissions from Refrigeration and Air Conditioning Equipment	AD: Number of households, employees, passenger cars EF: Industry data for Switzerland (FOEN 2008, Carbotech 2008)
2F7	Electrical Equipment	Emissions from use in electrical equipment	AD: Industry data EF: Industry data

Table 54 Specification of source category 2F "Consumption of Halocarbons and SF_6" (AD: activity data; EF: emission factors).

4.7.2. Methodological Issues

2F1 Refrigeration and Air Conditioning Equipment

Methodology

Liechtenstein does not have the relevant import statistics or industry data which would allow developing specific data models to estimate the emissions under source category 2F1. Therefore the emissions for Liechtenstein are estimated by applying the rule of proportion on basis of the emissions reported by Switzerland and specific indicators such as number of households, number of employees, number of cars, etc. As it can be assumed that the consumption patterns for industry, service sector and household sector of Liechtenstein are very similar to Switzerland, this approach will result in reliable figures for Liechtenstein. While the emission factors are assumed to be identical for both countries, the specific indicators for the rule of proportion calculation are chosen under the criteria that they shall be suitable to derive the activity data for Liechtenstein on basis of data for Switzerland.

More details of the underlying data models can be seen from the National Inventory Report for Switzerland (FOEN 2008) and Carbotech 2008.

Manufacturing of refrigeration and air conditioning equipment is not occurring in Liechtenstein. Disposal of retired equipment falling under the categories of Domestic Refrigeration, Mobile Air Conditioning and Transport Refrigeration is by large through a single recycling company in Liechtenstein (Elkuch Recycling AG). The recycling company collects the equipment and exports to Switzerland or Austria without recovery of the synthetic gases in the refrigeration or Air Conditioning units. Nevertheless, Liechtenstein's emissions are estimated on basis of the rule of proportion applied onto the sum of emissions for Switzerland including manufacturing, product life emissions and disposal losses. For more precision, the rule of proportion should be restricted to product life emissions and the Swiss manufacturing emissions should be excluded from the calculation. Since the manufacturing emissions in Switzerland are of low relative importance, this bias is neglected. The inclusion of emissions from disposal are a conservative estimate for Liechtenstein. As the statistical basis for a more detailed analysis is not available, the effect is also neglected and the conservative estimation is accepted. For Switzerland, the emissions from manufacturing and disposal account for 11% of the total emissions under source category 2F1 (emission data of the inventory year 2006).

The inventory under this sub-source category includes the following types of equipment: domestic refrigeration, commercial and industrial refrigeration, transport refrigeration, stationary air conditioning and mobile air conditioning. The indicators used for the rule of proportion calculations are summarised in the following table.

Application	**Refrigerant**	**Base value**	**Indicator for calculation by rule of proportion**
Domestic Refrigeration	HFC-134a	Total emissions reported for Switzerland	Number of households
Commercial Refrigeration	HFC-125 HFC-134a HFC-143a	Total emissions reported for Switzerland	Number of persons employed in industrial and service sector
Transport Refrigeration	HFC-125 HFC-134a HFC-143a	Total emissions reported for Switzerland	Number of inhabitants
Industrial Refrigeration	Included in commercial refrigeration		
Stationary Air Conditioning	HFC-32 HFC-125 HFC-134a HFC-143a	Total emissions reported for Switzerland	Number of persons employed in industrial and service sector
Mobile Air Conditioning	HFC-134a	Total emissions reported for Switzerland (cars, trucks, railway)	Number of registered cars

Table 55 Indicators used in calculating Liechtenstein's emissions for source category 2F1 on basis of Switzerland's emissions by applying rule of proportion.

Emission Factors

Due to the approach chosen, the emission factors as reported in the Swiss National Inventory Report (FOEN 2008) are applicable.

The data reported in Table 56 is taken from FOEN 2008 and shows details to the emission factors. No manufacturing of refrigeration and air conditioning equipment is occurring in Liechtenstein.

Equipment type	Product life time [a]	Initial charge of new product [kg]	Manufacturing emission factor [% of initial charge]	Product life emission factor [% per annum]	Charge at end of life [% of initial charge of new product] *)	Disposal loss emission factor [% of remaining charge
Domestic Refrigeration	12	0.1	NO	0.5	94	19 **)
Commercial and Industrial Refrigeration	12	NR	1	10 (5)	100	10
Transport Refrigeration / Trucks	8	1.8 … 7.8	1	15	100	20
Transport Refrigeration / Railway	NA	NR	NO	10	100	20
Stationary Air Conditioning (direct / indirect cooling system)	15	1.6 … 3.1 / 18.5	1	10 (3) / 6 (4)	100	28 / 19
Heat Pumps	15	4.7 …7.5 till 1999 Going down to 2.8 …4.5 in 2010	1	0.65	100	10
Mobile Air Conditioning / Cars	12	0.78	NO	8.5 (3)	60	100 (30)
Mobile Air Conditioning / Trucks	10	1.1	NO	10 (8.5)	35	100 (30)
Mobile Air Conditioning / Railway	12	20	NO	4	100	10

*) takes into account refill of losses during product life where applicable.

**) takes into account R134a content in foams, based on information from the national recycling organisation SENS.

NA = not available
NR = not relevant as only aggregate data is used
NO = Not occurring (only import of charged units)

Table 56 Typical values on life time, charge and emission factors used in model calculations for Refrigeration and Air Conditioning Equipment. Where values in brackets are provided, the first value shows the assumption for 1995 while the second value (in brackets) shows the assumption for 2010. Data between 1995 and 2010 is linearly interpolated. Source: FOEN 2008, Carbotech 2008.

Activity Data

Activity data for Liechtenstein is calculated based on activity data for Switzerland with the methodology as described above. The following figures have been used for the indicators:

	1990		2007	
Number of households				
Liechtenstein	10’556	Source: National census 1990 (OEA 2000a)	15’333	Source: National census 2000 with trend extrapolation (OEA 2000a)
Switzerland	2’859’766	Source: National census 1990 (SFOE 2008a)	3’416’244	Source: National census 2000 with trend extrapolation (SFOE 2008a)
Conversion Factor CH→LIE	0.0036912		0.0044883	
Number of employees in industrial and service sector				
Liechtenstein	19’554	Source: National census of enterprises 1990 (OEA 2000b)	32’063	Source: National census of enterprises 2004, extrapolated (OEA 2000b)
Switzerland	3’664’214	Source: National census of enterprises 1985 and 1991, interpolated (SFOE 2008b)	3’711’224	Source: National census of enterprises 1998 and 2001, extrapolated(SFOE 2008b)
Conversion Factor CH→LIE	0.0053364		0.0086395	
Number of registered cars				
Liechtenstein	16’891	Source: National motor car statistics for Liechtenstein (OEA 2008c)	24’368	Source: National motor car statistic for Liechtenstein’s (OEA 2008c)
Switzerland	2’985’399	Source: National motorcar statistics for Switzerland (SFOE 2008c)	3’995’787	Source: National motorcar statistics for Switzerland (SFOE 2008c)
Conversion Factor CH→LIE	0.0056578		0.0062873	

Table 57 Figures used as indicators for calculation of activity data by applying rule of proportion.

2F4 Aerosols / Metered Dose Inhalers

Methodology

Liechtenstein does not have the relevant import statistics or industry data which would allow developing specific data models to estimate the emissions under source category 2F4 Aerosols / Metered Dose Inhalers. Therefore the emissions for Liechtenstein are estimated by applying the rule of proportion on basis of the emissions reported by Switzerland and using the number of inhabitants as indicator. As it can be assumed that the consumption patterns of Liechtenstein are very similar to Switzerland, this approach will result in reliable figures for Liechtenstein. While the emission factors are assumed to be identical for both countries, the specific indicator for the rule of proportion calculation is chosen under the criteria that it shall be suitable to derive the activity data for Liechtenstein on basis of data for Switzerland. The absolute relevance of the emissions reported under 2F4 is very low (less than 0.1 Gg CO_2eq) and therefore inaccuracies in the estimation model are considered negligible.

More details of the underlying data models can be seen from the National Inventory Report for Switzerland (FOEN 2008) and Carbotech 2008.

Emission Factors

Due to the approach chosen, the emission factors as reported in the Swiss National Inventory Report (FOEN 2008) are applicable.

Activity Data

Activity data for Liechtenstein is calculated based on activity data for Switzerland with the methodology as described above. The following figures have been used as indicator:

	2007	
Number of Inhabitants		
Liechtenstein	35'365	Source: National census 2000 with trend extrapolation (OEA 2000a)
Switzerland	7'508'739	Source: National census 2000 with trend extrapolation (SFOE 2008a)
Conversion Factor CH→LIE	0.004710	

Table 58 Figures used as indicator for calculation of activity data by applying rule of proportion.

2F7 Electrical Equipment

Methodology

The only SF_6 emissions in Liechtenstein stem from the transformers operated by the utility Liechtensteinische Kraftwerke (LKW). The LKW reports on activity data and emissions. No production of equipment with SF_6 is occurring.

Emission Factors

Emission factors for this sub-source category are based on industry information.

Activity Data

Activity data is based on industry information. Before 1995/1996 a different technology was applied which did not use SF_6.

4.7.3. Uncertainties and Time-Series Consistency

For source category 2F Consumption of halocarbons and SF6 no specific uncertainties have been determined. For the Swiss GHG inventory (FOEN 2008), the uncertainties of the emissions of source category 2F were at approx. 17% (Monte Carlo simulation based on 2007 data). For Liechtenstein's uncertainty analysis, this value was adopted although it will be somewhat higher due to the conversion of Swiss into Liechtenstein data.

The methods for calculating the emissions of the full time series 1990–2007 are consistent.

4.7.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out.

4.7.5. Source-Specific Recalculations

The data for the years 1990 – 2006 for source category 2F1 has been recalculated using the final Swiss emission factors as reported in the Swiss GHG inventory 2007 (FOEN 2008). Table 59 summarises the changes in the Swiss GHG inventory which are underlying the recalculation and which correspondingly affects the modelling for Liechtenstein.

Category	**Remarks**
Commercial Refrigeration	According to information from the declaration of equipment with more than 3 kg refrigerant which was introduced in the year 2006, it was possible to do a better modelling of the distribution of the gases to different applications. The assumptions were approved by different experts.
Air-Conditioning	According to information from the declaration of equipment with more than 3 kg refrigerant which was introduced in the year 2006, it was possible, to do a better modelling of the distribution of the gases to different application
Heat pumps	According to information from the declaration of equipment with more than 3 kg refrigerant which was introduced in the year 2006, it was possible, to do a better modelling of the distribution of the gases to different application.
General refrigeration	Due to new information data on buses was added to the model. The data is provided by experts and manufacturers, wherever no data was available the data for trucks was used.
Mobile air condition	Specific data on buses was collected and used.

Table 59 Summary of recalculations in source category 2F as reported under the Swiss GHG inventory 2007 (FOEN 2008, Table 82).

4.7.6. Source-Specific Planned Improvements

Gradual improvement of the data quality in co-operation with industry is ongoing for the Swiss GHG inventory. Methodologies and emission models will be updated during the yearly process of F-gas inquiry. The focus will be on improvements of HFC-emission calculations from refrigeration and air-conditioning equipment. As the GHG emissions for Liechtenstein under source category 2F are methodologically based on the Swiss GHG inventory data this will also benefit the GHG inventory for Liechtenstein.

Further analysis is planned on the delineation of emissions from disposal reported by Liechtenstein and Switzerland under Domestic Refrigeration, Mobile Air-Conditioning and Transport Refrigeration. For this purpose, additional information will be collected from the Swiss importers of Domestic Refrigeration and Air-Conditioning equipment and the recycling company in Liechtenstein. Depending on the collected information, OEP will decide about further improvements.

4.8. Source Category 2G – Other

Source category 2G "Other" is **not a key category.**

GHG emissions from source category 2G are not occurring in Liechtenstein.

5. Solvent and Other Product Use

5.1. Overview

Emissions within this sector comprise NMVOC emissions from the use of solvents and other related compounds. Also included are indirect CO_2 emissions from the atmospheric decomposition of NMVOC.

Furthermore, evaporative emissions of N_2O are included arising from other types of product use and from medical use. Emissions from the use of halocarbons and sulphur hexafluoride are reported in the Industrial Processes Chapter under 2F. Other non-energy emissions not included under Industrial Processes are reported in this chapter.

Source category 3 "Solvent and Other Product Use" is **not a key category.** CO_2 emissions from sector 3 were a key category regarding trend in the previous submission (OEP 2008). They are no longer a key category, because other categories have become more important for the trend.

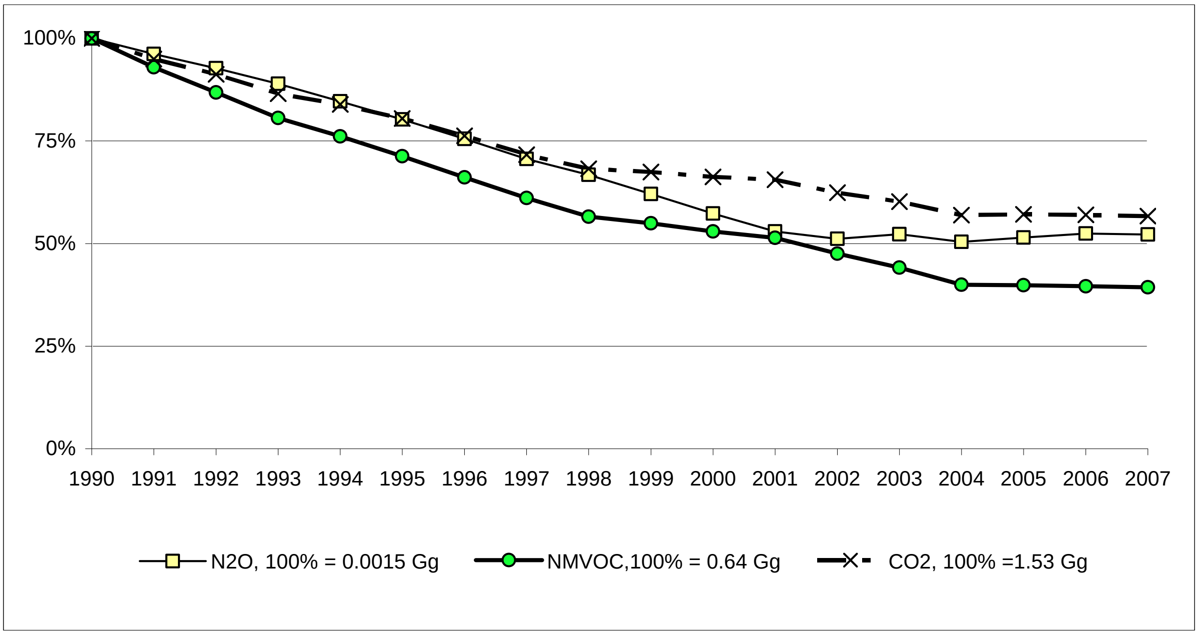

Figure 15 Overview of emissions in category 3 Solvent and Other Product Use in Liechtenstein 1990–2007.

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	Gg									
CO_2	1.53	1.45	1.39	1.32	1.28	1.23	1.16	1.09	1.04	1.03
N_2O	0.0015	0.0015	0.0014	0.0013	0.0013	0.0012	0.0011	0.0011	0.0010	0.0009
NMVOC	0.60	0.56	0.52	0.48	0.46	0.43	0.40	0.37	0.34	0.33

Gas	2000	2001	2002	2003	2004	2005	2006	2007
	Gg							
CO_2	1.01	1.00	0.95	0.92	0.87	0.87	0.87	0.86
N_2O	0.0009	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
NMVOC	0.32	0.31	0.29	0.26	0.24	0.24	0.24	0.24

Table 60 Emissions of source category 3 Solvent and Other Product Use.

The emissions of NMVOC, CO_2 and N_2O are all calculated by a country specific method from the corresponding Swiss emissions by using the specific emission per inhabitant as conversion factors. Two reduction efforts are responsible for the decrease of the emissions: The limitation of the application of NMVOC brought by the legal restrictions (Government 1986 and 2003) and the introduction of the VOC-levy in 2000 in Liechtenstein and Switzerland (based on the Customs Union Treaty the Swiss VOC-levy is also applicable in Liechtenstein). Also CO_2 and N_2O emissions decreased significantly.

5.2. Source Category 3A – Paint Application

5.2.1. Source Category Description

Source category 3A "Paint Application" comprises NMVOC emissions from paints, lacquers, thinners and related materials used in coatings in industrial, commercial and household applications. Also, it includes indirect CO_2 emissions resulting from post-combustion of NMVOCs to reduce NMVOCs in exhaust gases.

	Source	Specification	Data Source
3A	Paint Application	Paint application in households, industry and construction	AD: OEA 2008b EF: FOEN 2008

Table 61 Specification of source category 3A "Paint Application".

5.2.2. Methodological Issues

a) Methodology

In order to establish rough estimates of emissions for Liechtenstein, the specific emissions per inhabitant in Switzerland are used as a proxy:

Emissions of the source category in Liechtenstein are the product of *the specific emissions per inhabitant in Switzerland* times *the number of inhabitants in Liechtenstein*.[12]

[12] This approach is used for all years but the latest (2007). Here, for Liechtenstein the specific emissions of Switzerland of the previous year (2006) are used, because the Swiss National Inventory is published only after the drafting of Liechtenstein's NIR. For the next submission, the emission factors used for Liechtenstein will be updated according to the latest Swiss NIR.

This allows for a first preliminary estimate of emissions. The rationale behind this simple approach is that the general characteristics of Liechtenstein and Switzerland determining emissions are roughly similar.

b) Emission Factors

Source	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3A. Paint Application											
CO_2	g/inhabitant	14'612	14'223	13'804	13'227	12'604	11'874	11'067	10'214	9'280	8'865
NMVOC	g/inhabitant	6'175	5'953	5'719	5'468	5'185	4'874	4'531	4'167	3'766	3'584

Source	Unit	2000	2001	2002	2003	2004	2005	2006	2007
3A. Paint Application									
CO_2	g/inhabitant	8'443	8'020	6'816	5'592	4'189	4'149	4'268	4'220
NMVOC	g/inhabitant	3'404	3'224	2'724	2'201	1'615	1'598	1'580	1'563

Table 62 Emission factors - specific emissions per inhabitant, 1990 to 2007 (Source: Swiss emissions from FOEN 2008; inhabitants see Section 4.2.2).

The emission factor for the indirect CO_2-emissions from NMVOC for 3A is 2.35 Gg CO_2/Gg NMVOC [RIVM 2005: p. 5-2ff.].

c) Activity Data

The development of the number of inhabitants in Liechtenstein is provided in Section 4.2.2.

5.2.3. Uncertainties and Time-Series Consistency

The uncertainty of total CO_2 emissions from the entire category 3 Solvent and Other Product Use is estimated to be 80% (expert estimate based on uncertainty of Swiss data and uncertainty of simple approach).

For non-CO_2 emissions, a preliminary uncertainty assessment results in medium confidence in emission estimates.

The time series is consistent.

5.2.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out.

5.2.5. Source-Specific Recalculations

The proxy data of the specific emissions per inhabitant in Switzerland have been updated and recalculations have been carried out for the whole time series.

5.2.6. Source-Specific Planned Improvements

It is planned to update and recalculate proxy data of the Swiss population to increase consistency with the Swiss NIR.

5.3. Source Category 3B – Degreasing and Dry Cleaning

5.3.1. Source Category Description

Source category 3B “Degreasing and Dry Cleaning” comprises NMVOC emissions from degreasing, dry cleaning and cleaning in electronic industry. Also, it includes indirect CO_2 emissions resulting from post-combustion of NMVOCs to reduce NMVOCs in exhaust gases.

	Source	Specification	Data Source
3B	Degreasing and Dry Cleaning	Degreasing, Dry Cleaning, Cleaning of electronic components, cleaning of parts in metal processing, other industrial cleaning, if applicable in Liechtenstein.	AD: OEA 2008b EF: FOEN 2008

Table 63 Specification of source category 3B “Degreasing and Dry Cleaning”.

5.3.2. Methodological Issues

a) Methodology

Data availability is very limited. In order to establish rough estimates of emissions for Liechtenstein, the specific emissions per inhabitant in Switzerland are used as a proxy:

Emissions of the source category in Liechtenstein are the product of *the specific emissions per inhabitant in Switzerland* times *the number of inhabitants in Liechtenstein*. [13]

This allows for a first preliminary estimate of emissions. The rationale behind this simple approach is that the general characteristics of Liechtenstein and Switzerland determining emissions are roughly similar.

b) Emission Factors

Source	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3B. Degreasing and Dry Cleaning											
CO_2	g/inhabitant	4'102	3'726	3'387	3'071	2'765	2'475	2'205	1'952	1'709	1'599
NMVOC	g/inhabitant	1'834	1'666	1'511	1'368	1'231	1'101	981	868	759	710

Source	Unit	2000	2001	2002	2003	2004	2005	2006	2007
3B. Degreasing and Dry Cleaning									
CO_2	g/inhabitant	1'488	1'381	1'323	1'279	1'229	1'190	1'150	1'137
NMVOC	g/inhabitant	660	612	586	567	544	527	509	503

Table 64 Emission factors - specific emissions per inhabitant, 1990 to 2007 (Source: Swiss emissions from FOEN 2008; inhabitants see Section 4.2.2).

The emission factor for the indirect CO_2-emissions from NMVOC for 3B is 2.24 Gg CO_2 per Gg NMVOC [RIVM 2005[14]: p. 5-2ff.].

c) Activity Data

The development of the number of inhabitants in Liechtenstein is provided in Section 4.2.2.

[13] This approach is used for all years but the latest (2007). Here, for Liechtenstein the specific emissions of Switzerland of the previous year (2006) are used, because the Swiss National Inventory is published only after the drafting of Liechtensteins NIR. For the next submission, the emission factors used for Liechtenstein will be updated according to the latest Swiss NIR.

[14] There seems to be a typo in the relevant section of the RIVM 2005 regarding the Emission Factor for the indirect CO_2-emissions from NMVOC for 3B.

5.3.3. Uncertainties and Time-Series Consistency

The uncertainty of total CO_2 emissions from the entire category 3 Solvent and Other Product Use is estimated to be 80% (expert estimate based on uncertainty of Swiss data and uncertainty of simple approach).

The time series is consistent.

5.3.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out.

5.3.5. Source-Specific Recalculations

The proxy data of the specific emissions per inhabitant in Switzerland have been updated and recalculations have been carried out for the whole time series.

5.3.6. Source-Specific Planned Improvements

It is planned to update and recalculate proxy data of the Swiss population to increase consistency with the Swiss NIR.

5.4. Source Category 3C – Chemical Products, Manufacture and Processing

5.4.1. Source Category Description

Source category 3C "Chemical Products, Manufacture and Processing" comprises NMVOC emissions from manufacturing and processing chemical products. Also, it includes indirect CO_2 emissions resulting from post-combustion of NMVOCs to reduce NMVOCs in exhaust gases.

	Source	**Specification**	**Data Source**
3C	Chemical Products, Manufacture and Processing	Handling and storage of solvents; fine chemical production; production of pharmaceuticals; manufacturing of paint, inks, glues, adhesive tape, rubber; processing of PVC, polystyrene foam, polyurethane and polyester; if applicable in Liechtenstein.	AD: OEA 2008b EF: FOEN 2008

Table 65 Specification of source category 3C "Chemical Products, Manufacture and Processing".

5.4.2. Methodological Issues

a) Methodology

Data availability is very limited. In order to establish rough estimates of emissions for Liechtenstein, the specific emissions per inhabitant in Switzerland are used as a proxy:

Emissions of the source category in Liechtenstein are the product of *the specific emissions per inhabitant in Switzerland* times *the number of inhabitants in Liechtenstein*. [15]

[15] This approach is used for all years but the latest (2007). Here, for Liechtenstein the specific emissions of Switzerland of the previous year (2006) are used, because the Swiss National Inventory

This allows for a first preliminary estimate of emissions. The rationale behind this simple approach is that the general characteristics of Liechtenstein and Switzerland determining emissions are roughly similar.

b) Emission Factors

Source	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3C. Chemical Products, Manufacture and Processing											
CO_2	g/inhabitant	11'395	9'758	8'378	6'943	6'524	5'999	5'494	5'140	4'883	4'911
NMVOC	g/inhabitant	4'162	3'366	2'644	1'952	1'743	1'512	1'290	1'137	965	906

Source	Unit	2000	2001	2002	2003	2004	2005	2006	2007
3C. Chemical Products, Manufacture and Processing									
CO_2	g/inhabitant	4'707	4'560	4'679	4'769	4'892	4'986	4'895	4'840
NMVOC	g/inhabitant	804	731	706	690	660	652	643	636

Table 66 Emission factors - specific emissions per inhabitant, 1990 to 2007 (Source: Swiss emissions from FOEN 2008; inhabitants see Section 4.2.2).

The emission factor for the indirect CO_2 emissions from NMVOC for 3C is 2.31 Gg CO_2 per Gg NMVOC [RIVM 2005: p. 5-2ff.].

c) Activity Data

The development of the number of inhabitants in Liechtenstein is provided in Section 4.2.2.

5.4.3. Uncertainties and Time-Series Consistency

The uncertainty of total CO_2 emissions from the entire category 3 Solvent and Other Product Use is estimated to be 80% (expert estimate based on uncertainty of Swiss data and uncertainty of simple approach).

The time series is consistent.

5.4.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out.

5.4.5. Source-Specific Recalculations

The proxy data of the specific emissions per inhabitant in Switzerland have been updated and recalculations have been carried out for the whole time series.

5.4.6. Source-Specific Planned Improvements

It is planned to update and recalculate proxy data of the Swiss population to increase consistency with the Swiss NIR.

is published only after the drafting of Liechtensteins NIR. For the next submission, the emission factors used for Liechtenstein will be updated according to the latest Swiss NIR.

5.5. *Source Category 3D – Other*

5.5.1. Source Category Description

Source category 3D "Other" comprises emissions from many different solvent applications. Besides NMVOC also emissions of N_2O are relevant. Also, 3D includes indirect CO_2 emissions resulting from post-combustion of NMVOCs to reduce NMVOCs in exhaust gases.

The application of N_2O in households and hospitals and CO_2 from the use of fireworks are the only direct greenhouse gas emission considered in this category.

	Source	Specification	Data Source
3D	Other	Use of spray cans in industry and households; domestic solvent use application of glues and adhesives; use of concrete additives; removal of paint and lacquer; car underbody sealant; use of cooling lubricants and other lubricants; use of pesticides; use of pharmaceutical products in households; house cleaning industry/craft/services; hairdressers; scientific laboratories; industrial production; cosmetic institutions; use of tobacco products; wood preservation; medical practitioners; other health care institutions; no-attributable solvent emissions; use of N_2O in households and in hospitals; other use of gases; use of fireworks; if applicable in Liechtenstein.	AD: OEA 2008b EF: FOEN 2008

Table 67 Specification of source category 3D "Other".

5.5.2. Methodological Issues

a) Methodology

Data availability is very limited. In order to establish rough estimates of emissions for Liechtenstein, the specific emissions per inhabitant in Switzerland are used as a proxy:

Emissions of the source category in Liechtenstein are the product of *the specific emissions per inhabitant in Switzerland* times *the number of inhabitants in Liechtenstein*. [16]

This allows for a first preliminary estimate of emissions. The rationale behind this simple approach is that the general characteristics of Liechtenstein and Switzerland determining emissions are roughly similar.

[16] This approach is used for all years but the latest (2007). Here, for Liechtenstein the specific emissions of Switzerland of the previous year (2006) are used, because the Swiss National Inventory is published only after the drafting of Liechtensteins NIR. For the next submission, the emission factors used for Liechtenstein will be updated according to the latest Swiss NIR.

b) Emission Factors

Source	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3D1. Other. Use of N_2O for Anaesthesia											
N_2O	g/inhabitant	43	40	38	35	32	30	27	25	22	19
3D3. Other. N_2O from Aerosol Cans											
N_2O	g/inhabitant	9	9	9	9	10	10	10	10	10	10
3D5. Other. Other. Spray cans, cosmetic institutions, etc.											
CO_2	g/inhabitant	22'448	21'607	21'052	20'311	19'918	19'375	18'583	17'606	16'653	16'366
NMVOC	g/inhabitant	8'489	7'995	7'566	7'164	6'757	6'344	5'937	5'529	5'107	4'958

Source	Unit	2000	2001	2002	2003	2004	2005	2006	2007
3D1. Other. Use of N_2O for Anaesthesia									
N_2O	g/inhabitant	17	14	13	13	12	12	13	12
3D3. Other. N_2O from Aerosol Cans									
N_2O	g/inhabitant	10	10	10	10	10	10	10	10
3D5. Other. Other. Spray cans, cosmetic institutions, etc.									
CO_2	g/inhabitant	16'127	15'882	15'295	15'156	14'785	14'651	14'410	14'250
NMVOC	g/inhabitant	4'796	4'627	4'406	4'258	4'113	4'067	4'019	3'975

Table 68 Emission factors - specific emissions per inhabitant, 1990 to 2007 (Source: Swiss emissions from FOEN 2008; inhabitants see Section 4.2.2).

The emission factor for the indirect CO_2-emissions from NMVOC for 3D is 2.53 Gg CO_2/Gg NMVOC [RIVM 2005: p. 5-2ff.].

c) Activity Data

The development of the number of inhabitants in Liechtenstein is provided in Section 4.2.2.

5.5.3. Uncertainties and Time-Series Consistency

The uncertainty of total CO_2 emissions from the entire category 3 Solvent and Other Product Use is estimated to be 80% (expert estimate based on uncertainty of Swiss data and uncertainty of simple approach).

For non-CO_2 emissions, a preliminary uncertainty assessment results in medium confidence in emission estimates. The time series is consistent.

5.5.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out.

5.5.5. Source-Specific Recalculations

The proxy data of the specific emissions per inhabitant in Switzerland have been updated and recalculations have been carried out for the whole time series.

5.5.6. Source-Specific Planned Improvements

It is planned to update and recalculate proxy data of the Swiss population to increase consistency with the Swiss NIR.

6. Agriculture

6.1. Overview

This chapter provides information on the estimation of the greenhouse gas emissions from the agriculture sector (Sectoral Report for Agriculture, Table 4 in the Common Reporting Format). The following source categories are reported:

- CH_4 emissions from enteric fermentation in domestic livestock,
- CH_4 and N_2O emissions from manure management,
- N_2O emissions from agricultural soils.

Total greenhouse gas emissions from agriculture in 2007 were 22.6 Gg CO_2 equivalents in total, which is a contribution of 9.3% to the total of Liechtenstein's greenhouse gas emissions (excluding LULUCF). Main agricultural sources of greenhouse gases in 2007 were enteric fermentation emitting 10.4 Gg CO_2 equivalents, followed by agricultural soils with 8.8 Gg CO_2 equivalents. In general, emissions decreased until 2000 and are since then increasing again. The overall emissions from agriculture in CO_2 equivalents in 2007 are for the first time since 1990 slightly higher than in 1990.

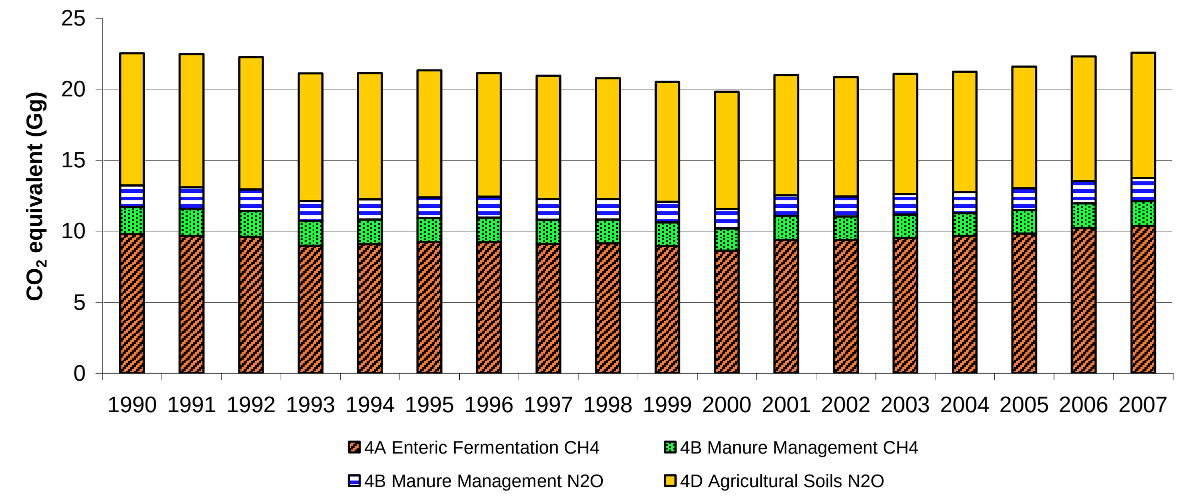

Figure 16 Greenhouse gas emissions in Gg CO_2 equivalents of agriculture 1990-2007.

No CO_2 emissions are reported in the agricultural sector. CO_2 emissions from energy use in agriculture are reported under Energy, Other Sectors (1A4c).

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)									
CH_4	11.7	11.6	11.4	10.7	10.8	11.0	11.0	10.8	10.8	10.6
N_2O	10.8	10.9	10.8	10.4	10.3	10.4	10.2	10.1	9.9	9.9
Sum	**22.5**	**22.5**	**22.3**	**21.1**	**21.1**	**21.3**	**21.1**	**21.0**	**20.8**	**20.5**

Gas	2000	2001	2002	2003	2004	2005	2006	2007	*1990-2007*
	CO2 equivalent (Gg)								*%*
CH_4	10.2	11.1	11.0	11.2	11.3	11.5	12.0	12.1	*3.6*
N_2O	9.6	9.9	9.8	9.9	10.0	10.1	10.3	10.5	*-3.4*
Sum	**19.8**	**21.0**	**20.9**	**21.1**	**21.2**	**21.6**	**22.3**	**22.6**	***0.2***

Table 69 Greenhouse gas emissions in Gg CO_2 equivalents of agriculture 1990-2007.

CH_4 emissions increased since 2000 and are now 3.6% higher than in 1990 due to higher emission factors for dairy cattle and an increase of the number of some animal populations (e.g. dairy cattle). N_2O emissions decreased mainly due to a reduced input of mineral fertilizers.

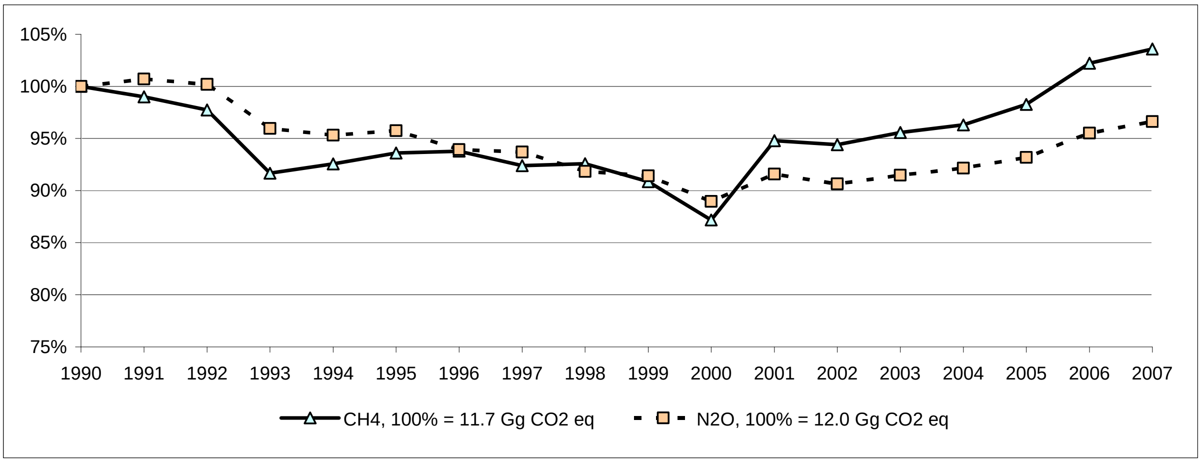

Figure 17 Trend of greenhouse gases of the agricultural sector 1990-2007. The base year 1990 represents 100%.

Among the key sources of the inventory, three are out of the agricultural sector: CH_4 emissions from enteric fermentation, direct N_2O emissions from agricultural soils and indirect N_2O emissions from agricultural soils.

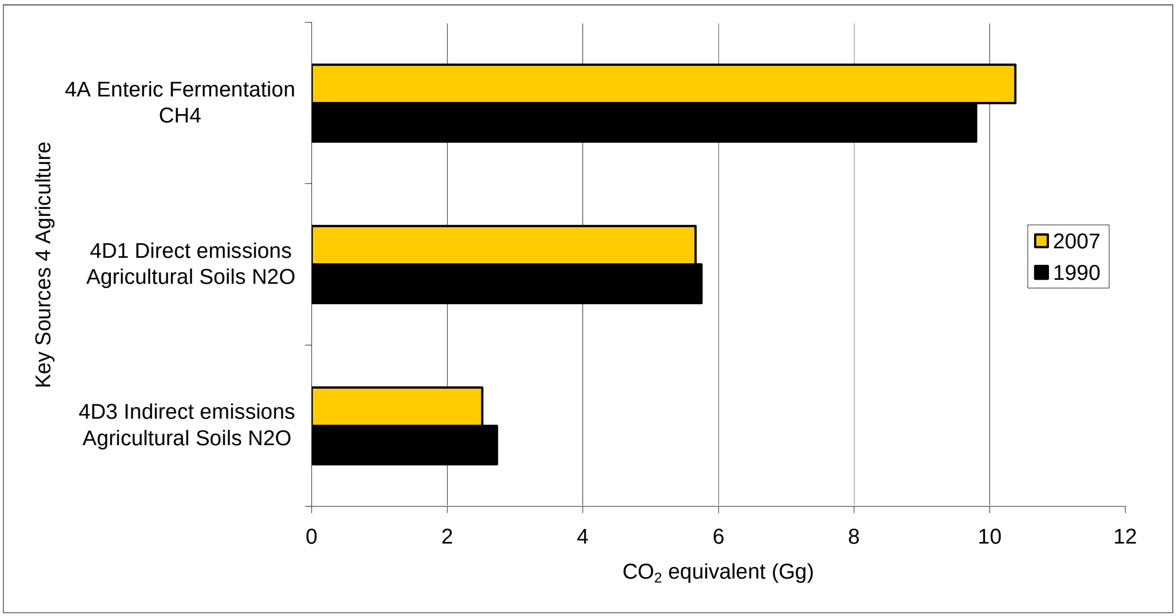

Figure 18 Key sources in agriculture. Emissions in CO_2 equivalents (Gg) per key source category in 2007 and in the base year 1990.

6.2. Source Category 4A – Enteric Fermentation

6.2.1. Source Category Description

Key source 4A
The CH_4 emissions from 4A Enteric Fermentation are a key source by level and trend.

CH_4 emissions from enteric fermentation are increasing since 1990 due to different reasons. The main reason is that the overall CH_4 production from cattle is higher as a consequence of the higher productivity of the dairy cattle (high-yield cattle) resulting in a higher per animal emission factor. Unless the overall cattle population was slightly lower in 2007 than in 1990, the CH_4 emissions from cattle would be even more increasing. Another reason for the higher CH_4 emissions since 1990 is the increase of the non-dairy cattle population and the young fattening cattle population. Emissions from cattle contribute to 80% of the emissions from enteric fermentation.

4A	Source	Specification	Data Source
4A1	Cattle	Mature dairy cattle	AD: Livestock data from OFIVA/OA 2008 (since 2002), OA 2002 (before 2002) Net energy and metabolisable energy (calves) from RAP 1999 EF: Soliva 2006a
		Mature non-dairy cattle	
		Young cattle (milk-fed calf, suckler cow calf, breeding calf, breeding cattle (4-12 months), fattening calf, fattening cattle	
		Breeding cattle (more than one year)	
4A3 4A4	Sheep Goats		AD: Livestock data from OFIVA/OA 2008 (since 2002), OA 2002 (before 2002) Data on net energy and feed intake losses from SBV 2006 EF: Soliva 2006a
4A6 4A8	Horses Swine		AD: Livestock data from OFIVA/OA 2008 (since 2002), OA 2002 (before 2002) Data on digestible energy and feed intake losses from SBV 2006 EF: Soliva 2006a
4A7	Mules and asses		AD: Livestock data from OFIVA/OA 2008 (since 2002), OA 2002 (before 2002) Data on digestible energy and feed intake losses from SBV 2006 EF: Soliva 2006a
4A9	Poultry		AD: Livestock data from OFIVA/OA 2008 (since 2002), OA 2002 (before 2002) Data on metabolisable energy and feed intake losses from SBV 2006 EF: Hadorn and Wenk 1996 sited in Soliva 2006a.

Table 70 Specification of source category 4A “Enteric Fermentation”. AD: activity data; EF: emission factors.

6.2.2. Methodological Issues

Methodology

Liechtenstein adopted the Swiss calculation methodology, Tier 2, for CH_4 emissions in agriculture by applying the same calculation and therefore the same values for the gross energy intake (except for dairy cattle) and by adjusting the activity data.

The following paragraph gives some further explanations about the Swiss calculation of CH_4 emissions from enteric fermentation.

Swiss methodology (excerpt from NIR CH, chp. 6.2.2, FOEN 2007):

The calculation is based on methods described in the IPCC Good Practice Guidance (IPCC 2000, equation 4.14). CH_4 emissions from enteric fermentation of the livestock population have been estimated using Tier 2 methodology. This means that detailed country specific data on nutrient requirements, feed intake and CH4 conversion rates for specific feed types are required.

*For calculating the **gross energy intake** a country specific method based on available data on net energy (lactation, growth), digestible energy and metabolisable energy has been applied. Data on energy intakes are taken from SBV 2006 and from RAP 1999. The method is described in detail in Soliva 2006a.*

Different energy levels (Figure 19) are used to express the energy conversion from energy intake to the energy required for maintenance and performance.

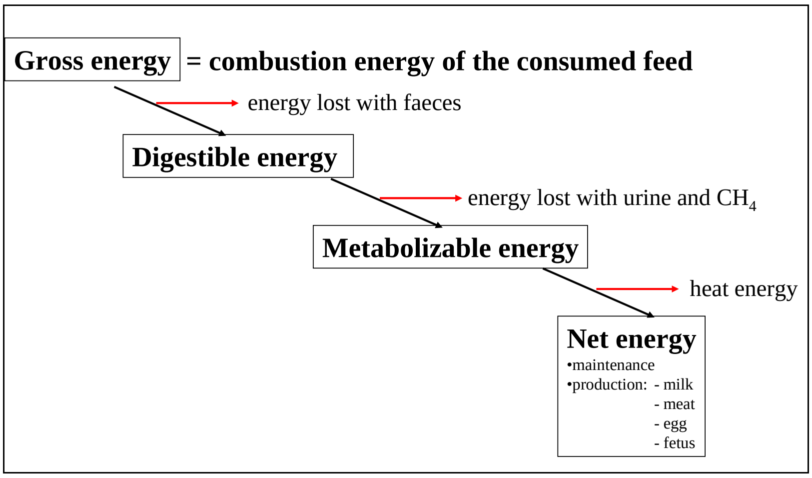

Figure 19 Levels of feed energy conversion. Reference: Soliva 2006a.

Net energy (NE) is used to express the energy required by the ruminants such as cattle, sheep and goats. NE in cattle feeding is further sub-divided into NE for lactation (NEL) and NE for growth (NEV). Exceptions in the cattle category are the calves, whose requirements for energy are expressed as metabolisable energy (ME). Horses, mules, asses and swine are fed on the basis of digestible energy (DE), whereas poultry are fed according to metabolisable energy (ME).

In the energy estimation also some feed energy losses are integrated. Feed losses are defined as the feed not eaten by the animal and therefore represent a loss of net energy. Calculation for NE, DE and ME consumption was used for the livestock categories sheep, goats, horses, mules and asses, swine and poultry, respectively.

For the livestock category cattle detailed estimations for NE are necessary. As the Swiss Farmers Union does not calculate the NE for detailed cattle sub-categories, NE data for each cattle sub-category was calculated individually according to the animal's requirements following the feeding recommendations of RAP 1999. These RAP recommendations are also used by the Swiss farmers as basis for their cattle feeding regime and for filling in application forms for subsidies for ecological services, and are therefore highly appropriate. In the calculation of the NE data, the animal's weight, daily growth rate, daily feed intake (DM), daily feed energy intake, and energy required for milk production for the respective sub-categories were considered.

For estimating the gross energy intake out of the available data on net energy, metabolisable energy and digestible energy, the following conversion factors were applied:

Livestock Category			***Conversion Factors***	
Cattle	*Mature dairy cattle*		*NEL to GE*	*0.318*
	Mature non-dairy cattle (suckler cow)		*NEL to GE*	*0.275*
	Young cattle			
		Milk-fed calf	*ME to GE*	*0.930*
		Suckler cow calf	*NEL to GE*	*0.291*
		Breeding calf	*NEL to GE*	*0.341*
		Breeding cattle (4-12 months)	*NEL to GE*	*0.322*
		Fattening calf	*NEV to GE*	*0.350*
		Fattening cattle	*NEV to GE*	*0.401*
	Breeding cattle (more than one year)		*NEL to GE*	*0.313*
Sheep	*Sheep (breeding)*		*NEL to GE*	*0.287*
	Sheep (fattening)		*NEV to GE*	*0.350*
Goats			*NEL to GE*	*0.283*
Horses, mules, asses			*DE to GE*	*0.560*
Swine			*DE to GE*	*0.682*
Poultry			*ME to GE*	*0.700*

Table 71 *Conversion factors used for calculation of energy requirements of individual livestock categories. Reference: Soliva 2006a: p.3. GE: Gross energy; DE: Digestible Energy; ME: Metabolisable Energy; NEL: Net energy for lactation; NEV: Net energy for growth.*

*For the **methane conversion rate Ym** (%) only few country specific data exist. Therefore mainly default values recommended by the IPCC for developed countries in Western Europe were used (IPCC 1997b: Reference Manual: p. 4.32–4.35 and IPCC 2000: p. 4.27). For poultry a country specific value ($Y_{poultry}$ = 0.1631) was used since no default value is given by the IPCC. This value was evaluated in an in vivo trial with broilers (Hadorn and Wenk 1996).*

Emission factors

All emission factors for enteric fermentation are country specific emission factors of Switzerland from the year 2007 They are based on IPCC equation 4.14 IPCC 2000, p. 4.26.

$$EF = \frac{GE * Y_m * 365\, days / y}{55.65\ MJ / kg\, CH_4}$$

GE: Gross energy intake

Y_m = Methane conversion rate

55.65 MJ/kg = energy content of methane.

The following calculated gross energy intakes are used:

Gross Energy Intake	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	MJ/head/day									
Cattle										
Mature dairy cattle	282.1	282.6	284.3	285.5	281.7	283.7	284.1	287.9	290.6	292.0
Mature non-dairy cattle	205.1	205.1	205.1	205.1	205.1	205.1	205.1	205.1	205.1	205.1
Young cattle (average)	48.9	47.9	47.2	46.2	46.2	45.8	45.0	44.6	43.6	43.4
Milk-fed calf	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*
Suckler cow calf	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*
Breeding calf	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*
Breeding cattle (4-12 months)	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*
Fattening calf	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*
Fattening cattle	*124.5*	*124.6*	*124.6*	*124.6*	*124.6*	*124.6*	*124.6*	*124.6*	*124.6*	*124.6*
Breeding cattle (> 1 year)	129.1	129.1	129.1	129.1	129.1	129.1	129.1	129.1	129.1	129.1
Sheep	20.8	21.4	21.7	21.1	23.2	24.3	21.4	21.8	21.6	22.8
Goats	31.7	32.0	32.3	32.3	33.2	34.8	32.4	29.3	29.2	28.9
Horses	145.3	135.1	133.4	125.2	153.3	176.8	131.9	133.9	134.1	134.1
Ponies, Mules and Asses	162.0	158.1	159.7	152.9	161.0	156.1	118.3	115.0	110.3	101.7
Swine	35.2	36.0	36.2	36.1	36.8	40.4	43.0	37.0	36.5	37.4
Poultry	1.8	1.9	1.9	1.7	1.7	1.8	1.7	1.8	1.7	1.6

Gross Energy Intake	2000	2001	2002	2003	2004	2005	2006	2007
	MJ/head/day							
Cattle								
Mature dairy cattle	296.4	303.6	305.5	306.3	311.4	308.9	307.9	307.6
Mature non-dairy cattle	205.1	205.1	205.1	205.1	205.1	205.1	205.1	205.1
Young cattle (average)	41.9	46.4	52.0	50.4	53.0	53.7	52.1	51.5
Milk-fed calf	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*
Suckler cow calf	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*
Breeding calf	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*
Breeding cattle (4-12 months)	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*
Fattening calf	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*
Fattening cattle	*124.6*	*124.6*	*124.6*	*124.6*	*124.6*	*124.6*	*124.6*	*124.6*
Breeding cattle (> 1 year)	129.1	129.1	129.1	129.1	129.1	129.1	129.1	129.1
Sheep	22.1	22.8	22.6	22.5	23.0	22.7	22.7	22.7
Goats	31.9	31.9	30.9	31.4	30.9	31.7	30.5	30.4
Horses	134.1	139.4	139.2	139.6	139.7	140.3	140.8	142.0
Ponies, Mules and Asses	100.9	98.9	95.3	92.0	89.2	87.0	85.0	82.8
Swine	36.4	35.2	34.9	34.9	35.1	34.6	33.5	33.5
Poultry	1.7	1.7	1.7	1.7	1.6	1.7	1.8	1.7

Table 72 Gross energy intake of different livestock groups. Calculation is based on the above mentioned parameters net energy, digestible energy, metabolisable energy according to the method described in Soliva 2006a. Input data on net energy, digestible energy and metabolisable energy is taken from SBV 2006 and RAP 1999. All sub-categories displayed in italic.

The gross energy intake per head for some animal categories revealed some fluctuations during the inventory period. The energy intake for all cattle categories (except dairy cattle) is estimated to be constant. The value for mature dairy cattle increased which is mainly a result of higher milk production (milk production was 5’792 kg per head and year in 1990 and 6’736 kg per year in 2007). The gross energy intake for mature non-dairy cattle is significantly higher than IPCC default values, since this category only comprehends mature cows to produce offspring for meat. The gross energy intake of young cattle was calculated separately for all sub-categories displayed in Table 72 (in italic) and subsequently averaged. The values for all sub-categories summarized under young cattle are constant over time. Since the composition of the young cattle category is changing over time, the average gross energy intake for young cattle is also changing over time. The gross energy intake for the horse categories showed higher values for 1994 and 1995. According to the Swiss Farmers Union data comparison of these years can be made only partially due to changes in livestock survey methods (SBV 1998).

Activity data

The activity data input has been obtained from the Office for Food-control and Veterinary (Amt für Lebensmittelkontrolle und Veterinärwesen) in cooperation with the Office for Agriculture (OFIVA/OA 2008, for all years since 2002) and from the Office of Agriculture (OA 2002, for the years before 2002).

Data for the livestock categories mature dairy cattle, breeding cattle, sheep, goats and swine are available annually for the whole time series. For the other livestock categories data from the year 1990 was interpolated for all the years between 1991 and 2001. Since 2002 data for all livestock categories is available on an annual basis. Livestock data is collected each year in March.

Population Size	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	head									
Cattle	6'117	5'950	5'947	5'545	5'675	5'814	5'748	5'657	5'546	5'461
Mature dairy cattle	2'850	2'843	2'747	2'601	2'677	2'643	2'652	2'622	2'614	2'589
Mature non-dairy cattle	20	25	31	36	42	47	52	58	63	69
Young cattle	1'713	1'647	1'683	1'642	1'780	1'850	1'830	1'890	1'840	1'931
Milk-fed calf	*40*	*47*	*54*	*62*	*69*	*76*	*83*	*90*	*98*	*105*
Suckler cow calf	*25*	*24*	*22*	*21*	*19*	*18*	*17*	*15*	*14*	*12*
Breeding calf	*280*	*302*	*323*	*345*	*366*	*388*	*410*	*431*	*453*	*474*
Breeding cattle (4-12 months)	*856*	*725*	*697*	*590*	*664*	*669*	*584*	*580*	*464*	*491*
Fattening calf	*205*	*225*	*244*	*264*	*284*	*304*	*323*	*343*	*363*	*382*
Fattening cattle	*307*	*325*	*342*	*360*	*378*	*396*	*413*	*431*	*449*	*466*
Breeding cattle (> 1 year)	1'534	1'434	1'486	1'266	1'177	1'274	1'213	1'087	1'029	873
Sheep	2'781	2'689	2'878	2'641	2'627	2'632	3'352	3'234	3'608	3'264
Goats	171	213	277	181	136	145	275	269	287	313
Horses	156	178	183	202	190	204	220	218	227	231
Ponies, Mules and Asses	50	58	66	75	83	91	99	107	115	124
Swine	3'251	3'543	2'902	3'236	2'787	2'429	2'392	2'128	2'056	2'122
Poultry	4'386	4'049	3'712	3'375	3'037	2'700	3'592	4'484	5'376	6'268

Population Size	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
	head							
Cattle	5'229	5'270	5'235	5'539	5'768	5'587	5'822	6'088
Mature dairy cattle	2'440	2'639	2'560	2'543	2'460	2'489	2'589	2'593
Mature non-dairy cattle	74	112	149	199	279	362	405	466
Young cattle	1'804	1'652	1'529	1'781	2'084	1'776	1'829	2'078
Milk-fed calf	*112*	*92*	*71*	*89*	*87*	*83*	*63*	*106*
Suckler cow calf	*11*	*56*	*101*	*141*	*252*	*266*	*283*	*339*
Breeding calf	*496*	*386*	*276*	*262*	*219*	*209*	*299*	*278*
Breeding cattle (4-12 months)	*299*	*360*	*451*	*493*	*663*	*392*	*418*	*410*
Fattening calf	*402*	*283*	*164*	*290*	*287*	*250*	*212*	*311*
Fattening cattle	*484*	*475*	*466*	*506*	*576*	*576*	*554*	*634*
Breeding cattle (> 1 year)	911	868	997	1'016	945	960	999	951
Sheep	3'319	3'319	3'201	3'070	3'149	3'603	3'687	3'683
Goats	239	210	205	241	286	324	362	319
Horses	153	284	196	220	255	266	286	279
Ponies, Mules and Asses	132	140	148	127	159	143	140	162
Swine	2'013	2'248	2'101	1'979	990	1'703	1'723	1'735
Poultry	7'159	8'772	10'384	10'408	11'130	10'453	11'742	12'224

Table 73 Activity for calculating methane emissions from enteric fermentation (OFIVA/OA 2008, OA 2002).

The number of swine was declining during the last 17 years whereas the number of sheep, goats, horses and poultry were increasing. The massive increase in the poultry population is a result of two new poultry farms that were established in Liechtenstein. The drastic decrease of the swine population between 2003 and 2004 was caused by a disease. The number of cattle decreased by 17% between 1990 and the beginning of the new century, but is growing again since 2003.

6.2.3. Uncertainties and Time-Series Consistency

For the uncertainty analysis the following input data from the Swiss Agroscope Reckenholz-Tänikon Research Station ART was used (ART 2007):

Input data for uncertainty analysis 4A	Lower bound (2.5 Percentile)	Upper bound (97.5 Percentile)	Mean uncertainty
Activity data (head)	-6.4%	+6.4%	±6.4%
Emission factor (kg CH_4 /head/yr)	-14.7%	+19.6%	±17.2%

Table 74 Input data for the uncertainty analysis of the source category 4A “Enteric Fermentation” (ART 2007).

It is assumed that uncertainty estimations from Switzerland are also applicable for Liechtenstein. Liechtenstein applies the same methods and emission factors and has since 2002 a sophisticated livestock data collection system with low inaccuracies.

To apply for the Tier 1 uncertainty analysis, the arithmetic mean of lower and upper bound is used for activity data and for emission factors. For further results see Section 1.7.

Time series between 1990 and 2007 is consistent.

6.2.4. Source-Specific QA/QC and Verification

Documentation about the calculation method of Switzerland assures transparency and traceability of the calculation methods (Soliva 2006a). Additionally a document in German lists all the methodological differences between the former calculations and the current methodology (Soliva 2006b).

Calculations were made by Acontec. A quality control was done by INFRAS by a counter-check of the calculation sheets.

The agriculture expert, the NIC and the NIR author report their QC activities in a checklist (see Annex 8).

Source-specific activities have not been carried out.

6.2.5. Source-Specific Recalculations

A recalculation for 2006 has been carried out because the Swiss implied CH_4 emission factors 2006 have not yet been available for Liechtenstein’s submission on 29 February 2008. Meanwhile, the factors 2006 are known and have been used for the recalculation.

Note that there are very small deviations in the methane emissions between the previous and the latest version for the whole time series 1990-2006 as identified by the CRF Reporter. For 1990, the difference is 0.00028 Gg CO_2 eq. The differences appear due to a minor change in the interface between the Swiss back-ground tables for agriculture and Liechtenstein’s background tables. They are not interpreted as substantial change of the results but as minor difference due to technical reasons.

6.2.6. Source-Specific Planned Improvements

There are no source-specific planned improvements.

6.3. Source Category 4B – Manure Management

6.3.1. Source Category Description

Key source 4B
Source category 4B Manure Management CH_4 and N_2O are not key sources.

CH_4 and N_2O emissions from manure management are reported. CH_4 emissions from manure management in 2007 are lower than the emissions in 1990, which is mainly a result of the reduction of dairy cattle and swine population. N_2O emissions from manure management of solid manure storage and dry lot slightly increased on a low level due to an increase of the poultry population.

4B	Source	Specification	Data Source
4B1	Cattle	Mature dairy cattle	AD: OFIVA/OA 2008 (since 2002), OA 2002 (before 2002) EF: IPCC 2000; IPCC 1997c; FAL/RAC 2001; Menzi et al. 1997; Soliva 2006a.
		Mature non-dairy cattle	
		Young cattle (milk-fed calf, suckler cow calf, breeding calf, breeding cattle (4-12 months), fattening calf, fattening cattle	
		Breeding cattle (more than one year)	
4B3 4B4 4B6 4B8	Sheep Goats Horses Swine		AD: OFIVA/OA 2008 (since 2002), OA 2002 (before 2002) EF: IPCC 2000; IPCC 1997c; FAL/RAC 2001; Menzi et al. 1997; Soliva 2006a.
4B7	Mules and Asses		AD: OFIVA/OA 2008 (since 2002), OA 2002 (before 2002) EF: IPCC 2000; IPCC 1997c; FAL/RAC 2001; Menzi et al. 1997; Soliva 2006a.
4B9	Poultry		AD: OFIVA/OA2008 (since 2002), OA 2002 (before 2002) EF: IPCC 2000; IPCC 1997c; FAL/RAC 2001; Menzi et al. 1997; Soliva 2006a.

Table 75 Specification of source category 4B “Manure Management (CH_4)”. AD: Activity data; EF: Emission factors.

4B	Source	Specification	Data Source
4B11 4B12	Liquid Systems Solid storage and dry lot		AD: OFIVA/OA 2008 (since 2002), OA 2002 (before 2002); FAL/RAC 2001; Menzi et al. 1997; Soliva 2006a EF: IPCC 2000; IPCC 1997c

Table 76 Specification of source category 4B “Manure Management (N_2O)”. AD: Activity data; EF: Emission factors.

6.3.2. Methodological Issues

Liechtenstein adopted the Swiss calculation methodology, Tier 2, for emissions from manure management by adjusting the activity data.

For calculation of CH_4 and N_2O emissions slightly different livestock sub-categories are used. The livestock categories reported in the CRF tables are the same, but the respective sub-categories as a basis for the calculation are slightly different. Nevertheless there is no inconsistency in the total number of animals as they are the same both for CH_4 and N_2O emissions.

Calculation of CH_4 emissions is based on the domestic livestock populations mature dairy cattle, mature non-dairy cattle (suckler cows), young cattle (milk-fed calf, suckler cow calf, breeding calf, breeding cattle (4-12 months), fattening calf, fattening cattle), breeding cattle (more than one year), sheep, goats, horses, mules, asses, swine and poultry as reported for enteric fermentation.

Calculation of N_2O emissions is based on a slightly different livestock population break down with the following sub-groups: mature dairy cattle, mature non-dairy cattle (suckler cows), young cattle (milk-fed calf, suckler cow calf, breeding calf, breeding cattle (4-12 months), fattening calf, fattening cattle), breeding cattle (more than one year), fattening pig places, breeding pig places, sheep places, goat places, horses (foals < 1 year, foals 1-2 years, other horses), ponies, mules and asses and poultry (laying hens, young hens < 18 weeks, broilers, other poultry).

The following paragraph gives some further explanations about the reason for the Swiss specific calculation of N_2O emissions from manure management.

Swiss methodology (excerpt from NIR CH, chp. 6.3.2, FOEN 2007):

This calculation is chosen because more detailed data on N excretion for the particular animal categories are available (FAL/RAC 2001).The categories for sheep, swine and goats as provided by FAL/RAC (2001) do not correspond to the categories of the Swiss Farmers Union (SBV 2006). The conversion from the FAL/RAC (2001) classification to the available livestock categories according to SBV is done as follows (Schmid et al. 2000):

- *One fattening pig place corresponds to one fattening pig over 25 kg, 1/6 fattening pig place to one young pig below 30 kg.*
- *One breeding pig place corresponds to one sow, ½ breeding pig place to one boar.*
- *One sheep place corresponds to one ewe over one year. Other sheep such as lambs or rams are not included.*
- *One goat place corresponds to one (female) goat older than 1.5 years. All goats younger than 1.5 years are not included[17].*

a) CH_4 Emissions

Methodology

Calculation of CH_4 emissions from manure management is based on IPCC Tier 2 (IPCC 2000, equation 4.17).

Emission factor

Liechtenstein is using Swiss and IPCC emission factors for CH_4 emissions from manure management. The following paragraph gives explanations to the origin of the Swiss emission factor for manure management.

Swiss emission factor (excerpt from NIR CH, chp. 6.3.2, FOEN 2007):

Calculation of the emission factor is based on the parameters volatile substance excreted (VS), the maximum CH_4 producing capacity for manure (B_o) and the CH_4 conversion factors for each manure management system (MCF).

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[17] Since the number of (female) goats older than 1.5 years are not known, the following approximation is used: GP = DG + 0.3508*OFG. GP goat places, DG dairy goats, OFG other female goats older than 1 year.

*No country specific values for the **daily excretion of VS** are available in Switzerland. For the livestock categories swine, sheep, goats, horses, mules and asses, and poultry default values from IPCC 1997 (1997c: Reference Manual: p. 4.41 to 4.47) were taken. The VS for cattle sub-categories were estimated according to IPCC (2000: equation 4.16: p. 4.31).*

*The **ash content** of cattle manure is assumed to amount to 8% on average (IPCC 1997c: Reference Manual: p. 4.47). The digestible energy of the feed for cattle is assumed to be 60% on average, except for calves with 65% (IPCC 1997c: Reference Manual: p. 4.39). The calculation of gross energy intake per head is described in detail in chapter 6.2.2.*

For the Methane Producing Potential (B_o) default values are used (IPCC 1997c: Reference Manual: p. 4.39 to 4.47).

*For the Methane Conversion Factor (**MCF**) IPCC default values are used (IPCC 2000, p. 4.36 and IPCC 1997c: Reference Manual: p. 4.25). In Switzerland mainly two manure management systems exist, solid storage and liquid/slurry storage. Calves are mainly kept in deep litter systems and there are also specific MCF values for pasture and poultry systems: The following MCF's were used:*

Table 77 Manure management systems and Methane conversion factors (MCFs). References: IPCC 2000, p. 4.36 and IPCC 1997b: p. 4.25 (for liquid/slurry).

Manure management system	***Description***	***MCF***
Solid manure	*Dung and urine are excreted in a barn. The solids (with and without litter) are collected and stored in bulk for a long time (months) before disposal.*	*1%*
Liquid/slurry	*Combined storage of dung and urine under animal confinements for longer than 1 month.*	*10%*
Pasture	*Manure is allowed to lie as it is, and is not managed (distributed, etc.).*	*1%*
Deep litter	*Dung and urine is excreted in a barn with lots of litter and is not removed for a long time (months). This is applied for the cattle sub-categories of milk-fed calves and fattening calves, and for sheep and goats.*	*3.9%*
Poultry system	*Manure is excreted on the floor with or without bedding.*	*1.5%*

*According to the Swiss methodology, the fraction of animal's manure handled using different manure management systems (**MS**) was separately calculated for each livestock category and the respective manure management systems. The information about the percentage of a livestock category kept in a specific housing system is based on FAL/RAC (2001). The percentages of solid manure or slurry produced by different animals within specific housing systems were obtained from Menzi et al. (1997), as were the percentages of the grazing time for each livestock category.*

Activity data

Data on population sizes are taken from the Office of Food-control and Veterinary (OFIVA/OA 2008) and the Office of Agriculture (OA 2002). For details refer to chapter 6.2.2.

b) N_2O Emissions

Methodology

Liechtenstein follows the Swiss approach for calculating N_2O emissions from manure management using a Tier 2 method. The Swiss methodology is explained in the following paragraph.

Swiss methodology (excerpt from NIR CH, chp. 6.3.2, FOEN 2007):

For calculation of N_2O emissions the country specific method IULIA is applied. IULIA is an IPCC-derived method for the calculation of N_2O emissions from agriculture that basically uses the same emission factors, but adjusts the activity data to the particular situation of Switzerland. Further information is provided under the chapter 6.5.2. IULIA is described in detail in Schmid et al. (2000).

For calculation of emissions from manure management IULIA applies other values for the nitrogen excretion per animal category than IPCC (refer to information about activity data) and differentiates the animal waste management systems Liquid systems and Solid storage. The combined systems (liquid/slurry) are split up into Liquid systems and Solid storage. N_2O emissions from pasture range and paddock appears under the category „D Agricultural soils, subcategory 2 animal production". IPCC categories „daily spread" and „other systems" are not occurring. The basic animal waste management systems included in IULIA are defined in Menzi et al. (1997).

Emission factors

IPCC default emission factors are used for the two animal waste management systems (IPCC 1997c: Reference Manual: p. 4.104).

Source	**Emission factor per animal waste management system (kg N_2O-N / kg N)**
Liquid systems	0.001
Solid storage	0.020

Table 78 Emission factors for calculating N_2O emissions from manure management (IPCC 1997c: p. 4.104).

Activity data

Input data on all livestock groups are taken from OFIVA/OA 2008 and OA 2002. Data are converted into the following livestock categories.

Population Size	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	head									
Cattle	6'117	5'950	5'947	5'545	5'675	5'814	5'748	5'657	5'546	5'461
Mature dairy cattle	2'850	2'843	2'747	2'601	2'677	2'643	2'652	2'622	2'614	2'589
Mature non-dairy cattle	20	25	31	36	42	47	52	58	63	69
Young cattle	1'713	1'647	1'683	1'642	1'780	1'850	1'830	1'890	1'840	1'931
Milk fed calf, suckler cow calf, breeding calf and breed-ing cattle less than one year	*1'201*	*1'098*	*1'097*	*1'017*	*1'118*	*1'151*	*1'094*	*1'117*	*1'028*	*1'082*
Fattening calf	*205*	*225*	*244*	*264*	*284*	*304*	*323*	*343*	*363*	*382*
Fattening cattle	*307*	*325*	*342*	*360*	*378*	*396*	*413*	*431*	*449*	*466*
Breeding cattle (> 1 year)	1'534	1'434	1'486	1'266	1'177	1'274	1'213	1'087	1'029	873
Sheep (Sheep places)	1'391	1'345	1'439	1'321	1'314	1'316	1'676	1'617	1'804	1'632
Goats (Goat places)	94	117	152	100	75	80	151	148	158	172
Horses	156	178	183	202	190	204	220	218	227	231
Foals (< 1 year)	*i.e.*	*i.e.*	*i.e.*	*i.e.*	*i.e.*	*i.e.*	*i.e.*	*i.e.*	*i.e.*	*i.e.*
Foals (1-2 years)	*16*	*16*	*17*	*17*	*18*	*18*	*18*	*19*	*19*	*20*
Other horses	*140*	*161*	*166*	*184*	*173*	*186*	*202*	*199*	*207*	*211*
Ponies, Mules and Asses	50	58	66	75	83	91	99	107	115	124
Swine	2'256	2'491	2'041	2'231	1'924	1'702	1'646	1'542	1'454	1'516
Fattening pig places	1'983	2'097	1'717	2'003	1'720	1'449	1'488	1'169	1'200	1'208
Breeding pig places	273	394	324	228	204	253	158	373	254	308
Poultry	4'386	4'049	3'712	3'375	3'037	2'700	3'592	4'484	5'376	6'268
Laying hens	4'118	3'802	3'486	3'170	2'854	2'538	3'403	4'268	5'133	5'998
Young hens	105	96	88	79	70	61	53	44	35	26
Broilers	i.e.	i.e.	i.e.	i.e.	i.e.	i.e.	36	71	107	143
Other poultry	163	151	138	126	113	101	101	101	101	100

Population Size	2000	2001	2002	2003	2004	2005	2006	2007
	head							
Cattle	5'229	5'270	5'235	5'539	5'768	5'587	5'822	6'088
Mature dairy cattle	2'440	2'639	2'560	2'543	2'460	2'489	2'589	2'593
Mature non-dairy cattle	74	112	149	199	279	362	405	466
Young cattle	1'804	1'652	1'529	1'781	2'084	1'776	1'829	2'078
Milk fed calf, suckler cow calf, breeding calf and breed-ing cattle less than one year	*918*	*894*	*899*	*985*	*1'221*	*950*	*1'063*	*1'133*
Fattening calf	*402*	*283*	*164*	*290*	*287*	*250*	*212*	*311*
Fattening cattle	*484*	*475*	*466*	*506*	*576*	*576*	*554*	*634*
Breeding cattle (> 1 year)	911	868	997	1'016	945	960	999	951
Sheep (Sheep places)	1'660	1'660	1'601	1'535	1'575	1'802	1'844	1'842
Goats (Goat places)	131	116	113	133	157	178	199	175
Horses	153	284	196	219	249	258	284	278
Foals (< 1 year)	*i.e.*	*i.e.*	*i.e.*	*1*	*5*	*6*	*5*	*3*
Foals (1-2 years)	*20*	*12*	*4*	*10*	*18*	*20*	*25*	*24*
Other horses	*133*	*272*	*192*	*209*	*231*	*238*	*254*	*251*
Ponies, Mules and Asses	132	140	148	127	159	143	140	162
Swine	1'401	1'593	1'435	1'357	662	1'173	1'184	1'191
Fattening pig places	1'221	1'306	1'329	1'240	654	1'056	1'076	1'084
Breeding pig places	180	287	106	117	8	117	108	107
Poultry	7'159	8'772	10'384	10'408	11'130	10'453	11'742	12'224
Laying hens	6'863	8'449	10'034	10'113	10'549	10'112	11'398	11'357
Young hens	18	9	0	11	9	0	9	1
Broilers	179	214	250	250	520	250	300	702
Other poultry	100	100	100	34	52	91	35	164

Table 79 Activity data for calculating N_2O emissions from manure management (OFIVA/OA 2008, OA 2002). Note that for sheep, goats and swine the number of places are given instead of heads, which explains the difference to the numbers given in Table 73. For the calculation of sheep places, goat places, fattening pig places and breeding pig places, refer to corresponding paragraphs in this chapter above.

No national data on nitrogen excretion per animal category (kg N/head/year) are available in Liechtenstein (except the ones for dairy cattle, which are calculated based on country specific milk production data). Therefore Swiss data is taken from FAL/RAC (2001, p. 48/49), Walther et al. (1994) and Schmid et al. (2000) (see Annex 3.1). These data are calculated according to the method IULIA. Unlike IPCC, IULIA distinguishes the age structure of the animals and the different use of the animals (e.g. fattening and breeding). Calculation of nitrogen excretion of dairy cattle is based on milk production reported. This more disaggregated approach leads to 30% lower calculated nitrogen excretion rates compared to IPCC, which therefore also implies to lower total N_2O emissions from manure management.

The split of nitrogen flows into the different animal waste management systems including ammonia emissions are taken from Menzi et al. (1997).

6.3.3. Uncertainties and Time-Series Consistency

For the uncertainty analysis the following input data from the Swiss Agroscope Reckenholz-Tänikon Research Station ART was used (ART 2007):

Input data for uncertainty analysis 4B	**Lower bound (2.5 Percentile**	**Upper bound (97.5 Percentile)**	**Mean uncertainty**
Activity data CH_4 (head)	-6.4%	+6.4%	±6.4%
Activity data N_2O (liquid systems and solid storage, kg N)	-29.9%	+29.2%	±29.5%
Emission factor CH_4 (kg CH_4 /head/yr)	-54.7%	+53.6%	±54.1%
Emission factor N_2O (liquid systems, kg N_2O-N / kg N)	-100%	+0%	±50%
Emission factor N_2O (solid storage, kg N_2O-N / kg N)	-75%	+50%	±62.5%

Table 80 Input data for the uncertainty analysis of the source category 4B “Manure Management”. (ART 2007).

It is assumed that uncertainty estimations from Switzerland are also applicable for Liechtenstein. Liechtenstein applies the same methods and emission factors and has since 2002 a sophisticated and livestock data collection system with low inaccuracies.

To apply for the Tier 1 uncertainty analysis, the arithmetic mean of lower and upper bound is used for activity data and for emission factors. For further results see Section 1.7.

For further results see Section 1.7. The time series 1990-2007 is consistent.

6.3.4. Source-Specific QA/QC and Verification

For CH_4 documentation about the calculation method of Switzerland assures transparency and traceability of the calculation methods (Soliva 2006a). Additionally a document in German lists all the methodological differences between the former calculations and the current methodology (Soliva 2006b). For N_2O estimations an internal Swiss documentation of the Agroscope Reckenholz-Tänikon Research Station (ART) is available (Berthoud 2004).

Calculations were made by Acontec. A quality control was done by INFRAS by a countercheck of the calculation sheets.

The agriculture expert, the NIC and the NIR author report their QC activities in a checklist (see Annex 2).

6.3.5. Source-Specific Recalculations

A recalculation for 2006 has been carried out because the Swiss implied CH_4 emission factors 2006 have not yet been available for Liechtenstein’s submission on 29 February 2008. Meanwhile, the factors 2006 are known and have been used for the recalculation. Only emission factors for methane are affected.

Note that there are very small deviations in the methane emissions between the previous and the latest version for the whole time series 1990-2006 as identified by the CRF Reporter. For 1990, the difference is 0.000025 Gg CO_2 eq. The differences appear due to a minor change in the interface between the Swiss back-ground tables for agriculture and

Liechtenstein's background tables. They are not interpreted as substantial change of the results but as minor difference due to technical reasons.

6.3.6. Source-Specific Planned Improvements

There are no source-specific planned improvements.

6.4. Source Category 4C – Rice Cultivation

Rice Cultivation does not occur in Liechtenstein.

6.5. Source Category 4D – Agricultural Soils

6.5.1. Source Category Description

Key source 4D1, 4D3
Direct (4D1) N_2O emissions from agricultural soils are key sources by level and trend.
Indirect (4D3) N_2O emissions from agricultural soils are key sources by level.

The source category 4D includes the following emissions: Direct N_2O emissions from soils and from animal production (emission from pasture range and paddock manure) and indirect N_2O emissions.

In general, direct and indirect N_2O emissions are slightly decreasing since 1990, mainly due to a reduced input of mineral fertilizer. Within the source category direct emissions a slight increase of emissions from fixation can be noted, which is a result of the growing areas of pasture range and paddock.

4D	Source	Specification	Data Source
4D1	Direct soil emissions	Includes emissions from synthetic fertilizer, animal manure, crop residue, N-fixing crops, organic soils, residues form pasture range and paddock, N-fixing pasture range and paddock	AD: OA 2000, OA 2003, OA 2008, FAL/RAC 2001, Leifeld et al. 2003, Menzi et al. 1997, Schmid et al. 2000, Walther et al. 1994 EF: IPCC 1997c (N_2O); IPCC 2000
4D2	Pasture, range and paddock manure		AD: OFIVA/OA 2008, OA 2008, OA 2002, FAL/RAC 2001, Menzi et al. 1997, Schmid et al. 2000, Walther et al. 1994 EF: IPCC 1997c
4D3	Indirect emissions	Leaching and run-off, N deposition air to soil	AD: OA 2008, FAL/RAC 2001, Prasuhn and Braun 1994, Braun et al. 1994, Schmid et al. 2000, Walther et al. 1994. EF: IPCC 2000

Table 81 Specification of source category 4D “Agricultural Soils”. (AD: Activity data; EF: Emission factors).

6.5.2. Methodological Issues

Methodology

Liechtenstein applies the Swiss method IULIA for calculating N_2O emissions. The methodology as well as differences between IULIA and the IPCC method are described in the following paragraph:

Swiss methodology (excerpt from NIR CH, chp. 6.5.2, FOEN 2007):

For calculation of N_2O emissions from agricultural soils the national method IULIA is applied. IULIA is an IPCC-derived method for the calculation of N_2O emissions from agriculture that basically uses the same emission factors, but adjusts the activity data to the particular situation of Switzerland (Schmid et al. 2000). According to Schmid et al. (2000) IULIA is better adapted to the conditions of Swiss agriculture, compared to the IPCC method. There is no indication that the adoption of the IPCC method would lead to a better estimation of the N_2O emissions in Switzerland.

Main differences between the IULIA method and IPCC are (Schmid et al. 2000, p. 74):

- *IULIA estimates lower nitrogen excretion per animal category, especially due to the lower excretions of cattle (refer to chapter 6.3.2).*
- *The amount of losses to the atmosphere from the excreted nitrogen is more than 50% higher compared to IPCC.*
- *The amount of leaching (of nitrogen excreted and of synthetic fertilizers) is lower by 1/3 compared to IPCC.*
- *The share of solid storage out of the total manure is more than twofold; the share of excretion on pasture range and paddock is lower by 1/3.*
- *The nitrogen inputs from biological fixation are higher by a factor of 30 since fixation on meadows and pastures are also considered. The consideration of nitrogen fixation from*

grassland is one of the major advantages of the method IULIA as the grassland accounts for the majority on nitrogen fixed in Swiss agricultural soils.

- *The nitrogen inputs from crop residues are only 25% higher although emissions from plant residue on grasslands are considered. This is explained by the fact that the emissions from plant residues returned to soils on cropland are estimated 50% below the IPCC defaults.*

Despite the different assumptions of the two methods, differences at the level of the N_2O emissions are quite moderate. In total IULIA estimations of the N_2O emissions from agriculture are 14% lower than the IPCC estimations (Schmid et al. 2000, p. 75).

Direct emissions from soil (4D1):

Calculation of direct N_2O emissions from soil is based on IPCC 2000 Tier 1b. Liechtenstein follows the Swiss method IULIA by using the same rates (e.g. N excretion per animal category) and standard values but using national activity data.

- Emissions from **synthetic fertilizer** include mineral fertilizer, compost and sewage sludge. For calculation of the amount of nitrogen in synthetic fertilizer and compost Swiss data from the Swiss Farmers Association were taken and adjusted to Liechtenstein by a rule of three (by estimating the nitrogen input per hectare of the agricultural area; SBV 2006). The amount of nitrogen in sewage sludge is taken from the Office of Agriculture (OA 2008). From the amount of nitrogen in fertilizer losses to the atmosphere in form of NH_3 are subtracted and the rest is multiplied with the corresponding emission factor. NO_x emissions are not subtracted since they occur mainly after the fertilizer application. According to the Swiss method IULIA losses to the atmosphere are set to 6% (NH_3) instead of the IPCC value of 10% for NH_3 and NO_x. (Schmid et al. 2000, p. 63 and IPCC 1997c, p. 4.94).
- To model the emissions of **pasture range and paddock manure**, nitrogen input from manure applied to soils is calculated. This is calculated by the total N excretion minus N excreted on pastures minus ammonia volatilization from solid and liquid manure. Following the Swiss method IULIA the losses (to the atmosphere) as ammonia are specified for each management category instead of using a fixed ratio of 20% (Schmid et al. 2000, p. 66). NO_x emissions are not subtracted since they occur after the application of animal wastes. For details regarding the volatized N refer to Table 83.
- Emissions from **crop residues** are based on the amount of nitrogen in crop residues returned to soil. According to IULIA (Schmid et al. 2000, p. 68 and p. 100) the calculation of nitrogen in crop residues is based on data reported on crop yields (OA 2008), the standard values for arable crop yields for Switzerland (FAL/RAC 2001 and Walther et al. 1994) and standard amounts of nitrogen in crop residues returned to soils for Switzerland (FAL/RAC 2001 and Walther et al. 1994). The calculation of the amount of nitrogen in crop residues returned to soil according to IULIA is as follows (Schmid et al. 2000, p. 101):

  $$F_{CR} = \sum_{Cr} (E_{Cr} * \frac{NR_{Cr}}{Y_{Cr}})$$

  F_{CR}: Amount of nitrogen in crop residues returned to soils (t N)
  E_{Cr}: Amount of crop yields for culture Cr (t)
  Y_{Cr}: Standard values for arable crop yields for culture Cr (t/ha)
  NR_{Cr}: Standard amount of nitrogen in crop residues returned to soils (t/ha)

  From 2001 on updated standard values and amounts of nitrogen returned to soil are used. In addition to the N transfer from crop residues, IULIA also takes into account the plant residue returned to soils on meadows and pastures (Schmid et al. 2000). The grassland area in Liechtenstein is almost as big as the agricultural land. Input data on the managed area of meadows and pastures are taken from (OA 2008).

- For calculation of emissions from **N-fixing crops**, the Swiss method IULIA assumes that 60% of the nitrogen in crops is caused by biological nitrogen fixation (Schmid et al. 2000, p. 70). This is in line with IPCC, assuming that biological nitrogen fixation supplies 50-60 per cent of the nitrogen in grain legumes (IPCC 1997c, p. 4.89). The total amount of nitrogen is calculated according to the calculation of nitrogen in crop residues. In addition, IULIA takes biological nitrogen fixation on meadows and pastures into account, assuming a nitrogen concentration of 3.5% in the dry matter from which 80% derives from biological nitrogen fixation. For the dry matter production of clover on pastures and meadows statistical data were used (Schmid et al. 2000, p. 70). The following table gives an overview of the calculation of emissions from N-fixing crops.

Fixation	Share of N caused by fixation	Share of N in Dry matter
Leguminous (N-fixing crops)	0.6	
Clover (Fixation meadows and pastures)	0.8	0.035

Table 82 Input values for calculation of emissions from N-fixing crops according to IULIA (Schmid et al. 2000, p. 70).

- Emissions from **cultivated organic soils** are based on estimations on the area of cultivated organic soils (OA 2008) and the IPCC default emission factor for N_2O emissions from cultivated organic soils (IPCC 1997b). The estimation of the area of cultivated organic soils was revised due to an inconsistency with the area reported in the LULUCF sector.

Emissions from pasture, range and paddock manure (4D2)

Calculation of these emissions is also based on the Swiss method IULIA. This equation is similar to equation 4.18, IPCC 2000, p. 4.42, but applies Swiss N excretion rates. For calculation of the N excretion per animal category, refer to chapter 6.3.2.

Only emissions of Pasture range and Paddock are to be reported under Agricultural Soils. Other emissions from animal production are reported under 4B Manure Management. The relevant input data are taken from Swiss statistics (FAL/RAC 2001, p. 48/49; Schmid et al. 2000; Walther et al. 1994 (nitrogen excretion in kg N/head/yr) and Menzi et al. 1997 (fraction of animal waste management system)).

Indirect emissions (4D3)

Calculation of the indirect emissions is based on IPCC 2000 Tier 1b.

- For calculation of N_2O emissions from **leaching and run-off**, N from fertilizers and animal wastes has to be estimated. The data for the cultivated area is taken from (OA 2008). Other relevant input data such as the information on leaching and run-off is taken from the Swiss statistics FAL/RAC (2001), Prasuhn and Braun (1994) and Braun et al. (1994). $Frac_{Leach}$ is set as 0.2 instead of the IPCC default of 0.3 (Prasuhn and Mohni 2003). This value is extrapolated from long-term monitoring and modelling studies from the canton of Berne. According to Schmid et al. (2000, p. 71), the default value of IPCC leads to an overestimation of the emissions from leaching and run-off. The default value is based on a model which assumes that 30% of nitrogen from synthetic fertilizer and deposition is reaching water bodies. According to Schmid et al. (2000) this amount cannot be applied to the N-excretion of animals for production.

- N_2O emissions from **deposition** are based on NH_3 and NO_x emissions. Losses to the atmosphere are calculated according to Menzi et al. (1997) and Schmid et al. (2000). For NH_3 emissions losses for all livestock categories are assumed. Furthermore, it is estimated that 6% of nitrogen in mineral fertilizer is emitted as NH_3 and 1.5 kg NH_3 - N/ha agricultural soil is produced during decomposition of organic material. 0.7% of nitrogen excretion from livestock and mineral fertilizer is emitted as NO_x (Schmid et al. 2000, p. 66, EMEP/CORINAIR, EEA 2005). Details about the amount of volatized N (NH_3 and NO_x) are provided in the following table.

	N excretion 2007 (t N)	**Losses NH_3 (%)**	**NH3 Emissions 2007 (t N)**	**Losses NO_x (%)**	**NOx Emissions 2007 (t N)**	**total volatized N 2007 (NH_3, NO_x in t N)**
Cattle						
Mature dairy cattle and non-dairy cattle	348.9	32%	111.6	0.7%	2.4	114.1
Young cattle	44.5	22-37%	13.0	0.7%	0.3	13.3
Milk fed calf, suckler cow calf, breeding calf and breeding cattle less than one year	*23.0*	*22%*	*5.1*	*0.7%*	*0.2*	*5.2*
Fattening calf	*0.6*	*37%*	*0.2*	*0.7%*	*0.0*	*0.2*
Fattening cattle	*20.9*	*37%*	*7.7*	*0.7%*	*0.1*	*7.9*
Breeding cattle (>1 year)	42.3	22%	9.3	0.7%	0.3	9.6
Sheep (Sheep places)	**22.1**	**14%**	**3.1**	**0.7%**	**0.2**	**3.2**
Goats (Goats places)	**2.8**	**29%**	**0.8**	**0.7%**	**0.0**	**0.8**
Horses	**12.1**	**32%**	**3.9**	**0.7%**	**0.1**	**4.0**
Foals (< 1 year)	*0.1*	*32%*	*0.0*	*0.7%*	*0.0*	*0.0*
Foals (1-2 years)	*1.0*	*32%*	*0.3*	*0.7%*	*0.0*	*0.3*
Other horses	*11.0*	*32%*	*3.5*	*0.7%*	*0.1*	*3.6*
Ponies, Mules and Asses	**4.2**	**32%**	**1.3**	**0.7%**	**0.0**	**1.4**
Swine	**17.8**	**46%**	**8.2**	**0.7%**	**0.1**	**8.3**
Fattening pig places	*14.1*	*46%*	*6.5*	*0.7%*	*0.1*	*6.6*
Breeding pig places	*3.7*	*46%*	*1.7*	*0.7%*	*0.0*	*1.7*
Poultry	**8.3**	**48-54%**	**4.5**	**0.7%**	**0.1**	**4.5**
Laying hens	*8.1*	*54%*	*4.4*	*0.7%*	*0.1*	*4.4*
Young hens (< 18 weeks)	*0.0*	*54%*	*0.0*	*0.7%*	*0.0*	*0.0*
Broilers	*0.0*	*48%*	*0.0*	*0.7%*	*0.0*	*0.0*
Other poultry (turkeys)	*0.2*	*48%*	*0.1*	*0.7%*	*0.0*	*0.1*
Total animals	**503**		**155.8**	**0.7%**	**3.5**	**159.3**
Mineral fertilizer, compost and sewage sludge (t N)	169.7	6%	10.2	0.7%	1.2	11.4
NH_3 emissions from cropland (ha)	5'476	1.5 kg/ha	8.2			8.2
Total			**174.2**		**4.7**	**178.9**

Table 83 Overview of the volatized N (NH_3 and NO_x) from animal wastes and fertilizer for 2007. The total amount of volatized N appears under the indirect emissions (atmospheric deposition) in the CRF, table 4D.

The estimations of the ammonia emissions is based on a Swiss study, which takes into account the specific farming and manure systems (Menzi et al. 1997, p. 37). Emission factors are lower for cattle, sheep, goats and horses due to the grazing regime. Higher emission factors are estimated under stall feeding conditions.

Emission factors

The following IPCC default emission factors for calculating N_2O emissions from agricultural soils are used.

Emission source	Emission factor
Direct emissions	
Synthetic fertilizer	0.0125 kg N_2O -N/kg N
Animal excreta nitrogen used as fertilizer	0.0125 kg N_2O -N/kg N
Crop residue	0.0125 kg N_2O -N/kg N
N-fixing crops	0.0125 kg N_2O -N/kg N
Organic soils	8 kg N_2O-N/ha/year
Residues pasture, range and paddock	0.0125 kg N_2O -N/kg N
N-fixing pasture, range and paddock	0.0125 kg N_2O -N/kg N
Indirect emissions	
Leaching and run-off	0.025 kg N_2O -N/kg N
Deposition	0.01 kg N_2O -N/kg N
Animal production	
Pasture, range and paddock	0.02 kg N_2O -N/kg N/a
Other (sewage sludge and compost used for fertilizing)	0.0125 kg N_2O –N/kg N

Table 84 Emission factors for calculating N_2O emissions from agricultural soils (IPCC 1997c, tables 4.18 (direct emissions), 4.22 (pasture, range and paddock) and 4.23 (indirect emissions); IPCC 2000: table 4.17 (organic soils)).

Activity data

Activity data for calculation of direct soil emissions has been provided by

- the Office of Agriculture (OA 2008): Use of synthetic fertilizer[18], crops produced, area of pasture range and paddock, area of cultivated organic soils,[19]
- and by FAL/RAC (2001 p. 48/49), Schmid et al. (2000), Walther et al. (1994): Nitrogen excretion.

Relevant activity data for calculating N_2O emissions from soils is displayed in the following table.

[18] As already mentioned in the paragraph about methodological issues of direct soil emissions, data on nitrogen in mineral fertilizer and compost were not available for Liechtenstein. Therefore the amounts of nitrogen were estimated by taking Swiss data from the Swiss Farmers Association and adjusting them to Liechtenstein by a rule of three. The amount of nitrogen in sewage sludge is taken from the Office of Agriculture (OA 2008a).

[19] The area of cultivated organic soils was revised for this submission. It is estimated to be constant for all the years between 1990 and 2006.

Emission type	Related activity data	unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
			Value									
Direct emissions												
Fertilizer	Sum	t N/yr	233	236	236	221	211	204	186	188	166	172
	Mineral fertilizer	t N/yr	202	192	199	180	173	172	164	164	145	156
	Sewage sludge	t N/yr	30	44	37	41	38	31	21	24	21	16
	Compost	t N/yr	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.3	0.3	0.4
Animal manure	Nitrogen input from manure applied to soils	t N/yr	281	283	276	262	261	262	263	263	262	260
N-fixing crops	Peas, dry beans, soybeans and leguminous vegetables produced	t N/yr	146	150	153	156	162	167	161	162	164	165
Crop residue	Dry production of other crops	t N/yr	197	204	205	206	209	213	203	202	200	198
Organic soils	Area of cultivated organic soils	ha	159	159	159	159	159	159	159	159	159	159
N-fixing pasture range and paddock	Area of pasture range and paddock	ha	4'181	4'202	4'224	4'245	4'267	4'288	4'298	4'307	4'317	4'326
	N fixation pasture range and paddock	t N/yr	1.7	1.8	1.8	1.9	1.9	1.9	2.0	2.0	2.0	2.0
Residues pasture range and paddock	Area of pasture range and paddock	ha	4'181	4'202	4'224	4'245	4'267	4'288	4'298	4'307	4'317	4'326
	N from residues pasture range and paddock	t N/yr	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.1
Indirect emissions												
Leaching and run-off	N excretion of all animals	t N/yr	519	519	509	480	477	481	482	480	478	470
	Fertilizer	t N/yr	233	236	236	221	211	204	186	188	166	172
	N from fertilizers and animal wastes that is lost through leaching and run off	t N/yr	150	151	149	140	138	137	134	134	129	129
Deposition	Emissions NH3 from fertilizers, animal wastes and cropland	t N/yr	180	182	177	169	167	167	166	166	164	164
	Emissions NOx from fertilizers and animal wastes	t N/yr	5	5	5	5	5	5	5	5	5	4
	Sum of volatized N (NH3 and NOx) from fertilizers, animal wastes and cropland	t N/yr	185	187	182	174	172	171	170	171	169	169
Pasture, range and paddock manure												
Pasture, range and paddock	N excretion on pasture range and paddock	t N/yr	84	81	83	75	74	76	77	74	73	68

Emission type	Related activity data	unit	2000	2001	2002	2003	2004	2005	2006	2007
			Value							
Direct emissions										
Fertilizer	Sum	t N/yr	173	187	182	175	176	172	170	170
	Mineral fertilizer	*t N/yr*	*162*	*180*	*176*	*169*	*176*	*172*	*169*	*169*
	Sewage sludge	*t N/yr*	*11*	*6*	*5*	*6*	*0*	*0*	*0*	*0*
	Compost	*t N/yr*	*0.4*	*0.4*	*0.5*	*0.5*	*0.4*	*0.5*	*0.4*	*0.5*
Animal manure	Nitrogen input from manure applied to soils	t N/yr	248	257	251	256	255	265	277	282
N-fixing crops	Peas, dry beans, soybeans and leguminous vegetables produced	t N/yr	167	169	171	177	180	181	180	183
Crop residue	Dry production of other crops	t N/yr	197	197	198	202	205	201	201	203
Organic soils	Area of cultivated organic soils	ha	159	159	159	159	159	159	159	159
N-fixing pasture range and paddock	Area of pasture range and paddock	ha	4'336	4'368	4'400	4'543	4'670	4'570	4'181	4'181
	N fixation pasture range and paddock	t N/yr	2.1	2.1	2.1	2.2	2.2	2.2	2.2	2.2
Residues pasture range and paddock	Area of pasture range and paddock	ha	4'336	4'368	4'400	4'543	4'670	4'570	4'546	4'568
	N from residues pasture range and paddock	t N/yr	2.1	2.1	2.1	2.1	2.2	2.1	2.1	2.1
Indirect emissions										
Leaching and run-off	N excretion of all animals	t N/yr	448	459	451	459	457	473	495	503
	Fertilizer	t N/yr	173	187	182	175	176	172	170	170
	N from fertilizers and animal wastes that is lost through leaching and run off	t N/yr	124	129	127	127	127	129	133	135
Deposition	Emissions NH3 from fertilizers, animal wastes and cropland	t N/yr	157	163	159	161	159	165	172	175
	Emissions NOx from fertilizers and animal wastes	t N/yr	4	5	4	4	4	5	5	5
	Sum of volatized N (NH3 and NOx) from fertilizers, animal wastes and cropland	t N/yr	161	167	164	165	163	170	177	180
Pasture, range and paddock manure										
Pasture, range and paddock	N excretion on pasture range and paddock	t N/yr	65	62	64	64	65	65	68	67

Table 85 Activity data for calculating N_2O emissions from agricultural soils. For the sake of completeness, values for mineral fertilizer, sewage sludge and compost are displayed. For calculation of the emissions only the total amount of synthetic fertilizer is used.

6.5.3. Uncertainties and Time-Series Consistency

For the uncertainty analysis the following input data from the Swiss Agroscope Reckenholz-Tänikon Research Station ART was used (ART 2007):

Input data for uncertainty analysis 4D	**Lower bound (2.5 Percentile**	**Upper bound (97.5 Percentile)**	**mean uncertainty**
Activity data 4D1 (fertilizer, kg N)	-12.4%	+10.3%	±11.3%
Activity data 4D1 (organic soils, hectares)	-29.4%	+29.4%	±29.4%
Activity data 4D2 (kg N)	-54.2%	+60.5%	±57.3%
Activity data 4D3 (deposition, kg N)	-34.6%	+48.3%	±41.4%
Activity data 4D3 (leaching and run-off, kg N)	-22.2%	+22.0%	±22.1%
Emission factor 4D1 (fertilizer, kg N_2O-N / kg N)	-80%	+80%	±80%
Emission factor 4D1 (organic soils, kg N_2O-N / kg N)	-75%	+87.5%	±81.3%
Emission factor 4D2 (kg N_2O-N / kg N)	-75%	+50%	±62.5%
Emission factor 4D3 (deposition, kg N_2O-N / kg N)	-80%	+100%	±90%
Emission factor 4D3 (leaching and run-off, kg N_2O-N / kg N)	-92%	+380%	±236%

Table 86 Input data for the uncertainty analysis of the source category 4D “Agricultural Soils”. (ART 2007).

It is assumed that uncertainty estimations from Switzerland are also applicable for Liechtenstein, since Liechtenstein applies the same methods and emission factors. Also for activity data country specific uncertainty estimations are not available. Therefore, Swiss estimations are used as a first guess.

To apply for the Tier 1 uncertainty analysis, the arithmetic mean of lower and upper bound is used for activity data uncertainty and for emission factor uncertainty. For further results see Section 1.7.

Time series between 1990 and 2007 is consistent.

6.5.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out. An internal documentation of the Agroscope Reckenholz-Tänikon Research Station (ART) about the calculation of the greenhouse gas emissions in agriculture assures transparency and traceability of the calculation methods (Berthoud 2004).

6.5.5. Source-Specific Recalculations

A recalculation for 2006 has been carried out because the activity data for 2006 for Switzerland had been updated for synthetic fertilizer. Correspondingly, Liechtenstein’s data 2006 were recalculated..

6.5.6. Source-Specific Planned Improvements

There are no source-specific planned improvements.

6.6. Source Category 4E – Burning of savannas

Burning of savannas does not occur (NO) in Liechtenstein.

6.7. Source Category 4F – Field Burning of Agricultural Residues

Field burning of agricultural residues is not occurring in Liechtenstein.

7. Land Use, Land-Use Change and Forestry

7.1. Overview

This chapter includes information about the estimation of greenhouse gas emissions and removals from land use, land-use change and forestry (LULUCF). The data acquisition and calculations are based on the Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC 2003). They are completed by country specific methodologies from Switzerland, which were almost fully adopted to Liechtenstein.

The land areas from 1990 to 2007 are represented by geographically explicit land-use data with a resolution of one hectare (following a Tier 3 approach; IPCC 2003). Direct and repeated assessment of land use with full spatial coverage also enables to calculate spatially explicit land-use change matrices. Land-use statistics for Liechtenstein are available for the years 1984, 1996 and 2002. They are based on the same methodology as the Swiss land-use statistics. The 2002 data are based on a newly designed set of land-use and land-cover categories of Switzerland (SFSO 2006a). The two earlier land-use statistics were re-evaluated according to the new approach.

In Liechtenstein, country specific emission factors and carbon stock values for forests and partially for agricultural land and grassland were implied. For other land use categories, IPCC default values or expert estimates from Switzerland are used.

The six main land categories required by IPCC (2003) are: A. Forest Land, B. Cropland, C. Grassland, D. Wetlands, E. Settlements and F. Other Land. These categories were further divided in 18 sub-divisions of land use (see Table 89). A further spatial stratification reflects the criteria ‘altitude’ (3 zones) and ‘soil type’ (mineral, organic).

Figure 20 shows the net CO_2 removals of the LULUCF sector. Table 87 and Figure 21 summarize the CO_2 equivalent emissions and removals in consequence of carbon losses and gains for the years 1990-2007. The total net removals/emissions of CO_2 equivalent vary between -4.9 Gg (1997) and -8.5 Gg (1996) from 1990 to 2007. Three components of the CO_2 balance are shown separately:

- Increase of living biomass on forest land: this is the growth of biomass on forest land remaining forest land; it is the largest sink of carbon.
- Decrease of living biomass on forest land: this is the decrease of carbon in living biomass (by harvest and mortality) on forest land remaining forest land; it is the largest source of carbon.
- Land-use change and soil: this is all the rest including carbon removals/emissions due to land-use changes and use of soils, especially of organic soils.

In all the years, growth of biomass exceeds the harvesting and mortality rate. Compared to these biomass changes in forests, the net CO_2 equivalent emissions arising from all land-use changes and from the soils are relatively small (see Figure 21).

LULUCF	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	Gg CO_2									
Increase of living biomass in forest	-68.7	-68.8	-68.9	-69.0	-69.1	-69.2	-69.2	-70.3	-70.3	-70.3
Decrease of living biomass in forest	50.3	50.4	50.5	50.5	50.6	50.6	50.7	51.0	51.0	51.0
Land-use change and soil	10.1	10.1	10.1	10.0	10.0	10.0	10.0	14.4	14.3	14.3
Sector 5 LULUCF	-8.3	-8.4	-8.4	-8.4	-8.5	-8.5	-8.5	-4.9	-4.9	-4.9

LULUCF	2000	2001	2002	2003	2004	2005	2006	2007
	Gg CO_2							
Increase of living biomass in forest	-70.3	-70.3	-70.3	-69.6	-69.6	-69.7	-69.7	-69.8
Decrease of living biomass in forest	51.0	51.0	51.0	50.8	50.9	50.9	51.0	51.0
Land-use change and soil	14.3	14.3	14.3	12.2	12.2	12.2	12.2	12.2
Sector 5 LULUCF	-4.9	-4.9	-4.9	-6.5	-6.5	-6.5	-6.5	-6.6

Table 87 Liechtenstein's CO_2 equivalent emissions/removals [Gg] of the source category 5 LULUCF 1990-2007. Positive values refer to emissions; negative values refer to removals from the atmosphere.

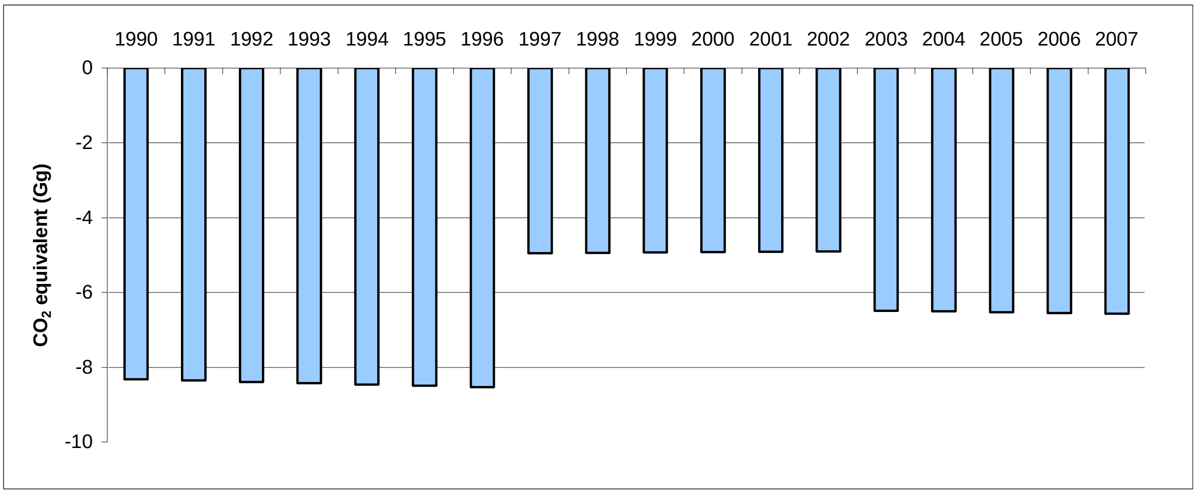

Figure 20 Liechtenstein's CO_2 emissions/removals of source category 5 LULUCF 1990–2007 in Gg CO_2 equivalent. Negative values refer to removals.

Increase and decrease of living biomass in forests are the dominant categories when looking at the CO_2 emissions and removals (refer to Table 87 and Figure 21). Emissions and removals from forest land are quite stable over time. The dominant category when looking at the changes in net CO_2 removals is grassland (refer to Table 88). It can be observed that land-use conversions from and to grassland differ significantly between the three time periods 1990 to 1996, 1997 to 2002 and 2003 to 2007. In the period 1997 to 2002 the conversion from grassland to forest land exceeded the conversion from forest land to grassland, which leads to lower net CO_2 removals from 1997 to 2002.

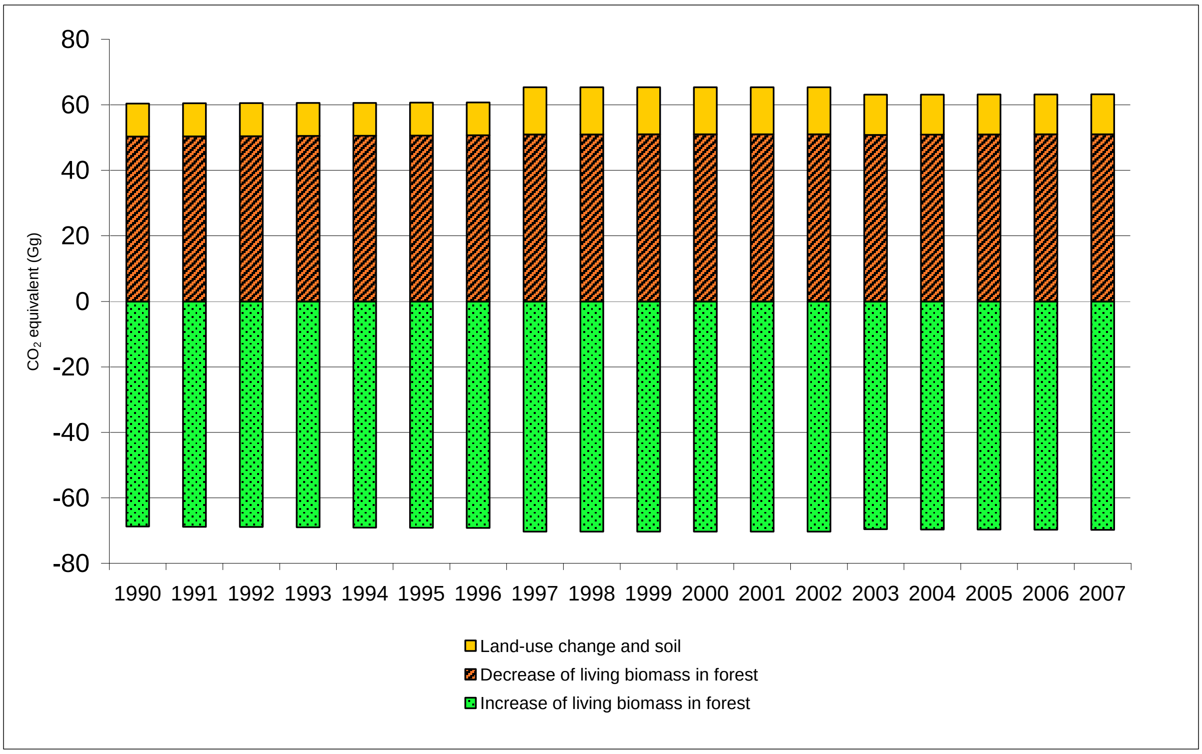

Figure 21 The CO_2 removals due to the increase (growth) of living biomass on forest land, the CO_2 emissions due to the decrease (harvest and mortality) of living biomass on forest land and the net CO_2 equivalent emissions due to land-use changes and from use of soils, 1990–2007.

Net CO2 emissions/removals	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total Land-Use Categories	**-8.32**	**-8.35**	**-8.39**	**-8.43**	**-8.46**	**-8.50**	**-8.53**	**-4.95**	**-4.94**	**-4.93**
A. Forest Land	**-18.74**	**-18.76**	**-18.78**	**-18.79**	**-18.81**	**-18.83**	**-18.85**	**-19.78**	**-19.77**	**-19.75**
1. Forest Land remaining Forest Land	-18.64	-18.65	-18.67	-18.69	-18.71	-18.72	-18.74	-19.71	-19.70	-19.68
2. Land converted to Forest Land	-0.10	-0.10	-0.10	-0.10	-0.10	-0.10	-0.10	-0.07	-0.07	-0.07
B. Cropland	**4.44**	**4.44**	**4.43**	**4.42**	**4.42**	**4.41**	**4.41**	**4.56**	**4.58**	**4.61**
1. Cropland remaining Cropland	4.33	4.32	4.32	4.31	4.31	4.30	4.29	4.32	4.34	4.36
2. Land converted to Cropland	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.24	0.24	0.24
C. Grassland	**2.05**	**2.04**	**2.03**	**2.02**	**2.00**	**1.99**	**1.98**	**4.27**	**4.24**	**4.21**
1. Grassland remaining Grassland	2.13	2.12	2.11	2.09	2.08	2.07	2.06	2.13	2.10	2.07
2. Land converted to Grassland	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	2.14	2.14	2.14
D. Wetlands	**0.11**	**0.11**	**0.11**	**0.11**	**0.11**	**0.11**	**0.11**	**0.46**	**0.46**	**0.46**
1. Wetlands remaining Wetlands	NO	NO	NO	NO	NO	NO	NO	0.00	0.00	0.00
2. Land converted to Wetlands	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.47	0.47	0.47
E. Settlements	**3.35**	**3.35**	**3.35**	**3.35**	**3.35**	**3.35**	**3.35**	**3.89**	**3.89**	**3.89**
1. Settlements remaining Settlements	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.07	0.07	0.07
2. Land converted to Settlements	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.82	3.82	3.82
F. Other Land	**0.47**	**0.47**	**0.47**	**0.47**	**0.47**	**0.47**	**0.47**	**1.66**	**1.66**	**1.66**
1. Other Land remaining Other Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Land converted to Other Land	0.47	0.47	0.47	0.47	0.47	0.47	0.47	1.66	1.66	1.66

Net CO2- emissions/removals	2000	2001	2002	2003	2004	2005	2006	2007
Total Land-Use Categories	**-4.92**	**-4.91**	**-4.90**	**-6.49**	**-6.51**	**-6.53**	**-6.55**	**-6.57**
A. Forest Land	**-19.74**	**-19.72**	**-19.71**	**-19.10**	**-19.11**	**-19.12**	**-19.12**	**-19.13**
1. Forest Land remaining Forest Land	-19.67	-19.65	-19.64	-19.00	-19.01	-19.01	-19.02	-19.03
2. Land converted to Forest Land	-0.07	-0.07	-0.07	-0.10	-0.10	-0.10	-0.10	-0.10
B. Cropland	**4.63**	**4.65**	**4.68**	**4.55**	**4.55**	**4.56**	**4.56**	**4.56**
1. Cropland remaining Cropland	4.39	4.41	4.43	4.44	4.44	4.44	4.45	4.45
2. Land converted to Cropland	0.24	0.24	0.24	0.11	0.11	0.11	0.11	0.11
C. Grassland	**4.18**	**4.15**	**4.12**	**2.74**	**2.72**	**2.70**	**2.68**	**2.67**
1. Grassland remaining Grassland	2.04	2.01	1.98	1.87	1.85	1.83	1.81	1.80
2. Land converted to Grassland	2.14	2.14	2.14	0.87	0.87	0.87	0.87	0.87
D. Wetlands	**0.46**	**0.46**	**0.46**	**0.76**	**0.76**	**0.76**	**0.76**	**0.76**
1. Wetlands remaining Wetlands	0.00	0.00	0.00	NO	NO	NO	NO	NO
2. Land converted to Wetlands	0.47	0.47	0.47	0.76	0.76	0.76	0.76	0.76
E. Settlements	**3.89**	**3.89**	**3.89**	**3.53**	**3.53**	**3.53**	**3.53**	**3.53**
1. Settlements remaining Settlements	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.06
2. Land converted to Settlements	3.82	3.82	3.82	3.47	3.47	3.47	3.47	3.47
F. Other Land	**1.66**	**1.66**	**1.66**	**1.04**	**1.04**	**1.04**	**1.04**	**1.04**
1. Other Land remaining Other Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Land converted to Other Land	1.66	1.66	1.66	1.04	1.04	1.04	1.04	1.04

Table 88 Net CO_2 removals and emissions per land-use category, 1990-2007.

The next chapter (7.2.) gives an overview of the methodical approach including the calculation of the activity data (land-use data) and carbon emissions. The following chapters (7.3-7.8) describe the details of the CO_2 equivalent removal/emission calculations for each main land-use category.

Non CO_2-emissions are very small or even zero (zero in 2007). They arise from soil disturbances associated with land-conversion to cropland (CRF Table 5 III). The calculation method is based on IPCC default procedures (IPCC 2003, chapter 3) and summarized in chapter 7.4.2.

7.2. Methodical Approach and Activity Data

7.2.1. General Approach for Calculating Carbon Emissions/Removals

The selected procedure for calculating carbon emissions and removals in the LULUCF sector is done as for Switzerland. It corresponds to a Tier 2 approach as described in IPCC (2003; chapter 3) and can be summarised as follows:

- Land use categories and sub-divisions with respect to available land-use data (see Table 89) were defined. For these carbon emissions and removals estimations so-called combination categories (CC) were defined on the basis of the land-use and land-cover categories of the Swiss land-use statistics (FOEN 2006; SFSO 2006a).

- Criteria for the spatial stratification of the land-use categories (altitude and soil type) were taken from Switzerland. Based on these criteria data for the spatial stratification of the land-use categories were collected in Liechtenstein.
- For carbon stocks and carbon stock changes for each spatial stratum of the land-use categories Swiss data based on measurements and estimations were taken.
- The land use and the land-use change matrix were calculated in each spatial stratum.
- Carbon stock changes in living biomass ($deltaC_l$), in dead organic matter ($deltaC_d$) and in soil ($deltaC_s$) were calculated for all cells of the land-use change matrix.
- Finally, the results were aggregated by summarising the carbon stock changes over land-use categories and strata according to the level of disaggregation displayed in the CRF tables.

The procedure of calculating emissions and removals in LULUCF and the different institutions involved are displayed in Figure 22.

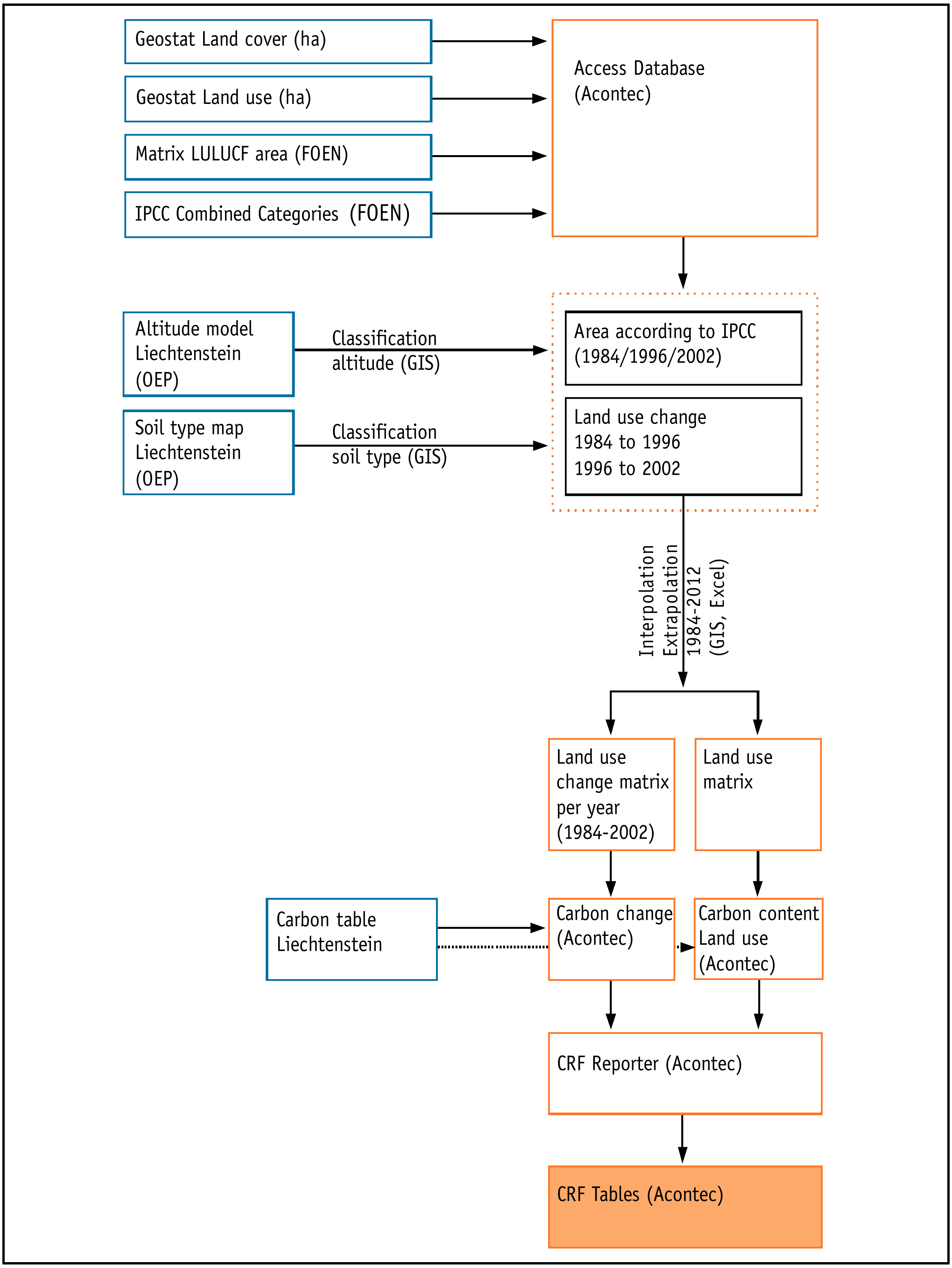

Figure 22 Procedure of calculating emissions and removals from LULUCF in Liechtenstein.

The following paragraph gives some further explanations about the Swiss calculation of carbon stock changes.

Swiss methodology (excerpt from NIR CH, chp. 7.2.1, FOEN 2007):

For calculating carbon stock changes, the following input parameters (mean values per hectare) must be quantified for all land-use categories (CC) and spatial strata (i):

$stockC_{l,i,CC}$:	*carbon stock in living biomass*
$stockC_{d,i,CC}$:	*carbon stock in dead organic matter*
$stockC_{s,i,CC}$:	*carbon stock in soil*
$increaseC_{l,i,CC}$:	*annual increase (growth) of carbon in living biomass*
$decreaseC_{l,i,CC}$:	*annual decrease (harvesting) of carbon in living biomass*
$changeC_{d,i,CC}$:	*annual net carbon stock change in dead organic matter*
$changeC_{s,i,CC}$:	*annual net carbon stock change in soil*

CC Main category	***CC Sub-division***	***Remarks***	**Managed or unmanaged**	***CC code***
A. Forest Land	*Afforestations*	*areas converted to forest by active measures, e.g. planting*[20]	managed	*11*
	Managed Forest	*dense and open forest meeting the criteria of forest land*	managed	*12*
	Unproductive Forest	*brush forest and inaccessible forest meeting the criteria of forest land*	managed	*13*
B. Cropland		*arable and tillage land (annual crops and leys in arable rotations)*	managed	*21*
C. Grassland	*Permanent Grassland*	*meadows, pastures (low-land and alpine)*	managed	*31*
	Shrub Vegetation	*agricultural and unproductive areas predominantly covered by shrubs*	managed	*32*
	Vineyards, Low-Stem Orchards, Tree Nurseries	*perennial agricultural plants with woody biomass (no trees)*	managed	*33*
	Copse	*agricultural and unproductive areas covered by perennial woody biomass including trees*	managed	*34*
	Orchards	*permanent grassland with fruit trees*	managed	*35*
	Stony Grassland	*grass, herbs and shrubs on stony surfaces*	unmanaged	*36*
	Unproductive Grassland	*unmanaged grass vegetation*	unmanaged	*37*
D. Wetlands	*Surface Waters*	*lakes and rivers*	unmanaged	*41*
	Unproductive Wetland	*reed, unmanaged wetland*	unmanaged	*42*
E. Settlements	*Buildings and Constructions*	*areas without vegetation such as houses, roads, construction sites, dumps*	managed	*51*
	Herbaceous Biomass in Settlements	*areas with low vegetation, e.g. lawns*	managed	*52*
	Shrubs in Settlements	*areas with perennial woody biomass (no trees)*	managed	*53*
	Trees in Settlements	*areas with perennial woody biomass including trees*	managed	*54*
F. Other Land		*areas without soil and vegetation: rocks, sand, screes, glaciers*	unmanaged	*61*

Table 89 Land-use categories used in this report (so-called combination categories CC): 6 main land-use categories and the 18 sub-divisions. Additionally, descriptive remarks, abbreviations used in the CRF tables, and CC codes are given. For a detailed definition of the CC categories see FOEN (2006) and SFSO (2006a). The column “Managed or unmanaged” was not included in the Swiss Inventory Report (FOEN 2007), but added for this submission for better clarification.

On this basis, the carbon stock changes in living biomass (deltaC$_l$), in dead organic matter (deltaC$_d$) and in soil (deltaC$_s$) are calculated for all cells of the land-use change matrix. Each cell is characterized by a land-use category before the conversion (b), a land-use category after the conversion (a) and the area of converted land within the spatial stratum (i). Equations 7.2.1.-7.2.3 show the general approach of calculating C-removals/emissions taking into account the net carbon stock changes in living biomass, dead organic matter and soils as well as the stock changes due to conversion of land use (difference of the stocks before and after the conversion):

$$deltaC_{l,i,ba} = [\ increaseC_{l,i,a} - decreaseC_{l,i,a} + W_l * (stockC_{l,i,a} - stockC_{l,i,b})\ ] * A_{i,ba} \qquad (7.2.1)$$

$$deltaC_{d,i,ba} = [\ changeC_{d,i,a} + W_d * (stockC_{d,i,a} - stockC_{d,i,b}\ )\ ] * A_{i,ba} \qquad (7.2.2)$$

$$deltaC_{s,i,ba} = [\ changeC_{s,i,a} + W_s * (stockC_{s,i,a} - stockC_{s,i,b}\ )\ ] * A_{i,ba} \qquad (7.2.3)$$

[20] Reforestation does not occur in Liechtenstein. For more than 100 years, the area of forest has not decreased anymore. Any reforestation would have required a deforestation within the last 50 years, but deforestation is prohibited by law (OEP 2007b).

where:

a: land-use category after conversion (CC = a)
b: land-use category before conversion (CC = b)
ba: land use conversion from b to a
$A_{i,ba}$: area of land converted from b to a in the spatial stratum i (activity data from the land-use change matrix)
W_l, W_d, W_s: weighting factors for living biomass, dead organic matter and soil, respectively.

The following values for W were chosen:

$W_l = W_d = W_s = 0$	*if land use after the conversion is 'Forest Land' (a = {11,12,13})*
$W_s = 0.5$	*if a or b is 'Buildings and Constructions' (a = 51 or b = 51)*
$W_l = W_d = W_s = 1$	*otherwise.*

The difference of the stocks before and after the conversion are weighted with a factor (W_l, W_d, W_s) accounting for the effectiveness of the land-use change in some special cases. For example, the succession from grassland to forest land is quite frequent in mountainous regions [in Switzerland]. Immediately after the conversion young forests have lower carbon stocks than the mean carbon stock values determined for 'managed forest'. Therefore, the weighting factors for the conversion 'to forest land' was set to zero in order to avoid an overestimation of C-sinks. In the case of land-use changes involving 'buildings and constructions' it is assumed that only 50% of the soil carbon is emitted as the humus layer is re-used on construction sites.

For all land-use categories applies: If a equals b, there is no change in land use and the difference in carbon stocks becomes zero.

For calculating annual carbon stock changes in soils due to land-use conversion, IPCC (2003) suggested a default delay time (inventory period) of 20 years. In this study, the inventory period of land-use changes is predetermined by the inter-survey period of the Swiss land-use statistics and averages approximately 12 years.

In the CRF tables 5.A to 5.F, land-use categories (CC) and associated spatial strata are partially shown at an aggregated level for optimal documentation and overview. The values of deltaC are accordingly summarised. Positive values of $deltaC_{l,i,ba}$ are inserted in the column "Increase" and negative values in column "Decrease", respectively (besides $increaseC_{l,i,CC}$ and $decreaseC_{l,i,CC}$ if land-use does not change).

7.2.2. General Approach for Compiling Land-use Data

a) Land-Use Statistics (AREA)

Land-use data from Liechtenstein are collected according to the same method as in Switzerland. Every hectare of the territory was assigned to one of 46 land-use categories and to one of 27 land-cover categories by means of stereographic interpretation of aerial photos (SLP 2006).

For the reconstruction of the land use conditions in Liechtenstein for the period 1990-2007 three data sets are used:

- Land-Use Statistics 1984
- Land-Use Statistics 1996
- Land-Use Statistics 2002

Land-use statistics from the years 1984 and 1996 were originally evaluated according to a set of different land-use categories. For this purposes they were being re-evaluated according to the newly designed land-use and land-cover categories (SFSO 2006a). For the interpretation of the 2002 data the new land-use and land-cover categories were used directly. Therefore, the whole territory of Liechtenstein can be interpreted coherently for the whole time series.

b) Combination Categories (CC) as derived from Land-Use Statistics

The 46 land-use categories and 27 land-cover categories of the land-use statistics were aggregated to 18 combination categories (CC, FOEN 2006) implementing the main categories proposed by IPCC as well as by Swiss country specific sub-divisions (see Table 89). The sub-divisions were defined with respect to optimal distinction of biomass densities, carbon turnover, and soil carbon contents.

The first digit of the CC-code represents the main category, whereas the second digit stands for the respective sub-division.

Table 90 Relation between the different land-use and land-cover categories and the combination categories (CC). FOEN 2006 (revised)

Land Use according to AREA

18 Kyoto Combination Categories

Settlements:

Land Cover according to AREA	Gebäudeareal								Verkehrsflächen					Besondere Siedlungsflächen							Erholungs- und Grünanlagen					
	101 Industrie- und Gewerbeareal > 1 ha	102 Industrie- und Gewerbeareal < 1 ha	103 Ein- und Zweifamilienhausareal	104 Reihen- und Terrassenhausareal	105 Mehrfamilienhausareal	106 Öffentliches Gebäudeareal	107 Landwirtschaftliches Gebäudeareal	108 Nicht spezifiziertes Gebäudeareal	121 Autobahnareal	122 Strassenareal	123 Parkplatzareal	124 Bahnareal	125 Flugplatzareal	141 Energieversorgungsanlagen	142 Abwasserreinigungsanlagen	143 Übrige Ver- und Entsorgungsanlagen	144 Deponien	145 Abbau	146 Baustellen	147 Bau- und Siedlungsbrachen	161 Öffentliche Parkanlagen	162 Sportanlagen	163 Golfplätze	164 Campingplätze	165 Schrebergärten	166 Friedhöfe
10 Artificial surfaces																										
11 Befestigte Flächen	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51
12 Gebäude	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51
13 Treibhäuser	52	52	52	52	52	52	52	52			52	52	52						52	52	52	52	52	52	52	52
14 Beetstrukturen	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52			52	52	52	52	52	52	52	52
15 Rasen	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52			52	52	52	52	52	52	52	52
16 Bäume auf künstlich angelegten Flächen	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54			54	54	54	54	54	54	54	54
17 Gemischte Kleinstrukturen	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52			52	52	52	52	52	52	52	52
20 Herbaceous vegetation																										
21 Gras-, Krautvegetation	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52
30 Shrub vegetation																										
31 Gebüsch	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53
32 Verbuschte Flächen	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53
33 Niederstammobst	53	53	53	53	53	53	53	53	53	53	53	53								53	53				53	53
34 Reben	53	53	53	53	53	53	53	53	53	53	53	53								53	53				53	53
35 Gärtnerische Dauerkulturen	52	52	52	52	52	52	52	52	52	52	52	52								52	52				52	52
40 Trees																										
41 Geschlossene Baumbestände	54	54	54	54	54	54	54	54	54		54									54	54	54		54	54	54
42 Waldecken	54	54	54	54	54	54	54	54	54		54			54	54	54				54	54	54	54	54	54	54
43 Waldstreifen	54	54	54	54	54	54	54	54	54		54			54	54	54				54	54	54		54	54	54
44 Aufgelöste Baumbestände	54	54	54	54	54	54	54	54	54		54			54	54	54				54	54	54		54	54	54
45 Gebüschwaldbestände																					53			53		
46 Lineare Baumbestände	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54
47 Baumgruppen	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54
50 Surfaces without vegetation																										
51 Anstehender Fels	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51
52 Lockergestein	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51
53 Versteinte Flächen	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52
60 Water and wetlands																										
61 Wasser	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41
62 Gletscher, Firn																										
63 Nassstandorte	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42
64 Schilfbestände	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42

Agricultural land / Forest land / Unproductive:

Land Cover according to AREA	Obstbau, Rebbau, Gartenbau			Acker- und Futterbau			Alp-wirtschaft			Wald (ohne landwirtschaftliche Nutzung)				Seen und Flüsse			Unproduktives Land			
	201 Obstbau	202 Rebbau	203 Gartenbau	221 Ackerland i.w.S.	222 Naturwiesen i.w.S.	223 Heimweiden i.w.S.	241 Alpwiesen i.w.S.	242 Alp- und Juraweiden i.w.S.	243 Schafalpen i.w.S.	301 Waldbestände	302 Aufforstungen	303 Holzschläge	304 Waldschadenflächen	401 Seen	402 Flüsse, Bäche	403 Hochwasserverbauungen	421 Keine Nutzung	422 Lawinen- und Steinschlagverbauungen	423 Alpine Sportinfrastruktur	424 Landschaftseingriffe
10 Artificial surfaces																				
11 Befestigte Flächen		51	51											51	51	51		51	51	51
12 Gebäude																				
13 Treibhäuser			21																	
14 Beetstrukturen		21	21	21	21		21			12										
15 Rasen		31	31																	
16 Bäume auf künstlich angelegten Flächen																				
17 Gemischte Kleinstrukturen		21	21																	
20 Herbaceous vegetation																				
21 Gras-, Krautvegetation	31	31	31	21	31	31	31	31	31		11	12	12	37	37	37	37	37	37	31
30 Shrub vegetation																				
31 Gebüsch		32	32								11	12	12	32	32	32	32	32	32	32
32 Verbuschte Flächen		32	32		32	32	32	32			11	12	12	32	32	32	32	32	32	32
33 Niederstammobst	33		33																	
34 Reben		33	33																	
35 Gärtnerische Dauerkulturen			33							12										
40 Trees																				
41 Geschlossene Baumbestände	35									12	11					12		12		
42 Waldecken	35									12	11	12	12			12		12		
43 Waldstreifen	35									12	11					12		12		
44 Aufgelöste Baumbestände	35				12	12	12	12	13	12	11	12	12			12		12	12	12
45 Gebüschwaldbestände										13						13		13		
46 Lineare Baumbestände	34	34	34	34	34	34	34	34	34		11	12	12	34	34	34	34	34	34	34
47 Baumgruppen	34	34	34	34	34	34	34	13	34		11	12	12	34	34	34	34	34	34	34
50 Surfaces without vegetation																				
51 Anstehender Fels												13	13	61	61	61	61	61	61	61
52 Lockergestein		61	61									12	12	61	61	61	61	61	61	61
53 Versteinte Flächen		36	36			36	36	36			11	13	13	36	36	36	36	36	36	36
60 Water and wetlands																				
61 Wasser														41	41	41				41
62 Gletscher, Firn																	61			
63 Nassstandorte					42	42	42	42	42			12	13	42	42	42	42	42	42	42
64 Schilfbestände				21	42	42	42	42	42					42	42	42	42			

Kyoto Combination Categories

- 11 Afforestations
- 12 Managed forest
- 13 Unproductive forest
- 21 Cropland
- 31 Permanent grassland
- 32 Shrub vegetation
- 33 Vineyards, Low-stem Orchads, Tree nurseries
- 34 Copse
- 35 Orchards
- 36 Stony grassland
- 37 Unproductive grassland
- 41 Surface waters
- 42 Unproductive wetland
- 51 Buildings and construction
- 52 Herbaceous biomass in settlements
- 53 Shrubs in settlements
- 54 Trees in settlements
- 61 Other land

c) Interpolation and extrapolation of the status for each year

The exact dates of aerial photo shootings are known for each hectare (in Liechtenstein data available for the years 1984, 1996 and 2002). However, the exact year of the land-use change on a specific hectare is unknown. The actual change can have taken place in any year between the two land-use surveys. It is assumed that the probability of a land-use change from 1984 and 1996 and from 1996 to the 2002 survey is uniformly distributed over the respective interim period between two surveys. Therefore, the land-use change of each hectare has to be equally distributed over its specific interim period (e.g. when a specific area increased by three hectares between 1996 and 2002, it was assumed that the annual increase was 0.5 hectares).

Thus, the land-use status for the years between two data collection dates can be calculated by linear interpolation. Dates of aerial photo and the land-use categories of 1984 and 1996 for every hectare are used for these calculations. The status after 2002 was estimated by linear extrapolation, assuming that the average trend observed between 1984 and 2002 would go on.

Example (Figure 23): A certain area has been assigned to the land-use category “Cropland” (CC 21) in 1984. A partial land-use change to “Shrubs in Settlements” (CC 53) has been discovered in 1996. And another partial change to “Buildings and construction” (CC 51) was discovered in 2002.

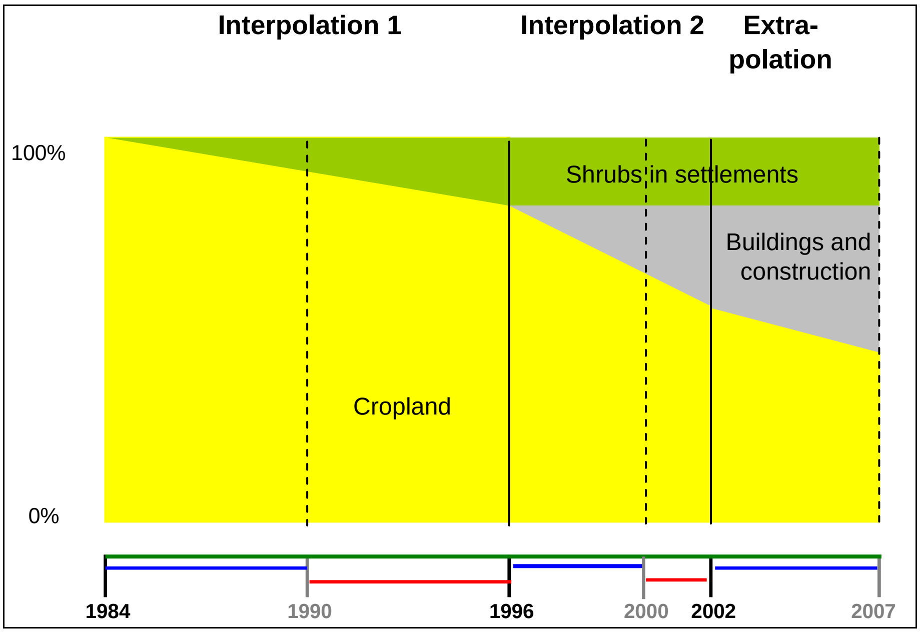

Figure 23 Hypothetical linear development of land-use changes between AREA1 and AREA2 and 2002 data considering as example a hectare changing from “cropland” to “shrubs in settlements” and then from "shrubs in settlements" to “buildings and constructions".

The ‘status 1990’ is determined by calculating the fractions of the two land-use categories for the year 1990. A linear development from “cropland” to “shrubs in settlements” during the whole interim period is assumed. The same procedure can be applied for two survey dates between 1996 and 2002 (see Figure 23: example ‘status 2000’). Extrapolation to 2007 is done by taking the average trend of the whole time period 1984 to 2002. The ‘status’ for each individual year in the period 1990-2007 for the whole territory of Liechtenstein results from the summation of the fractions of all hectares per combination category CC (considering the spatial strata where appropriate; see Table 92).

7.2.3. Spatial Stratification

In order to quantify carbon stocks and increases/decreases, a further spatial stratification of the territory turned out to be useful. For forests and grassland three different altitudinal belts were differentiated. The whole territory of Liechtenstein is considered to be part of the pre-alpine region (Thürig et al. 2004).

Altitude data were available on a hectare-grid from the Office of Environmental Protection (OEP 2006d) and classified in belts ≤ 600 m a.s.l. (metres above sea level), 601-1200 m a.s.l., and >1200 m a.s.l. (Figure 24).

For cropland and grassland, two soil types (organic and mineral soils) were additionally differentiated.

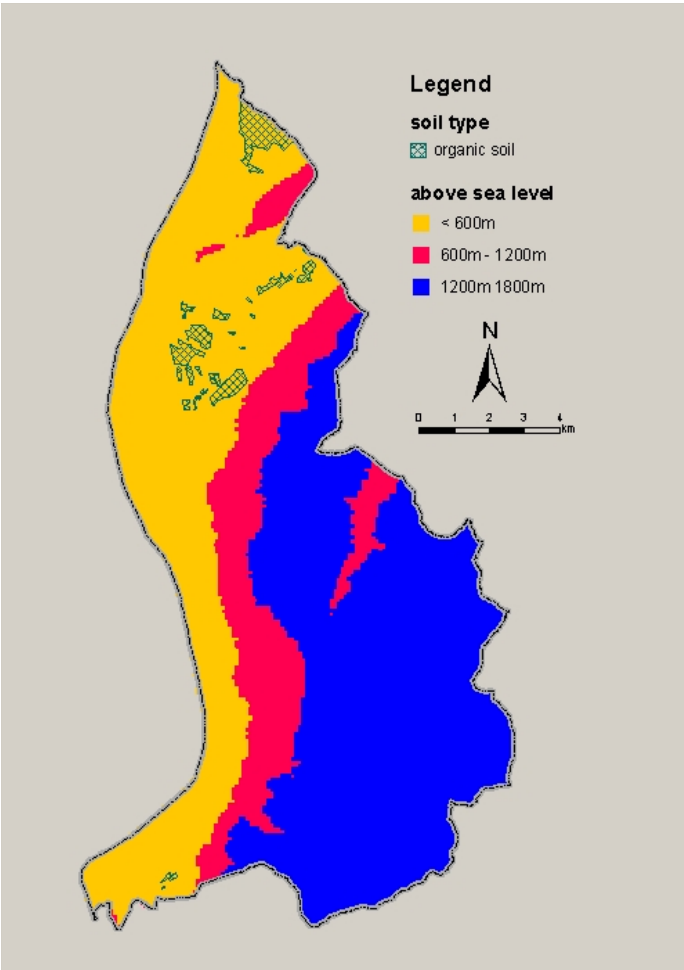

Figure 24 Map of Liechtenstein showing the altitude classes and soil types. Reference: OEP 2006d.

7.2.4. The Land-use Tables and Change Matrices (activity data)

Table 91 shows the overall trends of land-use changes between 1990 and 2007 for the source and sink categories according to the CRF.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Forest land	6036	6050	6063	6076	6089	6102	6113	6111	6109	6107	6104	6102	6100
Cropland	1953	1948	1943	1938	1933	1928	1923	1919	1915	1912	1908	1904	1900
Grassland	5312	5287	5262	5237	5212	5187	5162	5146	5130	5114	5097	5081	5063
Wetlands	376	376	376	376	376	376	376	376	377	377	377	378	378
Settlements	1366	1384	1401	1418	1435	1453	1470	1489	1508	1527	1547	1566	1585
Other Land	1008	1008	1007	1007	1007	1006	1006	1009	1012	1015	1018	1021	1024
Sum	16050	16050	16050	16050	16050	16050	16050	16050	16050	16050	16050	16050	16050

	2003	2004	2005	2006	2007	Change 1990-2007 (ha)	Change 1990-2007 (%)
Forest land	6108	6116	6124	6132	6139	103.0	1.7%
Cropland	1895	1891	1886	1882	1877	-75.3	-3.9%
Grassland	5041	5019	4997	4975	4953	-358.8	-6.8%
Wetlands	378	378	378	378	379	2.6	0.7%
Settlements	1603	1621	1639	1657	1674	308.0	22.5%
Other Land	1025	1026	1026	1027	1028	19.9	2.0%
Sum	16050	16050	16050	16050	16050	0	0%

Table 91 Statistics of land use for the whole period 1990-2007 (in ha) and change (absolute and relative) between 1990 and 2007. The table displays the data for the land-use categories remaining the same land-use category (excluding land converted to a specific category).

The most significant land-use changes in absolute terms since 1990 can be observed in the categories grassland (decrease by almost 7%) and settlements (increase by more than 22%).

Table 92 shows the same trends at the level of the more disaggregated land-use categories. The data is resulting from interpolation and extrapolation in time and from spatial stratification (altitude classes and soil types). For example, the area of afforestations (combination category 11) decreases in all altitude classes between 45 and 97% from 1990 to 2007, while the area of managed forests (combination category 12) increases by 3.7% since 1990 in an altitude over 1200 m.

CC	altitude	soil type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
11	≤ 600	n.s.	8.5	9.1	9.7	10.2	10.8	11.4	12.0	10.7	9.3	8.0	6.7	5.3	4.0
	601-1200	n.s.	7.0	6.0	5.0	4.0	3.0	2.0	1.0	1.3	1.7	2.0	2.3	2.7	3.0
	> 1200	n.s.	29.0	29.5	30.0	30.5	31.0	31.5	32.0	29.7	27.3	25.0	22.7	20.3	18.0
12	≤ 600	n.s.	993.5	993.9	994.3	994.7	995.2	995.6	996.0	996.0	996.0	996.0	996.0	996.0	996.0
	601-1200	n.s.	1954.5	1955.4	1956.3	1957.3	1958.2	1959.1	1960.0	1959.7	1959.3	1959.0	1958.7	1958.3	1958.0
	> 1200	n.s.	2158.0	2164.7	2171.3	2178.0	2184.7	2191.3	2197.0	2199.5	2202.0	2204.5	2207.0	2209.5	2212.0
13	≤ 600	n.s.	0.5	0.6	0.7	0.7	0.8	0.9	1.0	0.8	0.7	0.5	0.3	0.2	0.0
	601-1200	n.s.	9.0	9.2	9.3	9.5	9.7	9.8	9.0	8.5	8.0	7.5	7.0	6.5	6.0
	> 1200	n.s.	876.5	881.3	886.0	890.8	895.5	900.3	905.0	904.7	904.3	904.0	903.7	903.3	903.0
21	n.s.	mineral	1828.5	1823.8	1819.0	1814.3	1809.5	1804.8	1800.0	1795.5	1791.0	1786.5	1782.0	1777.5	1773.0
	n.s.	organic	124.0	123.8	123.7	123.5	123.3	123.2	123.0	123.7	124.3	125.0	125.7	126.3	127.0
31	≤ 600	mineral	1132.0	1124.5	1117.0	1109.5	1102.0	1094.5	1087.0	1082.3	1077.7	1073.0	1068.3	1063.7	1059.0
	≤ 600	organic	63.0	62.7	62.3	62.0	61.7	61.3	61.0	60.2	59.3	58.5	57.7	56.8	56.0
	601-1200	mineral	364.5	362.6	360.7	358.8	356.9	354.9	353.0	352.2	351.3	350.5	349.7	348.8	348.0
	601-1200	organic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	> 1200	mineral	1666.5	1663.1	1659.7	1656.3	1652.8	1649.4	1646.0	1647.0	1648.0	1649.0	1650.0	1651.0	1650.0
	> 1200	organic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	≤ 600	n.s.	20.0	20.2	20.3	20.5	20.7	20.8	21.0	20.7	20.3	20.0	19.7	19.3	19.0
	601-1200	n.s.	9.5	9.3	9.0	8.8	8.5	8.3	8.0	7.7	7.3	7.0	6.7	6.3	6.0
	> 1200	n.s.	563.0	556.0	549.0	542.0	535.0	528.0	521.0	518.7	516.3	514.0	511.7	509.3	507.0
33	n.s.	mineral	30.5	30.7	31.0	31.2	31.5	31.7	32.0	32.0	32.0	32.0	32.0	32.0	32.0
	n.s.	organic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	≤ 600	n.s.	382.5	380.9	379.3	377.7	376.2	374.6	373.0	366.3	359.7	353.0	346.3	339.7	333.0
	601-1200	n.s.	79.5	79.1	78.7	78.3	77.8	77.4	77.0	75.8	74.7	73.5	72.3	71.2	70.0
	> 1200	n.s.	255.0	255.2	255.3	255.5	255.7	255.8	256.0	255.5	255.0	254.5	254.0	253.5	253.0
35	n.s.	mineral	0.5	0.4	0.3	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	n.s.	organic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	n.s.	n.s.	346.5	345.4	344.3	343.3	342.2	341.1	340.0	341.8	343.7	345.5	347.3	349.2	351.0
37	n.s.	n.s.	398.5	396.6	394.7	392.8	390.9	388.9	387.0	385.7	384.3	383.0	381.7	380.3	379.0
41	n.s.	n.s.	216.0	215.8	215.7	215.5	215.3	215.2	215.0	214.7	214.3	214.0	213.7	213.3	213.0
42	n.s.	n.s.	160.0	160.2	160.3	160.5	160.7	160.8	161.0	161.7	162.3	163.0	163.7	164.3	165.0
51	n.s.	n.s.	903.5	916.6	929.7	942.7	955.8	968.9	982.0	999.0	1016.0	1033.0	1050.0	1067.0	1084.0
52	n.s.	n.s.	304.5	306.4	308.3	310.2	312.2	314.1	316.0	320.3	324.7	329.0	333.3	337.6	342.0
53	n.s.	n.s.	15.0	14.3	13.7	13.0	12.3	11.7	11.0	11.5	12.0	12.5	13.0	13.5	14.0
54	n.s.	n.s.	143.5	146.4	149.3	152.2	155.2	158.1	161.0	158.3	155.7	153.0	150.3	147.7	145.0
61	n.s.	n.s.	1008.0	1007.7	1007.3	1007.0	1006.7	1006.3	1006.0	1009.0	1012.0	1015.0	1018.0	1021.0	1024.0
Sum			16050	16050	16050	16050	16050	16050	16050	16050	16050	16050	16050	16050	16050

(continued next page)

CC-code	altitude	soil type	2003	2004	2005	2006	2007	Change 1990-2007 (ha)	Change 1990-2007 (%)
11	≤ 600	n.s.	3.9	3.9	3.8	3.8	3.7	-4.8	-56.1%
	601-1200	n.s.	2.4	1.9	1.3	0.8	0.2	-6.8	-96.8%
	> 1200	n.s.	17.6	17.1	16.7	16.2	15.8	-13.2	-45.6%
12	≤ 600	n.s.	996.3	996.6	996.8	997.1	997.4	3.9	0.4%
	601-1200	n.s.	1958.5	1959.0	1959.5	1960.0	1960.5	6.0	0.3%
	> 1200	n.s.	2217.2	2222.4	2227.7	2232.9	2238.1	80.1	3.7%
13	≤ 600	n.s.	0.0	0.0	0.0	0.0	0.0	-0.5	
	601-1200	n.s.	5.9	5.8	5.7	5.6	5.4	-3.6	-39.5%
	> 1200	n.s.	906.1	909.1	912.2	915.2	918.3	41.8	4.8%
21	n.s.	mineral	1768.3	1763.7	1759.0	1754.3	1749.7	-78.8	-4.3%
	n.s.	organic	127.1	127.2	127.3	127.4	127.6	3.6	2.9%
31	≤ 600	mineral	1052.4	1045.9	1039.3	1032.8	1026.2	-105.8	-9.3%
	≤ 600	organic	55.5	55.0	54.5	54.0	53.5	-9.5	-14.3%
	601-1200	mineral	346.4	344.9	343.3	341.8	340.2	-24.3	-6.2%
	601-1200	organic	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
	> 1200	mineral	1647.9	1645.9	1643.8	1641.8	1639.7	-26.8	-1.5%
	> 1200	organic	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
32	≤ 600	n.s.	19.0	19.0	19.0	19.0	19.0	-1.0	-5.0%
	601-1200	n.s.	5.7	5.4	5.2	4.9	4.6	-4.9	-51.4%
	> 1200	n.s.	501.6	496.1	490.7	485.2	479.8	-83.2	-14.8%
33	n.s.	mineral	32.2	32.3	32.5	32.7	32.8	2.3	7.7%
	n.s.	organic	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
34	≤ 600	n.s.	329.7	326.4	323.2	319.9	316.6	-65.9	-17.2%
	601-1200	n.s.	69.3	68.7	68.0	67.3	66.7	-12.8	-16.1%
	> 1200	n.s.	252.9	252.9	252.8	252.8	252.7	-2.3	-0.9%
35	n.s.	mineral	0.0	0.0	0.0	0.0	0.0	-0.5	
	n.s.	organic	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
36	n.s.	n.s.	350.9	350.8	350.7	350.6	350.4	3.9	1.1%
37	n.s.	n.s.	377.3	375.6	373.8	372.1	370.4	-28.1	-7.1%
41	n.s.	n.s.	212.8	212.6	212.3	212.1	211.9	-4.1	-1.9%
42	n.s.	n.s.	165.3	165.7	166.0	166.3	166.7	6.7	4.2%
51	n.s.	n.s.	1098.4	1112.8	1127.2	1141.6	1155.9	252.4	27.9%
52	n.s.	n.s.	344.7	347.4	350.2	352.9	355.6	51.1	16.8%
53	n.s.	n.s.	13.7	13.4	13.2	12.9	12.6	-2.4	-15.9%
54	n.s.	n.s.	146.1	147.1	148.2	149.2	150.3	6.8	4.7%
61	n.s.	n.s.	1024.8	1025.6	1026.3	1027.1	1027.9	19.9	2.0%
Sum			16050	16050	16050	16050	16050	0.0	0.0%

Table 92 Statistics of land use (CC = combination categories) for the whole period 1990-2007 (in ha) and change (absolute and relative) between 1990 and 2007. The table displays the data for the land-use categories remaining the same land-use category (excluding land converted to a specific category).

The mean annual rates of change in the whole country (change-matrix) are achieved by adding up the mean annual change rates of all hectares per combination category (CC). Table 93 shows an overview of the mean annual changes of all CC in 1990 as an example. The totals of the columns are equal to the total increase of one specific category. The totals of the rows are equal to the total decrease of one specific category. The absolute values of increases and decreases are identical.

For calculating the carbon stock changes, fully stratified land-use change matrices are used for each year. In principle, those matrices consists of various matrices like the one shown in Table 93, one for each spatial stratum (see section 7.2.3.).

Combination category code		To																		
		11	12	13	21	31	32	33	34	35	36	37	41	42	51	52	53	54	61	Decrease
From	11		3.1																	3.1
	12			0.7		0.1	0.2		0.2		0.2	0.1	0.2	0.1	1.3	0.2	0.3	0.3	0.2	4.1
	13	0.5	1.4			0.4	0.1												0.2	2.6
	21					3.2		0.2	0.5						3.3	0.9	0.1	0.2		8.2
	31	0.9	0.2	1.8	3.1		1.9	0.4	3.7		0.1			0.4	5.7	3.6		0.3	0.4	22.5
	32	0.2	4.1	4.7		1.5			1.3			0.1				0.1				11.9
	33				0.2	0.3									0.1					0.5
	34	0.2	2.2	0.1	0.1	2.8	0.2				0.1				1.6	0.8		0.3		8.5
	35								0.1											0.1
	36	0.3	0.1	0.1		0.3	0.5	0.1	0.1			0.3							0.3	2.1
	37	0.2	0.2	0.2			1.2		0.6		0.1				0.1					2.4
	41						0.1								0.1				0.5	0.7
	42	0.2	0.3																	0.5
	51	0.6				0.4	0.2		0.2					0.1		0.8	0.1			2.2
	52					0.1									2.5		0.2	2.5		5.2
	53	0.1	0.2						0.1						0.3	0.1		0.5	0.1	1.3
	54														0.4	0.8				1.2
	61		0.2			0.2	0.5	0.1			0.6	0.1	0.3	0.1						2.1
	Increase	3.2	12.0	7.5	3.3	9.3	4.8	0.7	6.7	0.0	1.0	0.5	0.5	0.7	15.3	7.2	0.7	4.1	1.7	79.2

Table 93 Mean annual rates of land-use change in 1990 (change matrix). Units: ha/year.

So far, also land-use changes between two combination categories of unmanaged land (e.g. stony and unproductive grassland) were taken into account. Land-use changes between two categories of unmanaged land are not human induced and should therefore not be considered. Due to IPCC Good Practice Guidance LULUCF (2003): *"Carbon stock changes and greenhouse gas emissions on unmanaged land are not reported under the IPCC Guidelines, although reporting is required when unmanaged land is subject to land use conversion"* (chapter 2 Basis for consistent representation of land areas[21]). During the In-country review of Liechtenstein's Initial Report and the National Inventory Report (11-15 June 2007), the review team brought up the issue as a potential problem. In its response, the party presented a quantification for the effect of omitting changes between unmanaged areas:

If the emissions and removals of these land-use changes are estimated, one finds that 1.70 Gg CO_2 were emitted and 3.76 Gg CO_2 were removed. The changes result, therefore, in a net removal of 2.07 Gg CO_2 within 18 years. This corresponds to an annual average of removal of 0.11 Gg CO_2. If this number is compared to Liechtenstein's total net removals in the LULUCF sector, which are varying between -9 to -4 Gg CO_2 equivalent in the period 1990-2004, the removals are overestimated in the order of 1% to 3%. (OEP 2007a. p.21)

The Inventory Group has meanwhile discussed the issue and decided to omit the changes between unmanaged areas for the subsequent submission in April 2010.

7.2.5. Carbon Emission Factors and Stocks at a Glance

Table 94 lists all values of carbon stocks, increases, decreases and net changes of carbon specified for land-use category (CC) and associated spatial strata for the year 1990. These values remain constant during the period 1990-2007 (exception of carbon stock of afforestations and of managed forests, which are increasing every year due to annual net growth).

[21] www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Chp2/Chp2_Land_Areas.pdf

CC-code	altitude zone z	soil type	carbon stock in living biomass (stockCl,i) 1990	carbon stock in dead organic matter (stockCd,i)	carbon stock in soil (stockCs,i)	growth of living biomass (increaseCl,i)	harvesting of living biomass (decreaseCl,i)	net change in dead organic matter (changeCd,i)	net change in soil (changeCs,i)
	Strata		Stocks (t C ha-1)			Changes (t C ha-1 yr-1)			
11	1	n.s.	12.35	0	75.30	2.56	0	0	0
	2	n.s.	6.70	0	75.30	1.70	0	0	0
	3	n.s.	2.41	0	75.30	0.85	0	0	0
12	1	n.s.	156.80	4.45	92.70	4.49	-3.05	0	0
	2	n.s.	152.16	4.01	92.70	4.18	-3.11	0	0
	3	n.s.	116.23	3.98	92.70	2.52	-2.06	0	0
13	1	n.s.	41.41	0	92.70	0	0	0	0
	2	n.s.	43.01	0	92.70	0	0	0	0
	3	n.s.	26.23	0	92.70	0	0	0	0
21	n.s.	0	5.66	0	53.40	0	0	0	0
	n.s.	1	5.66	0	240.00	0	0	0	-9.52
31	1	0	7.45	0	62.02	0	0	0	0
	1	1	7.45	0	240.00	0	0	0	-9.52
	2	0	6.26	0	67.50	0	0	0	0
	2	1	6.26	0	240.00	0	0	0	-9.52
	3	0	4.45	0	75.18	0	0	0	0
	3	1	4.45	0	240.00	0	0	0	-9.52
32	1	n.s.	11.60	0	68.23	0	0	0	0
	2	n.s.	11.60	0	68.23	0	0	0	0
	3	n.s.	11.60	0	68.23	0	0	0	0
33	n.s.	0	3.74	0	53.40	0	0	0	0
	n.s.	1	3.74	0	240.00	0	0	0	-9.52
34	1	n.s.	11.60	0	68.23	0	0	0	0
	2	n.s.	11.60	0	68.23	0	0	0	0
	3	n.s.	11.60	0	68.23	0	0	0	0
35	n.s.	0	24.63	0	64.76	0	0	0	0
	n.s.	1	24.63	0	240.00	0	0	0	-9.52
36	n.s.	n.s.	4.06	0	26.31	0	0	0	0
37	n.s.	n.s.	6.05	0	68.23	0	0	0	0
41	n.s.	n.s.	0	0	0	0	0	0	0
42	n.s.	n.s.	7.96	0	154.00	0	0	0	0
51	n.s.	n.s.	0	0	0	0	0	0	0
52	n.s.	n.s.	5.80	0	53.40	0	0	0	0
53	n.s.	n.s.	4.80	0	53.40	0	0	0	0
54	n.s.	n.s.	4.80	0	53.40	0	0	0	0
61	n.s.	n.s.	0	0	0	0	0	0	0

Legend

altitude zones:		*soil type:*		n.s. = no stratification
1	< 600 m	0	mineral soil	
2	601 - 1200 m	1	organic soil	
3	> 1200 m			

Table 94 Carbon stocks and changes in biomass, dead organic matter and soils for the combination categories (CC), disaggregated for altitude and soil type. These values are valid for the whole period 1990-2007 (no annual changes).

On organic soils, a value of 240 t C ha^{-1} for stock C_s was assumed for all land-use categories. Where no stratification according to soil type is indicated (e.g. in CC 12), all soils including organic soils are allocated to mineral soils.

Thus, when calculating carbon changes in soils as a consequence of land-use changes, the difference of carbon stocks in organic soils is always zero.

Carbon data for forests are derived from monitoring data of the Swiss National Forest Inventory NFI I and NFI II. The data for agriculture, grassland and settlements are based on experiments, field studies, literature and expert estimates from Switzerland. For wetlands and other land, expert estimates or default values are available. The deduction of the individual values is explained in the following chapters.

7.3. Source Category 5A – Forest Land

7.3.1. Source Category Description

Key source 5A1
CO_2 emissions and removals from 5A1 Forest Land remaining Forest land are a key source by level and trend. Source category 5A2 "Land converted to Forest Land" is not a key source.

38% of the total area of Liechtenstein is forest land. The annual net CO_2 removals range from 18.74 Gg CO_2 (1990) to 19.78 Gg CO_2 (1997). The sub-category 5A1 "Forest Land remaining Forest Land" is by far the most relevant sub-category accounting for 99.5% of net CO_2 removals from forest land.

All of the forest land is temperate forest. The definition of forest land is originally based on the Swiss definition and was revised after the In-Country Reviews carried out in Switzerland and Liechtenstein 2007. Forest land is now defined as follows (OEP 2007b):

- Minimum area of land: 0.0625 hectares with a minimum width of 25 m
- Minimum crown cover: 20%
- Minimum height of the dominant trees: 3 m (dominant trees must have the potential to reach 3 m at maturity in situ)

For reporting in the CRF tables, forest land was subdivided into afforestations (CC 11), managed forest (CC 12) and unproductive forest (CC 13) based on the land use and land cover categories (see Table 89; FOEN 2006; SFSO 2006a).

7.3.2. Methodological Issues

a) Forest Land remaining Forest Land (5A1)

The activity data collection follows the methods described in chapter 7.2.2. Carbon stocks and carbon stock changes are taken from Switzerland. Details are described in the following paragraphs.

a1. Swiss National Forest Inventories (NFI)

Data for growing stock, gross growth, cut (harvesting), and mortality was derived from the first and the second Swiss National Forest Inventory (see Table 95). The NFI I was conducted between 1983 and 1985 (EAFV/BFL 1988), the NFI II was conducted between 1993 and 1995 (Brassel and Brändli 1999).

	NFI I	NFI II	NFI III
Inventory cycle	1983-1985	1993-1995	2004-2006
Grid size	1 x 1 km	1.4 x 1.4 km	1.4 x 1.4 km
Terrestrial sample plots	~12'000	~6'000	~6'000
Measured single trees	~130'000	~70'000	~70'000

Table 95 Characteristics of the Swiss National Forest Inventories I, II and III.

a2. Stratification, Spatial strata

As in Switzerland, forests in Liechtenstein reveal a high heterogeneity in terms of elevation, growth conditions, and tree species composition. To find explanatory variables that significantly reduce the variance of gross growth and biomass expansion factors (BEFs) an analysis of variance was done in Switzerland (Thürig and Schmid 2007). The explanatory variables considered are (see also 7.2.3):

- altitude (≤ 600 m, 601-1200 m, > 1200 m)
- tree species (coniferous and deciduous species).

In Liechtenstein, most forests are mixed stands. It was assumed that the mix between coniferous and deciduous species in different altitudes is identical as in the prealpine region of Switzerland (no national data considered).

In Switzerland, the forest area derived by the land use statistics does not allow separating coniferous and deciduous sites. If species specific measures for growing stock, gross growth, harvesting and BEFs are to be applied, the total forest area has to be divided according to the species mixture. It was assumed that the space asserted by a single tree is highly correlated with its basal area. The required ratio of coniferous forest area (R_c) per spatial stratum (Table 96) was calculated by dividing the sum of the basal area of the conifers (BA_c) over the sum of the basal area of all trees (BA).

$R_{ci} = BA_{ci} / BA_i$ i = spatial strata

As both species add up to 1 (or 100%) the rate of deciduous forest area (R_d) is:

$R_{di} = 1 - R_{ci}$ i = spatial strata

The following Swiss ratio of coniferous and deciduous species per altitude class was implied:

Altitude [m]	Coniferous	Deciduous
≤ 600	0.395	0.605
601-1200	0.713	0.287
> 1200	0.925	0.075

Table 96 Ratio of coniferous and deciduous species (source: NFI II; Brassel and Brändli 1999).

a3. Biomass Expansion Factors (BEF)

The Swiss Biomass Expansion Factors were applied in Liechtenstein (FOEN 2008).

In the Swiss National Forest Inventory, growing stock, gross growth, cut (harvesting) and mortality is expressed as round wood over bark. Round wood over bark was expanded to total biomass as done in Thürig et al. (2005) by applying allometric single-tree functions to all trees measured at the NFI II. BEFs were then calculated for each spatial stratum as the ratio between round wood over bark (m^3 ha^{-1}) and the total above- and belowground biomass (t ha^{-1}). Table 97 shows the BEFs for coniferous and deciduous species stratified for altitude.

Altitude [m]	Conifers		Deciduous species	
	Number of trees measured	BEFs	Number of trees measured	BEFs
≤ 600	129	1.48	239	1.49
601-1200	4220	1.48	1980	1.49
> 1200	2909	1.59	241	1.56

Table 97 Biomass expansion factors (BEFs) to convert round-wood over bark (m^3 C ha^{-1}) to total biomass (t C ha^{-1}) for conifers and deciduous species, respectively (Thürig et al. 2005).

a4. Wood Densities

To convert round wood over bark (m^3 ha^{-1}) into t ha^{-1} it was multiplied by a species-specific density. Table 98 shows the applied densities.

	Wood density [t m^{-3}]
Coniferous trees	0.4
Deciduous trees	0.55

Table 98 Wood densities for coniferous and deciduous trees (Vorreiter 1949).

a5. Carbon Content

The IPCC default carbon content of solid wood of 50% was applied (IPCC 2003; p. 3.25).

a6. Growing Stock, Gross Growth and Cut & Mortality in Managed Forests (CC 12)

The Swiss values for growing stock, gross growth, cut and mortality were applied in Liechtenstein (FOEN 2007).

Growing stock, gross growth, cut and mortality for managed forests were derived from those 5'425 sample plots measured at both Swiss National Forest Inventories NFI I and NFI II (Kaufmann 2001). All values derived from the NFI I and II are related to round wood over bark (with stock, without branches) and are given in m^3 ha^{-1} per spatial stratum (Table 99 and Table 100).

Coniferous trees				
Altitude [m]	Growing stock 1985 [m^3 ha^{-1}]	Growing stock 1995 [m^3 ha^{-1}]	Gross growth [m^3 ha^{-1} 10.1yr^{-1}]	Cut and mortality [m^3 ha^{-1} 10.1yr^{-1}]
≤ 600	473.58	506.79	132.36	99.14
601-1200	482.43	515.95	132.71	98.85
> 1200	356.09	372.59	76.12	59.58

Note: 10.1 years correspond to the average inter-survey period between NFI I and NFI II; see below.

Table 99 Growing stock, gross growth, cut and mortality for coniferous trees (related to coniferous forest area).

Deciduous trees				
Altitude [m]	**Growing stock 1985 [m^3 ha^{-1}]**	**Growing stock 1995 [m^3 ha^{-1}]**	**Gross growth [m^3 ha^{-1} $10.1yr^{-1}$]**	**Cut and mortality [m^3 ha^{-1} $10.1yr^{-1}$]**
≤ 600	379.93	427.12	115.75	68.56
601-1200	374.75	427.88	113.4	60.82
>1200	257.27	311.7	72.32	17.88

Note: 10.1 years correspond to the average inter-survey period between NFI I and NFI II; see below.

Table 100 Growing stock, gross growth, cut and mortality for deciduous trees (related to deciduous forest area).

Conversion of NFI data to annual estimates of gross growth and cut & mortality

The average inter-survey period between the Swiss NFI I and NFI II is not exactly 10 years, but 10.1 years. With regard to the individual spatial strata, the variance is even larger (Table 101).

	Altitude [m]	
≤ 600	**601-1200**	**> 1200**
10.4	10.1	10.0

Table 101 Average inter-survey period [in years] between NFI I and NFI II for all spatial strata.

To convert gross growth and cut & mortality measured between NFI I and II into average annual gross growth and average annual cut & mortality, those data had to be divided by the time periods shown in Table 101.

[annual gross growth $_i$ = [gross growth between NFI I and II] $_i$ / time period $_i$

[annual cut & mortality] $_i$ = [cut & mortality between NFI I and II] $_i$ / time period $_i$

where i indicates the different altitudes.

Annual cut and mortality

In order to simplify the estimation of annual cut and mortality, it is assumed that the annual cut and mortality is constant over the whole time period. This is in difference to the Swiss calculation, where different annual cut and mortality amounts are estimated. Liechtenstein implies the Swiss values for the year 1990 for all years between 1990 and 2007.

To calculate the annual cut and mortality (CMy) for the year 1990, the total amount of cut and mortality was distributed among the ten years between 1986 and 1995 and weighted by the percentage of the annual harvesting amounts taken from the forest statistic (SFSO 2006b, SAEFL 2005b).

The annual cut and mortality for coniferous and deciduous trees is as follows:

Coniferous trees		
Altitude [m]	**Annual cut and mortality [m^3 ha^{-1}]**	**Annual cut and mortality [t C ha^{-1}]**
≤ 600	11.34	3.36
601-1200	11.3	3.35
> 1200	6.81	2.17

Table 102 Annual cut and mortality for coniferous trees in m^3 ha^{-1} and t C ha^{-1} (value for 1990, applied for all years).

Deciduous trees		
Altitude [m]	Annual cut and mortality [m^3 ha^{-1}]	Annual cut and mortality [t C ha^{-1}]
≤ 600	6.95	2.85
601-1200	6.16	2.53
> 1200	1.81	0.78

Table 103 Annual cut and mortality for deciduous trees in m^3 ha^{-1} and t C ha^{-1} (value for 1990, applied for all years).

Gross growth

It is assumed that the growth rate of living biomass is constant over the whole time period. Liechtenstein applies the Swiss annual growth values for the year 1990 for all the years between 1990 and 2007. These values are displayed in Table 104.

Growing stock of managed forests (CC 12) 1990-2007													
Altitude	carbon stock in living biomass (stockCl,i)												
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
≤ 600 m	156.8	158.2	159.7	161.1	162.6	164.0	165.5	166.9	168.3	169.8	171.2	172.7	174.1
601-1200 m	152.2	153.2	154.3	155.4	156.4	157.5	158.6	159.7	160.7	161.8	162.9	163.9	165.0
> 1200 m	116.2	116.7	117.1	117.6	118.1	118.5	119.0	119.5	119.9	120.4	120.8	121.3	121.8

	2003	2004	2005	2006	2007	annual growth of living biomass (increase)	annual harvesting of living biomass (decrease)
≤ 600 m	175.6	177.0	178.4	179.9	181.3	4.49	-3.05
601-1200 m	166.1	167.2	168.2	169.3	170.4	4.18	-3.11
> 1200 m	122.2	122.7	123.1	123.6	124.1	2.52	-2.06

Table 104 Growing stock of managed forests (CC12) 1990-2007 in t C ha^{-1}.

a7. Growing Stock in Unproductive Forests (CC 13)

The unproductive forest in Liechtenstein mainly consists of brush forest and inaccessible forest. Although unproductive, this type of forest is still categorized as managed forest. The same carbon stock per hectare as in Switzerland is assumed.

Brush forest

No data from the Swiss National Forest Inventory (NFI) are available to derive their growing stock. Therefore, following estimations were made:

Average growing stock: 40 m^3 ha^{-1}

Wood density for coniferous trees: 0.4 t m^{-3} (Vorreiter 1949)

BEF: 1.45 (Burschel et al. 1993)

Carbon content: 50% (IPCC default carbon content)

Carbon stock : 40 m^3 ha^{-1} * 0.4t m^{-3} * 1.45 * 0.5 = 11.6 t C ha^{-1}

Inaccessible forest

Inaccessible forest in Liechtenstein is mainly located in higher altitudes (above 1200 m). No data from the Swiss National Forest Inventory (NFI) are available to derive the stock growth. Therefore, the following assumptions were made:

Average growing stock: 150 m^3 ha^{-1}

Wood density for coniferous trees: 0.4 t m^{-3} (Vorreiter 1949)

BEF: 1.45 (Burschel et al. 1993)

Carbon content: 50% (IPCC default carbon content)

Carbon stock : 150 m^3 ha^{-1} * 0.4t m^{-3} * 1.45 * 0.5 = 43.5 t C ha^{-1}

Carbon content of unproductive forests (CC 13): Weighted means

The carbon content of unproductive forest was calculated as a weighted average of brush forest and inaccessible forest per spatial stratum:

$[\text{weighted C content}]_i = RS_i * CS + (1- RS_i) * CI$

where RS_i is the rate of the brush forest per spatial stratum i,

CS is the carbon content of brush forest (11.6 t C ha^{-1}),

CI is the carbon content of inaccessible forest (43.5 t C ha^{-1}).

Table 105 shows the carbon content per altitude class in t C ha^{-1}.

Altitude [m]	Rate of brush forest	Rate of inaccessible forest	Weighted C content [t C ha^{-1}]
≤ 600	0.0656	0.9344	41.41
601-1200	0.0154	0.9846	43.01
> 1200	0.541	0.459	26.23

* Derived from the NFI II (Brassel and Brändli 1999)

Table 105 Rate of brush forest and inaccessible forest and the resulting weighted carbon content in t C ha-1 of Swiss unproductive forests (CC 13) specified for all spatial strata.

a8. Dead Wood in managed forests (CC 12)

The Swiss carbon stock amounts per hectare are applied in Liechtenstein.

In the second Swiss NFI, all dead trees (standing and lying) larger than 12 cm were measured. Thus, an estimate of the dead-wood pool in Swiss managed forests (CC 12) can be done.

	Dead wood [m^3 ha^{-1}]
Lying trees	3.7
Standing trees	8.4
Total	12.2

Table 106 Dead wood in Swiss managed forests (CC12) (Brassel and Brändli 1999).

Applying the same wood densities, BEFs and carbon content as for the living growing stock, dead wood per spatial stratum can be estimated (Table 107).

Altitude [m]	Carbon in dead biomass [t C ha^{-1}]
≤ 600	4.45
601-1200	4.01
> 1200	3.98

Table 107 Dead wood in managed forests (CC12) per altitude class in t C ha-1.

a9. Carbon Stock of Afforestations (CC 11)

Growing stock and growth

The Swiss growing stock and growth rates are applied in Liechtenstein. The following paragraph gives some further explanations about the Swiss calculation of carbon stock changes.

Swiss methodology (excerpt from NIR CH, chp. 7.3.2, FOEN 2007):

The average growing stock and growth of afforestations were empirically assessed with NFI I and II, specifically with those stands that were approximately 10 years old in the first NFI and 20 years old in the second NFI. The average growing stock of those 20 year old stands was derived from NFI II. The NFI data were therefore stratified for site quality. It was assumed that forest areas below 600 m show a good site quality, areas between 600 and 1200 m a moderate site quality, and forest areas above 1200 m show a poor site quality. The growing stock of forest stands on good sites was 90 m^3 ha^{-1}. The growing stock on moderate sites was assumed to be one-third smaller than on good sites (60 m^3 ha^{-1}), and two-third smaller on bad sites (30 m^3 ha^{-1}). As trees below 12 cm DBH were not measured in the NFI, the growing stock of 10 year old stands on good sites was assumed to be 2 m^3 ha^{-1}. Within the first few years of stand age, the growing stock was assumed to develop exponentially. The development of the growing stock on good sites between 10 and 20 years was therefore simulated by calibrating an exponential growth function. To simulate the development of growing stock on intermediate and poor sites, growing stock was assumed to develop one-third slower on intermediate, and two-third slower on poor sites. The annual growth was calculated as the difference between growing stocks of two following years. These assumptions are not valid for single stands, but can be applied as a rough simplification. Table 108 shows the simulated growing stock and growth for all three site qualities.

Stand age [yr]	*≤ 600 m altitude*		*601 - 1200 m altitude*		*> 1200 m altitude*	
	Growing stock [m^{3}ha^{-1}]	*Growth [m^3 ha^{-1} year^{-1}]*	*Growing stock [m^{3}ha^{-1}]*	*Growth [m^3 ha^{-1} year^{-1}]*	*Growing stock [m^{3}ha^{-1}]*	*Growth [m^3 ha^{-1} year^{-1}]*
0-9	*0*	*0*	*0*	*0*	*0*	*0*
10	***2***	*2*	*0*	*0*	*0*	*0*
11	*7*	*5*	*0*	*0*	*0*	*0*
12	*13*	*6*	*1*	*1*	*0*	*0*
13	*19*	*6*	*5*	*4*	*0*	*0*
14	*27*	*8*	*10*	*5*	*0*	*0*
15	*35*	*8*	*16*	*6*	*1*	*1*
16	*44*	*9*	*23*	*7*	*5*	*4*
17	*54*	*10*	*31*	*8*	*10*	*5*
18	*66*	*12*	*40*	*9*	*16*	*6*
19	*78*	*12*	*50*	*10*	*23*	*7*
20	***90***	*12*	***60***	*10*	***30***	*7*

Table 108 Estimated average growing stock and annual growth of forest stands in stemwood (defined in Table 24) up to 20 years (CC11) specified for altitude zone.

To convert the estimated growing stock and growth into carbon, the following equations were applied:

*C stock in living biomass = Average growing stock * density * BEF * C-content*

*Growth of living biomass = Average growth * density * BEF * C-content*

In Table 109, abbreviations and units are explained. Table 110 shows the parameters and the converted values.

Name	***Description***	***Value***	***Unit***
Average growing stock	*Average growing stock of stemwood over bark, without branches*	*See Table 110*	$m^3\ ha^{-1}$
Average growth	*Average growth per ha and year*	*Table 110*	$m^3\ ha^{-1}\ year^{-1}$
Density	*Tree density averaged for coniferous and deciduous trees*	*0.47*	$t\ m^{-3}$
BEF	*Biomass expansion factor to convert stemwood over bark into total tree biomass (Burschel et al. 1993); averaged value for coniferous and deciduous trees.*	*1.45*	*-*
C-content	*Carbon to total biomass ratio (IPCC default)*	*0.5*	*-*
C stock in living biomass	*Carbon content in total above- and belowground biomass*	*See Table 110*	$t\ C\ ha^{-1}$
Growth of living biomass	*Growth of carbon in t C per ha and year*	*See Table 110*	$t\ C\ ha^{-1}\ year^{-1}$

Table 109 Conversion of growing stock and growth to total carbon in biomass.

Altitude [m]	***Average growing stock*** $[m^3\ ha^{-1}]$	***Average growth*** $[m^3\ ha^{-1} year^{-1}]$	***Density*** $[t\ m^{-3}]$	***BEF***	***Carbon content***	***Carbon stock in living biomass*** $[t\ C\ ha^{-1}]$	***Growth of living biomass*** $[t\ C\ ha^{-1}\ year^{-1}]$
≤ 600	*36.25*	*7.5*	*0.47*	*1.45*	*0.5*	*12.35*	*2.56*
601-1200	*19.67*	*5*	*0.47*	*1.45*	*0.5*	*6.70*	*1.70*
> 1200	*7.08*	*2.5*	*0.47*	*1.45*	*0.5*	*2.41*	*0.85*

Table 110 Carbon stock in living biomass and growth of living biomass in afforestations (CC11) specified for altitude zone.

a10. Soil carbon in Managed Forests (CC12), Unproductive Forests (CC13) and Afforestations (CC11)

According to a study of Perruchoud et al. (2000), a carbon stock of mineral forest soils of 76 t C ha $^{-1}$ in 0-30 cm topsoil is assumed for the pre-alpine region (which also covers the area of Liechtenstein).

The soil horizons L (litter), F (fermentation) and H (humus) were not included in the soil samples analyzed by Perruchoud et al. (2000). However, especially in forests, those horizons may contain substantial amounts of carbon and should be included in the estimation of forest soil carbon. In a study done by Moeri (2007) soil carbon of organic soil horizons on mineral soils were estimated. According to this study, the soil carbon in these soil horizons in the pre-alpine region, which is relevant for Liechtenstein, is 17.4 t C ha $^{-1}$. Further details are displayed in Table 111.

	L Horizon	F Horizon	H Horizon	Total
Soil carbon (in t C ha^{-1})	4.4 (± 3.2)	6.4 (± 9.4)	6.6 (± 19.8)	17.4 (± 28.5)

Table 111 Soil organic carbon of mineral forest soils (CC12, CC13) in organic soil horizons in t C ha^{-1} in the pre-alpine region. The average values ± standard deviation are given.

Unlike stated in the GPG LULUCF (IPCC 2003), soil carbon of mineral forest soils in organic soil horizons was added to the soil carbon of the mineral layer for Swiss managed and unproductive forests (CC 12 and CC 13). According to IPCC (2003; Table 3.1.2) soil carbon of the organic soil horizons should be accounted as dead organic matter, together with dead wood.

For afforestations (CC 11), the amount of soil carbon in the soil organic horizons was assumed to be zero. Total soil carbon for afforestated land was defined as soil carbon contained in the 0-30 cm mineral topsoil.

Due to following reasons it is assumed that in the years 1990 to 2007 forest soils in Switzerland as well as in Liechtenstein were no source of carbon:

- Within the last decades, no drastic changes of management practices in forests have been taken place due to restrictive forest laws.
- Fertilization of forests is prohibited in Liechtenstein. Drainage of forests is not common practice in Liechtenstein.
- As growing stock has increased since many years, soil carbon is assumed to increase due to increasing litter production.
- As shown in the study by Thürig et al. (2005), wind-throw may have a slightly increasing effect on soil carbon. However, this study neglected the effect of soil disturbances which could equalize those effects.

a11. N_2O Emissions from N Fertilization and Drainage of Soils

Fertilization of forests is prohibited by law in Liechtenstein. Therefore, no emissions are reported in CRF Table 5(I).

Drainage of forests is not common practice in Liechtenstein. As a first guess drainage activity was set to zero, and no emissions are reported for forest land in CRF Table 5(II).

a12. Emissions from Wildfires

Controlled burning of forests is not allowed in Liechtenstein. Some information on wildfires affecting forest land is available. It is however not taken into account since the area affected by wildfires in some years is always much below one hectare. Emissions from wildfires are insignificant and are therefore set to zero. No emissions are reported for forest land in CRF Table 5 (V).

b) Land converted to Forest Land (5A2)

Land conversion to forest land is of minor importance in terms of net CO_2 removals. In 2007 only 0.5% of net CO_2 removals from forest land result from a conversion to forest land. According to the land use statistic the areas switching to forest land are mainly areas that used to be grassland or woody biomass (see Table 93, combination category 32) not fulfilling the definition of minimal forest density and area.

The carbon fluxes in case of land-use change comprising forest land are specified as follows:

According to the stock change approach, the growing stock of e.g. shrub vegetation (CC 32; living biomass and soil carbon) should be subtracted and the average growing stock of forests should be added. However, these forests are supposed to have a growing stock smaller than the growing stock of an average forest and adding the average growing stock of forest areas would possibly overestimate the carbon increase. In terms of IPCC good practice a conservative assumption was met (see also Chapter 7.2.1): The amount of living biomass (carbon stock in living biomass) on land changing from non-forest to forest was not increased but left unchanged. The annual increase of biomass (carbon flux) on these areas was approximated by the annual gross growth rate of the respective forest type (CC 11, 12 or 13). The change of soil carbon was not considered and was set to zero.

Cut and mortality was inferred from the Swiss land-use statistics NFI I and NFI II, applying the stock change approach on forest areas remaining forest. Thus, the total harvesting amount was already considered. To avoid double-counting of the harvesting amount on areas changing from non-forested to forested areas, no additional loss in terms of cut and mortality was accounted for, but the converted areas were only multiplied with the average annual gross growth of the respective spatial stratum.

The annual area of forest changing to other land use categories was also derived by land use statistics. To account for the "decrease of carbon", above- and belowground biomass, the amount of dead-wood and the amount of soil carbon of forest areas changing into other land use categories were subtracted. To account for the "increase of carbon", the carbon stock in biomass and soil of the new land use category was added.

7.3.3. Uncertainties and Time-Series Consistency

No uncertainty assessments have been carried out in Liechtenstein. According to the Swiss National Inventory Report (FOEN 2008), the uncertainty of gross growth, cut and mortality is assessed as low. In case of BEFs, the uncertainty is assessed as medium. In case of soil carbon pool, the uncertainty is assessed as medium.

Time series are consistent.

7.3.4. Source-Specific QA/QC and Verification

The LULUCF expert, the NIC and the NIR author report their QC activities in a checklist (see Annex 2). No additional source-specific QA/QC activities have been carried out.

7.3.5. Source-Specific Recalculations

No source specific recalculations have been carried out.

7.3.6. Source-Specific Planned Improvements

As soon as uncertainty estimations for activity data and carbon factors are available from Switzerland, it will be assessed if Liechtenstein's uncertainty analysis should be extended accordingly.

7.4. Source Category 5B – Cropland

7.4.1. Source Category Description

Key source 5B1
Emissions from 5B1 Cropland remaining Cropland are a key source by level. Source category 5B2 “Land converted to Cropland” is not a key source.

Approximately 12% of Liechtenstein’s total surface is cropland. Land use changes to cropland or from cropland are not very common. The most important changes are from grassland to cropland on the one hand and from cropland to grassland and settlements on the other hand.

Croplands in Liechtenstein belong to the cold temperate wet climatic zone. Carbon stocks in aboveground living biomass and carbon stocks in mineral and organic soils are considered. Croplands (CC 21) and include annual crops and leys in arable rotations.

7.4.2. Methodological Issues

a) Cropland remaining Cropland (5B1)

The activity data collection follows the methods described in chapter 7.2.2. Carbon stocks and carbon stock changes are taken from Switzerland. Details are described in the following paragraphs.

a1. Carbon in Living Biomass

When cropland remains cropland, the carbon stocks of annual crops are not considered since they are harvested every year. Thus, there is no long-term carbon storage.

a2. Carbon in Soils

The Swiss mean soil organic carbon stocks for cropland (53.40 ± 5 t C ha^{-1}) and for cultivated organic soils (240 ± 48 t C ha^{-1}) were implied in Liechtenstein. Both are based on studies from Leifeld et al. (2003) and Leifeld et al. (2005).

a3. Changes in Carbon Stocks

Changes in carbon stocks in mineral soil are assumed to be zero for cropland remaining cropland. Carbon stock changes in soil for cropland remaining cropland occur only in the case of shifts from mineral to organic soils or vice versa. These carbon stock changes are not estimated in Liechtenstein since data on mineral and organic soils is only available for one year. Changes can therefore not be estimated.

a4. Carbon Emissions from Agricultural Lime Application

Emissions from lime application are not occurring in Liechtenstein.

b) Land converted to Cropland (5B2)

The activity data collection follows the methods described in chapter 7.2.2. Carbon factors are displayed in the following paragraphs.

b1. Carbon in Living Biomass

When a conversion of a land to cropland occurs, carbon stocks of annual crops are taken into account. This is in line with the Good Practice Guidance LULUCF (IPCC 2003, p. 3.88, table 3.3.8).

The Swiss mean biomass stock for cropland of 5.66 t C ha^{-1} was implied in Liechtenstein. The value is based on area-weighted means of standing stocks at harvest for the seven most important annual crops (wheat, barley, maize, silage maize, sugar beet, fodder beet, potatoes; FOEN 2007).

b2. Carbon in Soils

As mentioned under the sub-category "Cropland remaining cropland" the Swiss mean soil organic carbon stocks for cropland (53.40 ± 5 t C ha^{-1}) and for cultivated organic soils (240 ± 48 t C ha^{-1}) were implied in Liechtenstein.

b3. N_2O Emissions from Land Use Conversion to Cropland

N_2O emissions as a result of the disturbance associated with land-use conversion to cropland are reported in CRF Table 5 (III). The emissions are calculated with default values proposed by IPCC (2003, following Equations 3.3.14 and 3.3.15, and Chapter 3.3.2.3.1.2):

Emission (N_2O) = $deltaC_s$ * 1 / (C : N) * EF1 * 44 / 28 [Gg N_2O]

where:

$deltaC_s$: soil carbon loss in soils induced by land-use conversion to cropland [Gg C]

C:N: IPCC default C:N ratio = 15 in forest or grassland soils

EF1: IPCC default emission factor = 0.0125 kg N_2O-N $(kg N)^{-1}$

Where negative emissions would occur (when the $deltaC_s$ is negative), they are set to zero.

7.4.3. Uncertainties and Time-Series Consistency

No uncertainty assessments have been carried out in Liechtenstein. Some assessments have been carried out in Switzerland. Where available, uncertainties for soil carbon stocks are given together with the mean value in the text. The relative uncertainty in yield determination has been estimated at 13% for biomass carbon from agricultural land (Leifeld and Fuhrer 2005). Data on biomass yields for different elevations and management intensities as published by FAL/RAC (2001) are based on many agricultural field experiments and have a high reliability.

The time-series are consistent.

7.4.4. Source-Specific QA/QC and Verification

The LULUCF expert, the NIC and the NIR author report their QC activities in a checklist (see Annex 2). No additional source-specific QA/QC activities have been carried out.

7.4.5. Source-Specific Recalculations

No source specific recalculations have been carried out.

7.4.6. Source-Specific Planned Improvements

As soon as uncertainty estimations for activity data and carbon factors are available from Switzerland, it will be assessed if Liechtenstein's uncertainty analysis should be extended accordingly.

7.5. Source Category 5C – Grassland

7.5.1. Source Category Description

Key source 5C1 and 5C2
Emissions from 5C1 Grassland remaining Grassland are a key source by level and trend.
Source category 5C2 "Land converted to Grassland" is a key source by trend.

Approximately 31% of Liechteinstein's total surface is grassland, whereof 85.4% is managed and 14.6% is unmanaged grassland. Conversion to grassland occurs mainly from cropland to grassland and from forest to grassland. These changes are however less important than the reverse conversion from grassland to forest and from grassland to cropland. The total area of grassland decreased by 6.8% in 2007 compared to 1990.

Liechtenstein's grasslands belong to the cold temperate wet climatic zone. Carbon stocks in living biomass and carbon stocks in soils are considered. Grasslands include permanent grassland (CC 31), shrub vegetation (CC 32), vineyards, low-stem orchards ('Niederstammobst') and tree nurseries (CC 33), copse (CC 34), orchards ('Hochstammobst'; CC 35), stony grassland (CC 36), and unproductive grassland (CC 37). The combination categories CC 31-35 are considered as managed and CC 36-37 as unmanaged grasslands.

7.5.2. Methodological Issues

a) Grassland remaining Grassland (5C1)

The activity data collection follows the methods described in chapter 7.2.2. Carbon stocks are taken from Switzerland. Details are described in the following paragraphs.

a1. Carbon in Living Biomass

Permanent Grassland (CC 31)

Permanent grasslands range in altitude from < 300 m to 3000 m above sea level. Because both biomass productivity and soil carbon rely on the prevailing climatic and pedogenic conditions, grassland stocks were calculated separately for three altitude zones (corresponding to those used in source category 5A - Forest Land).

Swiss values for carbon stock in living biomass of permanent grassland are implied (FOEN 2007). The estimation of carbon stocks is based on annual cumulative yield of differentially managed grasslands (FAL/RAC 2001) and on root biomass-C (Ammann et al. 2007). The values for the different altitude zones including roots are displayed in Table 112.

Altitude [m]	C_l [t C ha^{-1}]
≤ 600	7.45
601-1200	6.26
>1200	4.45

Table 112 Living biomass Cl of permanent grassland (CC 31).

Shrub Vegetation (CC 32) and Copse (CC 34)

Swiss values for living biomass in shrub vegetation and copse were implied (FOEN 2007). Due to a lack of more precise data, the living biomass of shrub vegetation and copse was assumed to correspond with brush forest described in section 7.3.2. a7. Brush forest is assumed to contain 11.6 t C ha^{-1}.

Vineyards, Low-stem Orchards and Tree Nurseries (CC 33)

Swiss values for standing carbon stock of living biomass (Cl) for CC 33 were implied (FOEN 2007). Cl of vineyards is 3.61 t C ha^{-1}, Cl of low-stem orchards is 12.25 t C ha^{-1}. For tree nurseries no stand densities are available. The mean carbon stock for this combination category is 3.74 t C ha^{-1}.

Orchards (CC 35)

Orchards are loosely planted larger fruit trees (‘Hochstammobst’) with grass understory. Swiss values for the biomass stock of orchards were implied (FOEN 2007). The total biomass stock of this combination category (including the biomass of the grassland) is assumed to be 24.63 t C ha^{-1}.

Stony Grassland (CC 36)

Stony grassland is categorized as unmanaged grassland. Swiss values for carbon stock of stony grassland were implied (FOEN 2007). The carbon content is assumed to be 4.06 t C ha^{-1}.

Unproductive Grassland (CC 37)

Unproductive grassland is categorized as unmanaged grassland. The category includes grass and herbaceous plants at watersides of lakes and rivers including dams and other flood protection structures, constructions to protect against avalanches and rock slides, and alpine infrastructure. These areas are not used as grassland and are therefore categorised as unmanaged land.

Swiss mean value of all grasslands of 6.05 t C ha^{-1} is implied, as for none of these land-use types, biomass data are currently available (FOEN 2007).

a2. Carbon in Soils

Permanent Grassland (CC 31)

Carbon stocks in grassland soil refer to a depth of 0-30 cm.

Swiss values for carbon stocks in mineral and organic soils are implied (FOEN 2007). They are based on Leifeld et al. (2003) and Leifeld et al. (2005).

The mean carbon stock values for mineral soils are displayed in Table 113.

Altitude [m]	**C_S** [t C ha^{-1}, 0-30 cm]
≤ 600	62.02 ± 13
601-1200	67.50 ± 12
>1200	75.18 ± 9
Assumed mean carbon stock value	*68.23*

Table 113 Mean carbon stocks under permanent grassland on mineral soils.

The mean soil organic carbon stock (0-30 cm) for organic soils is 240 ± 48 t C ha^{-1}.

Shrub Vegetation (CC 32)

Due to lack of data, the Swiss mean value of carbon stocks under permanent grassland on mineral soils (CC 31) of 68.23 t ha^{-1} was used as the soil carbon default for this category (see Table 113).

Vineyards, Low-stem Orchards and Tree Nurseries (CC 33)

Swiss soil carbon values for cropland were implied as it is supposed that these land-use types don't have grass undercover. These soil carbon values are 53.40 t C ha^{-1} for mineral soils and 240 t ha^{-1} for organic soils.

Copse (CC 34)

Due to lack of data, the Swiss mean value of carbon stocks under permanent grassland on mineral soils (CC 31) of 68.23 t ha^{-1} was used as the soil carbon default for this category (see Table 113).

Orchards (CC 35)

Swiss soil carbon values for grassland from the two lower altitude zones (≤ 1200 m) were taken as no specific orchard values were available. These are 64.76 t C ha^{-1} for mineral soils and 240 t C ha^{-1} for organic soils.

Stony Grassland (CC 36)

Swiss values for soil organic carbon under stony grassland were implied (FOEN 2007). These grasslands are mainly located at altitudes > 1200m a.s.l. A carbon stock Cs of 26.31 t C ha^{-1} is assumed for this combination category.

Unproductive Grassland (CC 37)

The category CC 37 ‚unproductive grasslands' includes grass and herbaceous plants at watersides of lakes and rivers including dams and other flood protection structures, constructions to protect against avalanches and rock slides, and alpine infrastructure.

Swiss mean value of carbon stocks under permanent grassland on mineral soils of 68.23 t C ha^{-1} is implied (see Table 113), as for none of these land-use types, carbon soil data are currently available (FOEN 2007).

a3. Changes in carbon stocks

Changes in carbon stock in mineral soils are assumed to be zero for grassland remaining grassland. Carbon stock changes in soil for grassland remaining grassland occur only in the case of shifts from mineral to organic soils or vice versa. These carbon stock changes are not estimated in Liechtenstein since data on mineral and organic soils is only available for one year. Changes can therefore not be estimated.

b) Land converted to Grassland (5C2)

The activity data collection follows the methods described in chapter 7.2.2.

The carbon stocks in living biomass and in soil are reported in detail under "Grassland remaining grassland" and are summarized as follows:

Combination category	Carbon in living biomass	Carbon in soils	
		Mineral soils	Organic soils
Permanent grassland (CC 31)	4.45-7.45 t C ha $^{-1}$	62.02-75.18 t C ha $^{-1}$	240 t C ha $^{-1}$
Shrub vegetation (CC 32)	11.6 t C ha $^{-1}$	68.23 t C ha $^{-1}$	
Vineyards, low-stem Orchards and Tree Nurseries (CC 33)	3.74 t C ha $^{-1}$	53.4 t C ha $^{-1}$	240 t C ha $^{-1}$
Copse (CC 34)	11.6 t C ha $^{-1}$	68.23 t C ha $^{-1}$	
Orchards (CC 35)	24.63 t C ha $^{-1}$	64.76 t C ha $^{-1}$	240 t C ha $^{-1}$
Stony Grassland (CC 36)	4.06 t C ha $^{-1}$	26.31 t C ha $^{-1}$	
Unproductive Grassland (CC 37)	6.05 t C ha $^{-1}$	68.23 t C ha $^{-1}$	

Table 114 Summary table of carbon stocks in grassland (CC 31-37).

7.5.3. Uncertainties and Time-Series Consistency

No uncertainty assessments for LULUCF categories have been carried out in Liechtenstein.

Some assessments have been carried out in Switzerland. Where available, uncertainties for soil carbon stocks are given together with the mean value in the text. The relative uncertainty in yield determination has been estimated at 13% for biomass carbon from agricultural land (Leifeld and Fuhrer 2005). Data on biomass yields for different elevations and management intensities as published by FAL/RAC (2001) are based on many agricultural field experiments and have a high reliability.

The time-series are consistent.

7.5.4. Source-Specific QA/QC and Verification

The LULUCF expert, the NIC and the NIR author report their QC activities in a checklist (see Annex 2). No additional source-specific QA/QC activities have been carried out.

7.5.5. Source-Specific Recalculations

No source specific recalculations have been carried out.

7.5.6. Source-Specific Planned Improvements

Land-use changes between two unmanaged land categories and their implications for emissions/removals will be omitted in the next submission (see Chapter 7.2.4).

As soon as uncertainty estimations for activity data and carbon factors are available from Switzerland, it will be assessed if Liechtenstein's uncertainty analysis should be extended accordingly.

7.6. Source Category 5D – Wetlands

7.6.1. Source Category Description

2.4% of the total surface of Liechtenstein are wetlands. Land-use changes from and to wetlands are not very common and occur mainly from forest land to wetlands (e.g. in case of rivers with flood water). Wetlands consist of surface waters (CC 41) and unproductive wet areas such as shore vegetation and fens (CC 42) (see Table 89). Both types of wetland are categorized as unmanaged.

7.6.2. Methodological Issues

Source category 5D1 “Wetlands remaining Wetlands” and source category 5D2 “Land converted to Wetlands” are not key sources.

a) Wetlands remaining Wetlands (5D1)

The activity data collection follows the methods described in chapter 7.2.2. Carbon stocks are taken from Switzerland. Details are described in the following paragraphs.

a1. Carbon in Living Biomass

Surface Waters (CC 41)

Surface waters have no carbon stocks by definition.

Unproductive Wetland (CC 42)

Swiss carbon contents for unproductive wetlands are implied (FOEN 2007). The combination category was stratified according to different tags (e.g. tree group on wetland, biotope, linear tree group on wetland, clear-cut on wetland) and each tag was assigned to a carbon content of a known combination category (e.g. tree group on wetland was assigned to the category unproductive forest). Using the percentages (according to occurrence) and the assigned carbon stock values, a weighted average for this combination category was calculated. This calculation leads to an average carbon stock of 7.96 t C ha^{-1}.

a2. Carbon in Soils

Land cover in CC 42 includes peatlands and reed. Swiss soil carbon stock values are implied (FOEN 2007). Since only data on peatlands are available (240 t C ha^{-1} as for organic soils), it is suggested that the soil carbon stock of unproductive wetlands is the arithmetic mean of grassland on mineral soils (68.23 t C ha^{-1}) and organic soils (240 t C ha^{-1}), thus 154 t C ha^{-1}.

a3. N_2O emissions from drainage of soils

Drainage of intact wetlands is very unlikely. Therefore, no N_2O emissions are reported in CRF Table 5 (II).

b) Land converted to Wetlands (5D2)

The activity data collection follows the methods described in chapter 7.2.2. In the case of land-use change, the net changes in biomass and soil of both surface waters (CC 41) and unproductive wetland (CC 42) are calculated as described in chapter 7.2.1.

7.6.3. Uncertainties and Time-Series Consistency

No uncertainty assessments have been carried out in Liechtenstein. According to the Swiss National Inventory Report (FOEN 2008), the uncertainty of activity data is assessed as low. In case of carbon stocks, the uncertainty is assessed as high.

The time series are consistent.

7.6.4. Source-Specific QA/QC and Verification

The LULUCF expert, the NIC and the NIR author report their QC activities in a checklist (see Annex 2). No additional source-specific QA/QC activities have been carried out.

7.6.5. Source-Specific Recalculations

No recalculations have been carried out.

7.6.6. Source-Specific Planned Improvements

Land-use changes between two unmanaged land categories and their implications for emissions/removals will be omitted in the next submission (see Chapter 7.2.4).

As soon as uncertainty estimations for activity data and carbon factors are available from Switzerland, it will be assessed if Liechtenstein's uncertainty analysis should be extended accordingly.

7.7. Source Category 5E – Settlements

7.7.1. Source Category Description

Key source 5E2
Source category 5E1 "Settlements remaining Settlements" is not a key source. Emissions from 5E2 "Land converted to Settlements" is a key source by level.

10.4% of Liechtenstein's total surface are settlements. Between 1990 and 2007 308 hectares were converted to settlements, which is an increase of 22.5%. Settlements consist of buildings/constructions (CC 51), herbaceous biomass in settlements (CC 52), shrubs in settlements (CC 53) and trees in settlements (CC 54) as shown in Table 89.

7.7.2. Methodological Issues

a) Settlements remaining Settlements (5E1)

The activity data collection follows the methods described in chapter 7.2.2. Carbon stocks are taken from Switzerland. Details are described in the following paragraphs.

a1. Carbon in Living Biomass

Buildings and Constructions (CC 51)

Buildings/constructions contain no carbon by default.

Herbaceous Biomass, Shrubs and Trees in Settlements (CC 52, 53, 54)

Swiss values for carbon stocks of herbaceous biomass, shrubs and trees in settlements are implied (FOEN 2007). The calculation of carbon stock is based on the average crown cover area based annual growth rate (IPCC default value, IPCC 2003; p. 3.297), the percentage of vegetation coverage for the respective combination category (herbaceous biomass or shrubs in settlements) and the estimated average age of trees in settlements (20 years). The combination category "Herbaceous Biomass in Settlement" (CC 52) is estimated to contain an average carbon stock of 5.8 t C ha^{-1}, and the combination category "Shrubs in Settlements" (CC 53) a carbon stock of 4.8 t C ha^{-1}. Due to a lack of data, the carbon content of the combination category "Trees in Settlements" (CC 53) was also used for CC 54 (4.8 t C ha^{-1}).

a2. Carbon in Soils

Swiss values for soil carbon in settlements are implied (FOEN 2007).

The carbon stock in soil for the combination category "Buildings and Construction" (CC 51) was set to zero. However, a weighting factor of 0.5 was applied to soil carbon changes due to land-use changes involving CC 51 (see Chapter 7.2.1). The reason for this is that in general the soil organic matter on construction sites is stored temporarily and later used for replanting the surroundings or it is used to vegetate dumps for example. The oxidative carbon loss due to the disturbance of the soil structure may reach 50%.

The carbon stock in soil for CC 52, 53 and 54 is 53.40 t C ha^{-1} (0-30 cm, same value as for cropland).

b) Land converted to Settlements (5E2)

The activity data collection follows the methods described in chapter 7.2.2. Carbon factors are reported as described in a) "Settlements remaining Settlements".

7.7.3. Uncertainties and Time-Series Consistency

No uncertainty assessments have been carried out in Liechtenstein. According to the Swiss National Inventory Report (FOEN 2008), the uncertainty of activity data is assessed as low. In case of carbon stocks, the uncertainty is assessed as high.

7.7.4. Source-Specific QA/QC and Verification

The LULUCF expert, the NIC and the NIR author report their QC activities in a checklist (see Annex 2). No additional source-specific QA/QC activities have been carried out.

7.7.5. Source-Specific Recalculations

No source-specific recalculations have been carried out.

7.7.6. Source-Specific Planned Improvements

As soon as uncertainty estimations for activity data and carbon factors are available from Switzerland, it will be assessed if Liechtenstein's uncertainty analysis should be extended accordingly.

7.8. Source Category 5F – Other Land

7.8.1. Source Category Description

Source category 5F1 "Other Land remaining Other Land" and source category 5F2 "Land converted to Other Land" are not key sources.

As shown in Table 89, other land (CC 61) covers non-vegetated areas such as glaciers, rocks and shores.

7.8.2. Methodological Issues

By definition, other land has no carbon stocks. In the case of land-use change, the net changes in biomass and soil are calculated as described in chapter 7.2.1.

7.8.3. Uncertainties and Time-Series Consistency

No uncertainty assessments have been carried out in Liechtenstein. According to the Swiss National Inventory Report (FOEN 2008) the uncertainty of activity data and carbon stock data is assessed as low.

7.8.4. Source-Specific QA/QC and Verification

The LULUCF expert, the NIC and the NIR author report their QC activities in a checklist (see Annex 2). No additional source-specific QA/QC activities have been carried out.

7.8.5. Source-Specific Recalculations

No source-specific recalculations have been carried out.

7.8.6. Source-Specific Planned Improvements

Land-use changes between two unmanaged land categories and their implications for emissions/removals will be omitted in the next submission.

As soon as uncertainty estimations for activity data and carbon factors are available from Switzerland, it will be assessed if Liechtenstein's uncertainty analysis should be extended accordingly.

7.9. LULUCF reporting under the Kyoto Protocol

7.9.1. General Information

The supplementary information in this chapter is provided in accordance with Decision 15/CP.10 (FCCC/CP/2004/10/Add.2) and based on the information given in Liechtenstein's Initial Report (OEP 2006a) and the Corrigendum to the Initial Report of 19 Sep 2007 (OEP 2007b).

Temporary data on greenhouse gas emissions 2007 are listed in Annex 9 Voluntary Supplementary Information for Article 3 paragraph 3 of the Kyoto Protocol: Kyoto Table [CRF table 5(KP)].

a) Accounting periodicity for activities under Article 3, paragraph 3

According to paragraph 25 of the annex to decision 13/CMP.1, Liechtenstein had to determine for each activity of the LULUCF sector whether removal units (RMUs) shall be issued annually or for the entire commitment period. Liechtenstein has chosen to **account annually** for emissions and removals from the LULUCF sector (see Chapter 7 of the Initial Report OEP 2006a).The decision remains fixed for the entire first commitment period.

b) Definition of forest

For activities under Article 3, paragraphs 3 and 4 of the Kyoto Protocol, the Marrakech Accords (in the annex to decision 16/CMP.1) list the definitions to be specified by Parties. For forest, Liechtenstein has chosen the following definition (OEP 2007b, see there in Chapter 4):

- minimum area of land: 0.0625 hectares (with a minimum width of 25 m)
- minimum crown cover: 20 per cent
- minimum height of the dominant trees: 3 m (dominant trees must have the potential to reach 3 m at maturity in situ)

In Liechtenstein's Initial Report, the following precisions are stated (OEP 2006a, p.20f.):

The following forest areas are not subject to the criterion of minimum stand height: shrub forest consisting of dwarf pine (Pinus mugo prostrata) and alpine alder (Alnus viridis).

The following forest areas are not subject of the criteria of minimum stand height **and** minimum crown cover, but must have the potential to achieve both criteria:

a) afforested area on land not under forest cover for 50 years (afforestations);

b) regenerated forest, as well as burned, cut or damaged areas situated on land classified as forest.

Although orchards, parks, camping grounds, open tree formations in settlements, gardens, cemeteries, sports and parking fields may fulfil the (quantitative) forest definition, they are not considered as forests.

For reporting under the Convention and the Kyoto Protocol, Liechtenstein applies the forest definition of the Swiss Land Use Statistics (AREA) of the Swiss Federal Statistical Office. AREA provides an excellent data base to derive accurate, detailed information of not only forest areas, but all types of land use and land cover. Thus, AREA offers a comprehensive, consistent and high quality data set to estimate the surface area of the different land use categories in reporting under the Kyoto Protocol. For Liechtenstein, the Land Use Statistics has been built up identically to Switzerland (same method and data structures, same realisation). The use of the AREA data set implies the choice of the corresponding forest definition.

c) Elected activities

Liechtenstein has elected to not account for LULUCF activities under Article 3.4 during the first commitment period[22], as stated in its Initial Report (OEP 2006b, p.22).

7.9.2. Methodology

a) Afforestation, Deforestation and Reforestation

The definitions given below refer exclusively to directly human-induced activities.

Afforestation

Definition: Afforestation is the conversion to forest of an area not fulfilling the definition of forest for a period of at least 50 years if
(a) the definition of forest in terms of minimum area (625 m^2) is fulfilled, and
(b) the conversion is a direct human-induced activity.
Natural forest regeneration due to abandonment of agricultural land use land is not considered to be a direct human-induced activity.

The area of forest land reported for Afforestation under the Kyoto Protocol is equal to the area reported for Land use changes to forests. Afforestations in Liechtenstein is be identified

- by aerial photographs which form the basis of Liechtenstein's Land-Use Statistics. In afforestations, the trees are planted in regular patterns, which may easily be recognised in the identification process. This procedure is carried out for all afforestations that happened before 2002 where the latest land-use photographs were taken.
- The afforestations which are identified by aerial photographs by method referred to above are compared with the administrative registers on afforestations endorsed by the Office of Forest, Nature and Landscape since 1990. Through this cross check the consistency of the two data sources are verified.
- Afforestations in the period after 2003 will be identified referring to the administrative registers on afforestations endorsed by the Office of Forest, Nature and Landscape. Since afforestations need legal authorisation (Art. 12 and Art 24 of Forest Law), every afforestation is documented in a proper project containing information on geographic location, area, appointed time etc. Since subsidies are granted for afforestations, they are also documented in the national finances. After being afforested, an area is also legally characterised as forest.
- To ensure that the total area of forest does not decrease (Forest law Art. 1), areas affected by direct human-induced activities have to be compensated (Forest law Art. 7), mainly by afforestation of the same spatial extent. Natural forest regeneration due to higher temperatures (raising of timberline) or the abandonment of agricultural land use,

[22] Regierung des Fürstentums Liechtenstein: Kyoto-Protokoll – Initial Report – Anrechnung von Senken, RA 2006/2168-8642, Vaduz, 05.09.2006

mainly occurring in the Alpine area, is not counted as afforestation and is therefore not counted under Article 3, paragraph 3 of the Kyoto Protocol.

Afforestations since 1990 were not subject to harvesting or clear cutting, since there are no forests with such short rotation lengths. For reporting under the Kyoto Protocol, afforested areas always remain in the “afforestation” category. Therefore, the area of afforestations is increasing since 1990.

Deforestation

Definition: Deforestation is the permanent conversion of areas fulfilling the definition of forest in terms of minimum forest area (625 m^2) to areas not fulfilling the definition of forest as a consequence of direct human influence.

Deforestation is prohibited by the National Law on Forests with article 6 (Government 1991). Exceptions need governmental authorisation. The authorisation documents are collected by the Office of Forest, Nature and Landscape (OFNLM) and are annually reported to the Parliament. To ensure that the total area of forest does not decrease, areas affected by direct human-induced deforestation have to be compensated, mainly by afforestation of the same spatial extent. Natural forest regeneration due to abandonment of land, mainly occurring in the Alpine area, is not counted as afforestation and is therefore not counted under Article 3, paragraph 3 of the Kyoto Protocol.

In Liechtenstein, human-induced deforestation is subject to authorisation as mentioned above. Authorisations include the obligation to regenerate the forest area within a few years. Nevertheless such land-use change is classified as permanent deforestation and accordingly accounted for under Article 3, paragraph 3 of the Kyoto Protocol.

The area of forest land reported for Deforestation under the Kyoto Protocol is equal to the sum of deforested areas each with a minimal extension of 625 m^2 and for which authorisation has been granted by the Government of Liechtenstein. (That means that deforestations with an area smaller than 625 m^2 are not reported under the Kyoto Protocol.) Every single authorisation is documented including information on area as well as schedule and maps. The area reported from this source may differ from the area of deforested land as reported in the UNFCCC greenhouse gas inventory due to an other sampling method as described in chpts. 7.2.2 and 7.2.4 (Land-Use Statistics 1984, 1996, 2002: land-use changes identified by evaluation from aerial photographs)

Reforestation

Reforestation does not occur in Liechtenstein.

b) Information used for completing Kyoto tables

The spatial assessment unit for the voluntary submission of the Kyoto Protocol LULUCF tables 2008 covers the entire territory of Liechtenstein.

Since all forests in Liechtenstein are subject to forest management, the area of managed forest corresponds to the forest area derived from the Liechtenstein’s Land Use Statistics (SLP 2006).

Table NIR 1

The table contains information of country specific activities under Article 3.3.

Change in carbon pool: Liechtenstein does not distinguish between above- and below-ground biomass. the total changes are reported in the columns “above-ground biomass” (R), in the columns “below-ground biomass” implemented elsewhere (IE) is set correspondingly.

The columns “litter”, “dead wood” and “soil” are not reported (NR) since it is assumed that the emissions and removals are approximately counterbalanced (net zero).

Fertilisation, drainage of soils, disturbance associated with land-use conversion to croplands, liming and biomass burning are nor occurring (NO)

For Liechtenstein, only the two lines (rows) with „Articles 3.3 activities“ apply; “Art. 3.4 activities” are not elected by Liechtenstein (notation key NA)

TABLE NIR 1. SUMMARY TABLE
Activity coverage and other information relating to activities under Article 3.3 and elected activities under Article 3.4

Liechtenstein
2007
2009

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

[1] Indicate R (reported), NR (not reported), IE (included elsewhere) or NO (not occurring), for each relevant activity under Article 3.3 or elected activity under Article 3.4. If changes in a carbon pool are not reported, it must be demonstrated in the NIR that this pool is not a net source of greenhouse gases. Indicate NA (not applicable) for each activity that is not elected under Article 3.4. Explanation about the use of notation keys should be provided in the text.

[2] Indicate R (reported), NE (not estimated), IE (included elsewhere) or NO (not occurring) for greenhouse gas sources reported, for each relevant activity under Article 3.3 or elected activity under Article 3.4. Indicate NA (not applicable) for each activity that is not elected under Article 3.4. Explanation about the use of notation keys should be provided in the text.

[3] N_2O emissions from fertilization for Cropland Management, Grazing Land Management and Revegetation should be reported in the Agriculture sector. If a Party is not able to separate fertilizer applied to Forest Land from Agriculture, it may report all N_2O emissions from fertilization in the Agriculture sector.

[4] If CO_2 emissions from biomass burning are not already included under changes in carbon stocks, they should be reported under biomass burning; this also includes the carbon component of CH_4. Parties that include CO_2 emissions from biomass burning in their carbon stock change estimates should report IE (included elsewhere).

Table 115 KP(LULUCF) NIR 1

Table NIR 2

The change in area between the Activities under Article 3, paragraph 3 is listed in Kyoto Table NIR 2. For Liechtenstein, only columns with „Articles 3.3 activities“ apply. Area changes from afforestation to deforestation did not occur with the period 2006-2007 as explained above in Section a (Afforestation).

Table 116 KP(LULUCF) NIR 2

Table NIR 2. LAND TRANSITION MATRIX

Area change between the previous and the current inventory year (1), (2), (3)

Liechtenstein
2007
2009

FROM... / TO...		Article 3.3 activities: Afforestation and reforestation	Article 3.3 activities: Deforestation	Article 3.4 activities: Forest Management (if elected)	Article 3.4 activities: Cropland Management (if elected)	Article 3.4 activities: Grazing Land Management (if elected)	Article 3.4 activities: Revegetation (if elected)	Other	Total
		(kha)							
Article 3.3 activities	**Afforestation and Reforestation**	0.60	NO						0.60
	Deforestation		0.02						0.02
Article 3.4 activities	**Forest Management (if elected)**		0.00	NA					0.00
	Cropland Management[4] (if elected)	NA	NA		NA	NA	NA		0.00
	Grazing Land Management[4] (if elected)	NA	NA		NA	NA	NA		0.00
	Revegetation[4] (if elected)	NA			NA	NA	NA		0.00
Other		0.02	NA	NA	NA	NA	NA	NA	0.02
Total area		0.62	0.02	0.00	0.00	0.00	0.00	0.00	0.64

(1) This table should be used to report land area and changes in land area subject to the various activities in the inventory year. For each activity it should be used to report area change between the previous year and the current inventory year. For example, the total area of land subject to Forest Management in the year preceeding the inventory year, and which was deforested in the inventory year, should be reported in the cell in column B and in the row of Forest Management.

(2) Some of the transitions in the matrix are not possible and the cells concerned have been shaded.

(3) In accordance with section 4.2.3.2 of the IPCC good practice guidance for LULUCF, the value of the reported area subject to the various activities under Article 3.3 and 3.4 for the inventory year should be that on 31 December of that year.

(4) Lands subject to Cropland Management, Grazing Land Management or Revegetation which, after 2008, are subject to activities other than those under Article 3.3 and 3.4, should still be tracked and reported under Cropland Management, Grazing Land Management or Revegetation, respectively.

Table NIR 3

The criteria used for key category identification are described in line with the Key Category Analysis in Sect. 1.5.2.

TABLE NIR 3. SUMMARY OVERVIEW FOR KEY CATEGORIES FOR LAND USE, LAND USE CHANGE AND FORESTRY ACTIVITIES UNDER THE KYOTO PROTOCOL

Liechtenstein
2007
2009

KEY CATEGORIES OF EMISSIONS AND REMOVALS	GAS	CRITERIA USED FOR KEY CATEGORY IDENTIFICATION			COMMENTS (3)
		Associated category in UNFCCC inventory(1) is key (indicate which category)	Category contribution is greater than the smallest category considered key in the UNFCCC inventory (1) (including LULUCF)	Other (2)	
Specify key categories according to the national level of disaggregation used(1)					
For example: Cropland Management	*CO_2*	*X(Cropland remaining Cropland)*			
A. Forest Land	CO2	1. Forest land remaining forest land	Yes	Quantitative criteria for Key Category Analysis are sufficient in Liechtenstein	Level and trend assessment following IPCC 1997 and IPCC LULUCF GPG 2003
B. Cropland	CO2	1. Cropland remaining Cropland	Yes	Quantitative criteria for Key Category Analysis are sufficient in Liechtenstein	Level and trend assessment following IPCC 1997 and IPCC LULUCF GPG 2003
C. Grassland	CO2	1. Grassland remaining Grassland 2. Land converted to Grassland	No No	Quantitative criteria for Key Category Analysis are sufficient in Liechtenstein	Level and trend assessment following IPCC 1997 and IPCC LULUCF GPG 2003
E. Settlements	CO2	2. Land converted to Settlements	Yes	Quantitative criteria for Key Category Analysis are sufficient in Liechtenstein	Level and trend assessment following IPCC 1997 and IPCC LULUCF GPG 2003

(1) See section 5.4 of the IPCC good practice guidance for LULUCF.
(2) This should include qualitative consideration as per section 5.4.3 of the IPCC good practice guidance for LULUCF or any other criteria.
(3) Describe the criteria identifying the category as key.

Table 117 KP(LULUCF) NIR 3

Further Kyoto tables 5(KP)A

- 5(KP-I)A.1.1 Afforestation: Change in carbon stock is modelled by using the activity data from 5(KP-I)A.1.3 and carbon stock change factors from Table 94. Note that the cumulated area of afforested land over the whole commitment period is indicated in the table.
- 5(KP-I)A.1.2 Afforestation: there are no units of land afforested later than 1990 and harvested subsequently.
- 5(KP-I)A.2 Deforestation: Change in carbon stock is modelled by using the activity data from 5(KP-I)A.2.1 and carbon stock change factors from table Table 94. Note that the cumulated area of deforested land over the whole commitment period is indicated in the table. As mentioned above, only deforestations with an area larger than 625 m^2 are considered.

7.9.3. Further results

The data for afforestation 1990-2006 are taken from Table 92 as the sum over the period 1990-2006 and the change of 2006-2007 in CC11 of all three strata.

The data for deforestation is taken from the Office of Forest, Nature and Landscape (OFNLM) as reported to the Parliament. The next table shows details of deforestation happened in the years 1990-2007.

Jahr *year*	Waldbesitzer *Owner of forest*	Ursache, Ort *cause / location*	Rodungsfläche *deforested area (m2)*	Rodungsfl. kumul. *area cumul. (kha)*
Höhenstufe 1 [<600m] ***altitudinal belt 1 [<600m]***				
1990	Gemeinde Vaduz	Regierungsviertel	3350	0.00034
1994	Gemeinde Eschen	Deponie Rheinau	62000	0.00654
1995	Gemeinde Ruggell	Erweiterung Industriezone	5160	0.00705
1995	Gemeinde Triesen	Regenüberlaufbecken Leitawies	900	0.00714
1996	Gemeinde Vaduz	Erweiterung Tennisplätze	1330	0.00727
1998	Gemeinde Schaan	Deponie Ställa	3320	0.00761
2000	Gemeinde Gamprin	ARA, Bendern	10500	0.00866
2000	Gemeinde Ruggell	Erweiterung Steinbruch	5000	0.00916
2001	Gemeinde Schaan	Deponie Ställa	18000	0.01096
2002	Gemeinde Schaan	Deponie Ställa	10100	0.01197
2003	Gemeinde Gamprin	Betonwerk Wilhelm Büchel	950	0.01206
2003	Gemeinde Triesen	Deponie Säga	6000	0.01266
2003	Gemeinde Vaduz	Deponie Rain	8000	0.01346
2004	Gemeinde Gamprin	Erstellung Trottoir "Kehla"	735	0.01353
2004	Gemeinde Schaan	Deponie Ställa	18800	0.01541
2004	Gemeinde Triesenberg	Arealerweiterung Leitawies	3995	0.01581
2005	Gemeinde Vaduz	Deponie Rain	9000	0.01671
2005	Gemeinde Vaduz	Fussballplatzausbau	1510	0.01687
2006	Gemeinde Ruggell	Erweiterung Steinbruch	7200	0.01759
2007	Gemeinde Triesen	Erweiterung Motocrosspiste	1200	0.01771
Höhenstufe 2 [600-1200m] ***altitudinal belt 2 [600-1200m]***				
1992	Gemeinde Triesenberg	Wohncontainer (!)	1095	0.00011
1998	Gemeinde Triesenberg	Werkhöfe Guferwald	2350	0.00034
2002	Gemeinde Triesen	Erweiterung Sportplatz T'berg	9850	0.00133
2006	Gemeinde Triesenberg	Aussiedlungsbetriebe Studa	1710	0.00150
Höhenstufe 3 [>1200m] altitudinal belt 3 [>1200m]				
2006	Gemeinde Vaduz	Bergbahnen Malbun	7630	0.00076
Total 1990-2006				**0.01909**
Total 2006/2007			**1200**	**0.00012**

Table 118 Deforestation data communicated by the Office of Forests, Nature and Land Management (OFNLM) to Office of Environmental Protection (OEP).

The numbers for afforestations and deforestations are implemented in the KP-LULUCF tables (see Table 116).

- Afforestation:
  - The cumulated afforestation 1990-2006 is reported in the cell from “Afforestation and reforestation” to “Afforestation and reforestation” (0.60 kha)
  - The area change between the previous and the current inventory year, 2006 and 2007 respectively, are reported in the cell from “Other” to “Afforestation and Reforestation” (0.02 kha)
- Deforestation:
  - The cumulated deforestation 1990-2006 is reported in the cell from “Deforestation” to “Deforestation” (0.019 kha, see total 1990-2006 in Table 118)
  - The area change between the previous and the current inventory year, 2006 and 2007 respectively, are reported in the cell from “Forest management” to “Deforestation” (0.00012 kha, see total 2006/2007 in Table 118).

The afforested area caused removals of 11.2 Gg CO_2 (Table 119) cumulated for the period 1990-2006. Due to deforestation, 16.3 Gg CO_2 were emitted simultaneously in the period 1990-2006. Afforestation and deforestation resulted in a net emission of 5.1 Gg CO_2 within 1990-2006 (see Table 119).

Activity	**Area** (cumulated 1990-2007) kha	**Net CO_2 emisson/removal** (cumulated 1990-2007) Gg CO2
Afforestation	0.60	-11.2
Deforestation	0.02	16.3
Total		**5.1**

Table 119 Summary table of carbon stocks in grassland (CC 31-37). The numbers for afforestation are taken from Table KP(5-I)A.1.1. the numbers for deforestation from Table KP(5-I)A.2.

8. Waste

8.1. Overview GHG Emissions

Within the waste sector emissions from four source categories are considered:

- 6A "Solid Waste Disposal on Land"
- 6B "Wastewater Handling"
- 6C "Waste Incineration"
- 6D "Others".

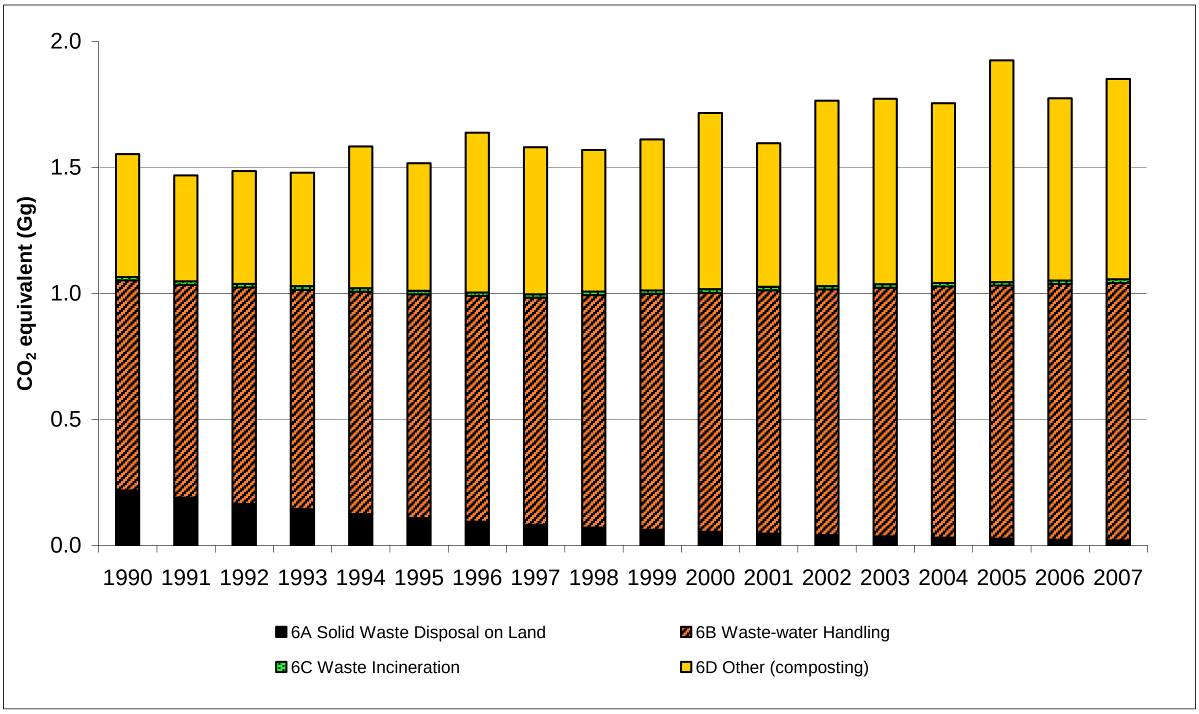

Figure 25 Liechtenstein's greenhouse gas emissions in the waste sector 1990–2007.

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)									
CO_2	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CH_4	0.65	0.56	0.56	0.54	0.62	0.55	0.65	0.59	0.57	0.59
N_2O	0.90	0.90	0.91	0.93	0.96	0.95	0.98	0.98	0.99	1.01
Sum	**1.55**	**1.47**	**1.49**	**1.48**	**1.58**	**1.52**	**1.64**	**1.58**	**1.57**	**1.61**

Gas	2000	2001	2002	2003	2004	2005	2006	2007	*1990-2007*
	CO2 equivalent (Gg)								*%*
CO_2	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	*4.2*
CH_4	0.67	0.55	0.68	0.68	0.65	0.79	0.66	0.71	*10.5*
N_2O	1.04	1.04	1.08	1.09	1.09	1.13	1.11	1.13	*25.6*
Sum	**1.72**	**1.60**	**1.77**	**1.77**	**1.75**	**1.93**	**1.78**	**1.85**	*19.2*

Table 120 GHG emissions of source category 6 Waste by gas in CO_2 equivalent (Gg), 1990–2007.

In the waste sector a total of 1.85 Gg CO_2 equivalents of greenhouse gases were emitted in 2007. 1% of the total emissions stem from 6A “Solid Waste Disposal on Land”, 55.2% from 6B “Wastewater Treatment”, 0.8% from 6C “Waste Incineration” and 43% from the sub-category 6D “Others” (composting). In response to the recommendations made by the UNFCCC Expert Review Team during the In-Country Review in June 2007, CH_4 emissions from 6A “Solid Waste Disposal on Land” have been estimated for the subsequent revised Initial Report submission for the first time, though the last landfill in Liechtenstein has been closed in 1974.

The total greenhouse gas emissions show an increase from 1990 until 2007 by +19.2%. This is mostly due to the increase in composting activities in the country (+63%), reducing the amount of municipal solid waste exported for incineration to Switzerland.

8.2. Source Category 6A – Solid Waste Disposal on Land

8.2.1. Source Category Description

Source category 6A "Solid Waste Disposal on Land" is **not a key category.**

The source category 6A1 “Managed Waste Disposal on Land” comprises all emissions from handling of solid waste on managed landfill sites.

Liechtenstein has historic unmanaged landfills. During the 1960ies, Liechtenstein stopped disposing of municipal solid waste on landfill sites and instead exported it for incineration to Switzerland. This transition was concluded in 1974, when the last municipality in the country stopped land-filling.

The landfills in Liechtenstein were unmanaged (in the definition of IPCC GPG), because municipal solid waste (MSW) was disposed off on the landfills by users directly (only on 3 of over 30 landfill sites a temporary control by landfill staff was executed). No mechanical compacting or levelling of waste has been carried out. No collection or treatment of leachate took place which caused environmental pollution[23]. Landfills are all less than 5 m deep[24].

No landfill gas was collected for flaring or energy recovery.

There are no *managed* waste disposal sites reported in Liechtenstein. Therefore emissions from the source category 6A1 “Managed Waste Disposal Sites” are not occurring.

[23] Source: E-mail Helmut Kindle/OEP of June 24, 2007.

[24] Source: Email Helmut Kindle/OEP of June 12, 2007, based on research in internal files on old landfills of OEP.

6A1	Managed Waste Disposal on Land	Not occurring in Liechtenstein	-
6A2	Unmanaged Waste Disposal Sites	Emissions from handling of solid waste on unmanaged landfill sites	EF: OEP, FOEN 2008 AD: OEP
6A3	Others	Not occurring in Liechtenstein	-

Table 121 Specification of source category 6A “Solid Waste Disposal on Land”.

8.2.2. Methodological Issues

Solid Waste Disposal on Unmanaged Waste Disposal Sites (6A2)

Methodology

A Tier 2 approach is chosen. The rate of CH_4 generation over time is based on the First Order Decay model (FOD) according to IPCC (IPCC 1997a-c). The following equation is applied to calculate the CH_4 generation in the year t:

$$CH_4 \text{ generated in the year t [Gg/year]} = \sum_x [A \cdot k \cdot M(x) \cdot L_0(x) \cdot e^{-k(t-x)}] \cdot (1-OX)$$

where

t =	current year
x =	the year of waste input, $x \leq t$
A =	(1-k)/k, norm factor (fraction)
k =	methane generation rate [1/yr]
M(x) =	the amount of waste disposed in year x
$L_0(x)$ =	methane generation potential (MCF(x) • DOC(x) • DOC_F • F • 16/12) [Gg CH_4 / Gg waste]
MCF(x) =	methane correction factor (fraction)
DOC(x) =	degradable organic carbon [Gg C/ Gg waste]
DOC_F =	fraction of DOC, that is converted to landfill gas (fraction)
F =	fraction of CH_4 in landfill gas (fraction)
16/12 =	factor to convert C to CH_4.
OX =	oxidation factor (fraction)

The following general assumptions are made:

MCF(x) = 0.4 = constant for all years (default value according to IPCC for unmanaged solid waste disposal sites of less than 5 m depth)

OX = 0 (default value according to IPCC 1997a-c)

DOC_F = 0.6 (default value according to IPCC 1997a-c)

F = 0.5 (default value according to IPCC 1997a-c)

The degradable organic carbon (DOC) is calculated based on the default values from IPCC 1997a-c and based on country specific data on waste composition for MSW in Switzerland for 1993 (source EMIS). It is assumed that the Swiss MSW composition is roughly representative for the situation in Liechtenstein:

	SA 1993	DOC IPCC 1997c
Paper and Textile and Cardboard %	28%	0.4
Garden waste and non-food organic putrescible %	5%	0.17
Food waste %	22%	0.15
Wood and Straw %	0%	0.3
Other materials (glass, metals, plastic, minerals, etc. with no contribution to methane generation) %	45%	0
Resulting DOC		**0.154**

Table 122 Calculation of DOC for Liechtenstein (Source DOC: IPCC, source waste fractions: EMIS)

For the calculation of CH_4 generation from unmanaged landfilling of MSW the k factor is based on FOEN 2008 (Table 151). The Swiss NIR assumes a half-life of 5 years, for which k = 0.139 y^{-1} results.

Emission Factors

For parameters in FOD-model see above.

Activity data

Activity data for unmanaged MSW Disposal on Land (6A2) have been estimated by OEF. The estimates are based on internal (unpublished) research done at OEF from 1985 - 1990 that analysed the development of waste quantities in the last century for the elaboration of a national waste strategy.

Based on this work, the following MSW quantities are assumed to have been landfilled from 1930 until the closure of the last landfill in 1974:

Year	**MSW/cap**	**Inhabitants**	**MSW**
	[kg/a]	(average)	[t/a]
1930-39	150	10500	1575
1940-49	100	12300	1230
1950-59	200	15200	3040
1960-69	300	18500	5550
1970-75	MSW declines linearly to 0		

Table 123 Amount of MSW landfilled in Liechtenstein (Source: OEP 2007c)

Because the transition from landfilling in the country to exporting MSW to Switzerland for incineration took place gradually, it is assumed that the amount of MSW landfilled declines linearly after 1970 to zero tons in 1975.

Emissions

The following Table 13 provides the results of the emission calculation based on the FOD-modelling as well as the waste quantities that have been annually disposed off:

Year	Annual Deposition Tons/Year	Emissions t CH_4	Emissions t CO_2 eq	Year	Annual Deposition Tons/Year	Emissions t CH_4	Emissions t CO_2 eq
1930	1575	5.0	105.4	1970	5550	120.5	2531.1
1931	1575	9.4	197.2	1971	4440	119.0	2499.8
1932	1575	13.2	277.0	1972	3330	114.2	2398.3
1933	1575	16.5	346.5	1973	2220	106.5	2235.7
1934	1575	19.4	406.9	1974	1110	96.2	2019.8
1935	1575	21.9	459.5	1975	0	83.7	1757.7
1936	1575	24.1	505.3	1976	0	72.8	1529.6
1937	1575	26.0	545.1	1977	0	63.4	1331.1
1938	1575	27.6	579.8	1978	0	55.2	1158.4
1939	1575	29.0	610.0	1979	0	48.0	1008.0
1940	1230	29.2	613.2	1980	0	41.8	877.2
1941	1230	29.3	615.9	1981	0	36.4	763.4
1942	1230	29.4	618.3	1982	0	31.6	664.3
1943	1230	29.5	620.4	1983	0	27.5	578.1
1944	1230	29.6	622.2	1984	0	24.0	503.1
1945	1230	29.7	623.8	1985	0	20.8	437.8
1946	1230	29.8	625.2	1986	0	18.1	381.0
1947	1230	29.8	626.4	1987	0	15.8	331.5
1948	1230	29.9	627.4	1988	0	13.7	288.5
1949	1230	29.9	628.3	1989	0	12.0	251.1
1950	3040	35.7	750.2	1990	0	10.4	218.5
1951	3040	40.8	856.4	1991	0	9.1	190.1
1952	3040	45.2	948.7	1992	0	7.9	165.5
1953	3040	49.0	1029.1	1993	0	6.9	144.0
1954	3040	52.3	1099.0	1994	0	6.0	125.3
1955	3040	55.2	1159.8	1995	0	5.2	109.0
1956	3040	57.8	1212.8	1996	0	4.5	94.9
1957	3040	59.9	1258.9	1997	0	3.9	82.6
1958	3040	61.9	1299.0	1998	0	3.4	71.9
1959	3040	63.5	1333.9	1999	0	3.0	62.5
1960	5550	73.0	1532.2	2000	0	2.6	54.4
1961	5550	81.2	1704.9	2001	0	2.3	47.4
1962	5550	88.3	1855.1	2002	0	2.0	41.2
1963	5550	94.6	1985.8	2003	0	1.7	35.9
1964	5550	100.0	2099.6	2004	0	1.5	31.2
1965	5550	104.7	2198.6	2005	0	1.3	27.2
1966	5550	108.8	2284.7	2006	0	1.1	23.6
1967	5550	112.4	2359.7	2007	0	1.0	20.6
1968	5550	115.5	2425.0	2008	0	0.9	17.9
1969	5550	118.2	2481.7	2009	0	0.7	15.6
				2010	0	0.6	13.6
				2011	0	0.6	11.8
				2012	0	0.5	10.3

Table 124 CH_4 emissions from MSW landfilled in Liechtenstein 1930 – 2012 (Result of FOD model calculation)

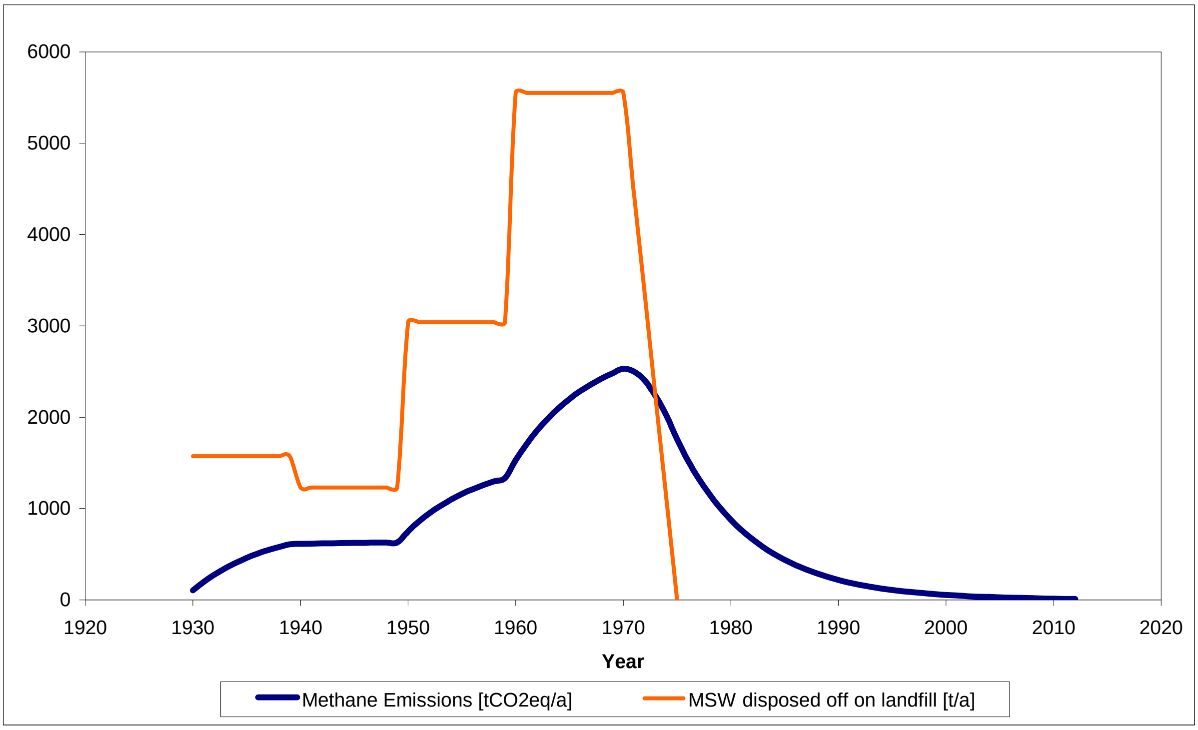

Figure 26 MMSW disposed off on landfill and corresponding emissions of CH_4 in Gg CO_2 equivalent.

8.2.3. Uncertainties and Time-Series Consistency

A preliminary uncertainty assessment based on expert judgment results in low confidence in emission estimates.

The time series is consistent.

8.2.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out.

8.2.5. Source-Specific Recalculations

No recalculations have been carried out.

8.2.6. Source-Specific Planned Improvements

No source-specific improvements are planned.

8.3. Source Category 6B – Wastewater Handling

8.3.1. Source Category Description

Source category 6B “Wastewater Handling” is **not a key source**.

The source category 6B1 “Industrial Waste Water” comprises all emissions from the handling of liquid wastes and sludge from industrial processes such as food processing, textiles, or pulp and paper production. Emissions from source category 6B1 are included in source category 6B2 “Domestic and Commercial Waste Water”. This is motivated by the fact that industrial waste water is generally only pre-treated and not treated on-site, and is then processed in the municipal waste water treatment plants considered under 6B2.

The source category 6B2 “Domestic and Commercial Waste Water” comprises all emissions from handling of liquid wastes and sludge from housing and commercial sources (including gray water and night soil).

6B	Source	Specification	Data Source
6B1	Industrial Waste Water	Emissions from handling of liquid wastes and sludge from industrial processes. (included in 6B2)	-
6B2	Domestic and Commercial Waste Water	Emissions from handling of liquid wastes and sludge from housing and commercial sources	AD: OS 2009, OEP 2008d EF: FOEN 2008, IPCC 1997c
6B3	Others	Not occurring in Liechtenstein	-

Table 125 Specification of source category 6B “Wastewater Handling” (AD: activity data; EF: emission factors).

8.3.2. Methodological Issues

a) Methodology

In Liechtenstein waste water treatment plants are equipped to collect sewage sludge. The sludge is processed in a digester to produce biogas. The biogas is used for co-generation of heat and power on-site.

For CH_4 emissions from domestic and commercial waste water treatment (6B2), a country specific method is used, in line with the method used in the Swiss NIR (FOEN 2008). The CH_4 emissions are calculated by multiplying the amount of biogas produced in the digesters times the emission factor.

N_2O emissions are calculated based on the IPCC default method (IPCC 1997c).

The emissions from the energy generation in the co-generation units itself are reported under 1A1 Energy Industries.

b) Emission Factors

For CH_4 it is assumed that 0.2% of the biogas (volume) is emitted as leakage (FOEN 2008). Based on actual measurements in wastewater treatment plants in Switzerland, a methane content of the biogas by volume of 65% is assumed. With this an overall emission factor of 0.0013 m^3 CH_4 per m^3 of biogas results.

N_2O is derived based on the IPCC-default method. Assuming a protein consumption of 36 kg/person/yr (taken from FEA 2004) and an N fraction of 0.16 kg N per kg protein (FracNPR; IPCC default), an emission factor of 90.5 g of N_2O per inhabitant results[25]. These assumptions are in line with the estimations in Switzerland, where similar conditions prevail (FOEN 2008).

[25] Calculation: 36 * 0.16 * 0.01 * 44/28 = 0.0905 kg N_2O per inhabitant.

c) Activity data

Activity data for CH_4 emissions from Domestic and Commercial Waste Water (6B2) are the total amount of gas resulting from waste water treatment in Liechtenstein. In 1990 three waste water treatment plants had been operational. In 2004, two plants remained, and since 2005 all waste water of the principality is treated in one plant in Bendern.

Gas production		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total gas production	m3	675'944	708'444	750'015	749'887	813'691	736'949	786'301	800'429	866'294	932'935
Balzers	m3	44'256	44'785	42'284	46'055	42'709	43'540	48'964	50'090	48'538	49'206
Vaduz	m3	66'024	55'745	58'464	64'464	64'436	57'713	47'703	0	0	0
Bendern	m3	565'664	607'914	649'267	639'368	706'546	635'696	689'634	750'339	817'756	883'729

Gas production		2000	2001	2002	2003	2004	2005	2006	2007
Total gas production	m3	941'707	905'828	868'172	899'829	939'399	903'804	978'237	1'053'052
Balzers	m3	54'321	53'834	51'144	45'723	5'715	0	0	0
Vaduz	m3	0	0	0	0	0	0	0	0
Bendern	m3	887'386	851'994	817'028	854'106	933'684	903'804	978'237	1'053'052

Table 126 Activity data in 6B2 Domestic and Commercial Waste Water: Amount of waste water treatment gas produced by the three treatment plants in Liechtenstein (source: OEP 2008d, AZV 2008).

Activity data for N_2O emissions from Domestic and Commercial Waste Water (6B2) are the number of inhabitants (total, i.e. connected and non-connected) in Liechtenstein (provided in Section 4.2.2).

8.3.3. Uncertainties and Time-Series Consistency

A preliminary uncertainty assessment based on expert judgment results in low confidence in emission estimates.

The time series is consistent.

8.3.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out.

8.3.5. Source-Specific Recalculations

No recalculations have been carried out.

8.3.6. Source-Specific Planned Improvements

There are no source-specific planned improvements.

8.4. Source Category 6C – Waste Incineration

8.4.1. Source Category Description

Source category 6C “Waste Incineration” is **not a key source**.

There are no waste incineration plants in Liechtenstein. Since the beginning of 1975 all municipal solid waste from Liechtenstein is exported to Switzerland for incineration.

Therefore, source category 6C includes only emissions from the illegal incineration of gardening and household wastes, and of wastes on construction sites (open burning).

8.4.2. Methodological Issues

a) Methodology

For the calculation of the greenhouse gas emissions from illegal incineration of wastes a country specific Tier 2 method is used, based on CORINAIR, adapted from the Swiss NIR (FOEN 2008).

GHG emissions are calculated by multiplying the estimated amount of illegally incinerated waste by emission factors.

b) Emission Factors

Country specific emission factors for CO_2, and CH_4 are adopted from the Swiss NIR (FOEN 2008).

The country specific emission factor for N_2O is derived from the emission factor for biomass of 1.6 kg N_2O/TJ with a net calorific value of the waste of 12.7 GJ/t, taken from the Swiss NIR (FOEN 2008). This is based on the assumption that the waste that is incinerated illegally in gardens, households or on construction sites is composed of a high share of wood.

The following table presents the emission factors used in 6C:

6C Waste Incineration			
Source	**CO_2** t/t	**CH_4** kg/t	**N_2O** kg/t
Illegal waste incineration	0.508	6	0.02

Table 127 Emission Factors for 6C "Waste Incineration" in 2007. CO_2 emission factor relates to *fossil* carbon only. (Source FOEN 2008)

The main source of fossil CO_2 emissions is plastic. It is assumed that the waste mix in illegal waste incineration is the same as the one for municipal solid waste incineration in Switzerland (FOEN 2008), i.e. 40% of the waste mix is of fossil origin.

c) Activity Data

The activity data for Waste Incineration (6C) are the quantities of waste incinerated illegally. This amount is calculated from the total amount of municipal solid waste generated in Liechtenstein by assuming that waste incinerated illegally represents 0.5% of waste generated[26] (OS 2009, OEP 2008d). Data for municipal solid waste has been interpolated.

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[26] This assumption is based on a Swiss study that showed that illegal incineration in private gardens and stoves are of the order of magnitude of 1% of total MSW generation. Assuming that no illegal incineration in gardens takes place in Liechtenstein, a value of 0.5% for illegal incineration in stoves is estimated.

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
MSW generated	t/a	8'000	8'020	8'040	8'060	8'080	8'100	8'120	8'140	8'160	8'180
Fraction incinerated illegally		0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
Waste incinerated illegally	t/a	40.0	40.1	40.2	40.3	40.4	40.5	40.6	40.7	40.8	40.9

		2000	2001	2002	2003	2004	2005	2006	2007
MSW generated	t/a	8'200	8'220	8'240	8'260	8'280	8'038	8'267	8'338
Fraction incinerated illegally		0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
Waste incinerated illegally	t/a	41.0	41.1	41.2	41.3	41.4	40.2	41.3	41.7

Table 128 Activity data for the different emission sources within source category 6C “Waste Incineration”. Source of amount of municipal solid waste (MSW) generated: OS 2009, OEP.

8.4.3. Uncertainties and Time-Series Consistency

A preliminary uncertainty assessment based on expert judgment results in low confidence in emissions estimates.

The time series is consistent.

8.4.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out.

8.4.5. Source-Specific Recalculations

No source specific recalculations have been carried out.

8.4.6. Source-Specific Planned Improvements

There are no source-specific planned improvements.

8.5. Source Category 6D – Other

8.5.1. Source Category Description

Source category 6D "Other" is **not a key category.**

The source category 6D “Other” comprises the GHG emissions from composting of organic waste. Composting covers the GHG emissions from larger centralized composting plants as well as from backyard composting.

Emissions from the application of compost to agricultural land are reported under category 4 Agriculture.

There are no shredding plants in Liechtenstein, therefore emissions from car shredding are not occurring.

6D	Source	Specification	Data Source
	Composting	Emissions from composting of organic waste	AD: OS 2009, OEP 2008d EF: FOEN 2008

Table 129 Specification of source category 6D “Other” (AD: activity data; EF: emission factors).

8.5.2. Methodological Issues

a) Methodology

For the CH_4 and N_2O emissions from composting a country specific method is used, based on the Swiss NIR (FOEN 2008). The GHG emissions are calculated by multiplying the quantity of wastes by the emission factors. For all years the same constant country specific emission factors have been applied. N_2O emissions from the product of composting that arise after their application in agriculture are reported under source category 4D4.

b) Emission Factors

Emission factors for composting have been adopted from the Swiss NIR (FOEN 2008): 5 kg CH_4/t and 0.07 kg N_2O/t. They are based on measurements and expert estimates, documented in the Swiss EMIS database.

c) Activity data

The office for Environmental Protection provides data on the amount of waste treated in centralized compost plants. In order to account for the numerous small compost sites in people's backyards, backyard composting has been estimated by an expert estimate[27]: it is estimated to amount to 8% in 1990 and 5% in 2005 and following years compared to the waste composted in centralized compost plants (in the years in between, the factor is linearly interpolated).

[27] Source: Andreas Gstoehl, OEP, email to J. Beckbissinger, Acontec, of August 16th, 2006.

Waste composting		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Composted centrally	t/a	3'567	3'078	3'287	3'311	4'143	3'734	4'686	4'316	4'167	4'460
Additionally in backyard		8.0%	7.8%	7.6%	7.4%	7.2%	7.0%	6.8%	6.6%	6.4%	6.2%
Composted total	t/a	3'852	3'318	3'537	3'556	4'441	3'995	5'005	4'601	4'433	4'737

Waste composting		2000	2001	2002	2003	2004	2005	2006	2007
Composted centrally	t/a	5'210	4'247	5'501	5'508	5'345	6'614	5'442	5'981
Additionally in backyard		6.0%	5.8%	5.6%	5.4%	5.2%	5.0%	5.0%	5.0%
Composted total	t/a	5'522	4'494	5'809	5'806	5'623	6'945	5'714	6'280

Table 130 Activity data in 6D Other.

8.5.3. Uncertainties and Time-Series Consistency

A preliminary uncertainty assessment based on expert judgment results in low confidence in emissions estimates.

The time series is consistent.

8.5.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out.

8.5.5. Source-Specific Recalculations

The quantities for waste composted centrally have been updated for the years 1992, 1996-1999, 2001 and 2006, because of new data in one commune. Recalculations have been carried out.

8.5.6. Source-Specific Planned Improvements

There are no source-specific planned improvements.

9. Recalculations

9.1. Explanations and Justifications for Recalculations

The recalculations have been described in the subsections (x.y.5) of the preceding chapters for all sectors. The recalculations are summarised below.

1 Energy

1A3b: The implied emission factors 2006 for CH_4 and N_2O have been updated due to the Swiss emission factors.

1A4a: Correction of a mistake in the CH_4 and N_2O implied emission factors for liquid fuels.

1A4c/1A5b: Due to an update of the Swiss off-road database, the CH_4 and N_2O implied emission factor were updated for off-road vehicles and machinery for the whole time series 1990-2006.

2 Industrial Processes

Some improvements in the Swiss inventory in the modelling of HFC have been transferred into Liechtenstein's inventory, which implied some recalculation of Source category 2F as described in detail in Sect. 4.7.5.

3 Solvent and other Product Use

The proxy data of the specific emissions per inhabitant in Switzerland have been updated and recalculations have been carried out for the whole time series.

4 Agriculture

4A and 4B have been recalculated for 2006 with updated implied CH_4 emission factors. As well, 4D has been recalculated for 2006 with updated activity data 2006.

Due to technical reasons, the methane emission time series 4A and 4B have been recalculated to technical reasons (see comment in Sect. 6.2.5). The differences are smaller than 0.01 Gg CO_2 eq. For the base year 1990, the cumulated difference (4A+4B) is 0.00031 Gg CO_2 eq.

5 LULUCF

No recalculations have been carried out.

6 Waste

6D: The data for quantities on composted waste have been updated for one commune, which implied recalculations for several years. Details see Sect. 8.5.5.

9.2. Implications for Emission Levels 1990 and 2006

Table 131 shows the recalculation results for the base year 1990. The recalculations have very slight effect on the emissions in 1990: They increased the national total emissions by 0.020 Gg CO_2 eq. The result holds with and without LULUCF. It corresponds to an increase of 0.009% of the national total.

Recalculation	CO_2			CH_4			N_2O			Sum (CO_2, CH_4 and N_2O)		
Emissions for 1990	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.
Source and Sink Categories	CO_2 equivalent (Gg)									CO_2 equivalent (Gg)		
1 Energy	202	202	0.00	1.1	1.1	0.00	0.9	0.9	0.01	203.5	203.5	0.01
2 Ind. Processes (without syn. gases)	NO	NO		NO	NO		NO	NO				
3 Solvent and Other Product Use	2	2	0.00				0.5	0.5	0.01	2.0	2.0	0.01
4 Agriculture				11.7	11.7	0.00	10.8	10.8	0.00	22.5	22.5	0.00
5 LULUCF	-8	-8	0.00	NO	NO		NO	NO		-8.3	-8.3	0.00
6 Waste	0	0	0.00	0.6	0.6	0.00	0.9	0.9	0.00	1.6	1.6	0.00
Sum (without synthetic gases)	195	195	0.00	13.4	13.4	0.00	13.1	13.1	0.02	221.2	221.2	0.02

Recalculation	HFC			PFC			SF6			Sum (synthetic gases)		
Emissions for 1990	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.
Source and Sink Categories	CO_2 equivalent (Gg)									CO_2 equivalent (Gg)		
2 Ind. Processes (only syn. gases)	0.00	0.00	0.00	NA,NO	NA,NO		NA,NO	NA,NO		0.0	0.0	0.00

Recalculation		Sum (all gases)		
Emissions for 1990		Prev.	Latest	Differ.
Source and Sink Categories		CO_2 equivalent (Gg)		
Total CO_2 eq Em. with LULUCF		**221.21**	**221.23**	**0.020**
		100.00%	100.01%	0.009%
Total CO_2 eq Em. without LULUCF		**229.53**	**229.55**	**0.020**
		100.00%	100.01%	0.009%

Table 131 Overview of implications of recalculations on 1990 data. Emissions are shown before the recalculation according to the previous submission in 2008 ”Prev.” (OEP 2008) and after the recalculation according to the present submission “Latest. The differences “Differ.” are defined as latest minus previous submission.

For 2006, the recalculations result in a small decrease of the total emissions in CO_2 equivalents (without emissions/removals from LULUCF) of 0.047 Gg CO_2 eq. This corresponds to a decrease of the latest submission compared to the previous submission of -0.02% of the national total.

Recalculation	CO_2			CH_4			N_2O			Sum (CO_2, CH_4 and N_2O)		
Emissions for 2006	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.
Source and Sink Categories	CO_2 equivalent (Gg)									CO_2 equivalent (Gg)		
1 Energy	241	241	0.00	1.8	1.8	-0.01	1.1	1.1	-0.03	243.6	243.6	-0.03
2 Ind. Processes (without syn. gases)	NO	NO		NO	NO		NO	NO				
3 Solvent and Other Product Use	0.9	0.9	-0.01				0.2	0.2	0.01	1.1	1.1	0.01
4 Agriculture				12.0	12.0	-0.01	10.4	10.3	-0.03	22.3	22.3	-0.03
5 LULUCF	-6.5	-6.5	0.00	NO	NO		NO	NO		-6.5	-6.5	0.00
6 Waste	0.0	0.0	0.00	0.7	0.7	0.00	1.1	1.1	0.00	1.8	1.8	0.00
Sum (without synthetic gases)	235	235	0.00	14.4	14.4	-0.01	12.9	12.8	-0.04	262.3	262.2	-0.06

Recalculation	HFC			PFC			SF6			Sum (synthetic gases)		
Emissions for 2006	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.
Source and Sink Categories	CO_2 equivalent (Gg)									CO_2 equivalent (Gg)		
2 Ind. Processes (only syn. gases)	4.15	4.16	0.01	NA,NO	NA,NO		0.1	0.1	0.00	4.2	4.2	0.01

Recalculation	Sum (all gases)		
Emissions for 2006	Prev.	Latest	Differ.
Source and Sink Categories	CO_2 equivalent (Gg)		
Total CO_2 eq Em. with LULUCF	**266.50**	**266.46**	**-0.047**
	100.00%	99.98%	-0.02%
Total CO_2 eq Em. without LULUCF	**273.05**	**273.00**	**-0.047**
	100.00%	99.98%	-0.02%

Table 132 Overview of implications of recalculations on 2006 data. Emissions are shown before the recalculation according to the previous submission in 2008 “Prev.” (OEP 2008) and after the recalculation according to the present submission “Latest”. The differences “Differ.” are defined as latest minus previous submission.

9.3. Implications for Emissions Trends, including Time Series Consistency

Due to recalculations, the emission trend 1990–2006 reported in the 2008 submission has changed. Compared to 1990, 2006 emissions (national total without emissions/removals from LULUCF) showed an increase of 18.96% before recalculation (previous submission). After recalculation, the increase turns out to be slightly smaller: 18.93% (latest submission).

Recalculation	**1990**		**2006**		**change 1990/2006**	
submission	previous	latest	previous	latest	previous	latest
	CO_2 eq (Gg)				%	
Total excl. LULUCF	229.53	229.55	273.05	273.00	18.96%	18.93%

Table 133 Change of the emission trend 1990–2006 due to recalculations.

All time series in the present submission are consistent.

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Annexes

Annex 1: Key Category Analysis

A1.1 Complete KCA 2007 without LULUCF categories.

IPCC Source Categories (and fuels if applicable)					Direct GHG	Base Year 1990 Estimate	Year t Estimate	Level Assessment	Trend Assessment	% Contribution in Trend	Result level assessment	Result trend assessment
						[Gg CO2eq]	[Gg CO2eq]					
TOTAL					*All*	***229.55***	***243.48***	*100.00%*	*0.513819*	*100.0%*		
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	57.10	27.62	11.35%	0.127542	24.8%	KC level	KC trend
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	2.51	22.54	9.26%	0.076974	15.0%	KC level	KC trend
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	8.70	27.40	11.25%	0.070348	13.7%	KC level	KC trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	14.77	27.13	11.14%	0.044390	8.6%	KC level	KC trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO2	18.74	8.97	3.68%	0.042251	8.2%	KC level	KC trend
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	18.74	8.97	3.68%	0.042251	8.2%	KC level	KC trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	60.53	55.85	22.94%	0.032351	6.3%	KC level	KC trend
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			HFC	0.00	4.47	1.84%	0.017314	3.4%	KC level	KC trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	16.48	21.84	8.97%	0.016879	3.3%	KC level	KC trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	CO2	0.00	2.71	1.11%	0.010504	2.0%	KC level	KC trend
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	0.12	2.44	1.00%	0.008942	1.7%	KC level	KC trend
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	2.36	3.33	1.37%	0.003196	0.6%	KC level	-
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	5.75	5.66	2.33%	0.001704	0.3%	KC level	-
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	2.73	2.51	1.03%	0.001487	0.3%	KC level	-
4A	4. Agriculture	A. Enteric Fermentation			CH4	9.80	10.38	4.26%	0.000066	0.0%	KC level	-
3	3. Solvent and Other Product Use				CO2	1.53	0.86	0.36%	0.002919	0.6%	-	-
1B2	1. Energy	B. Fugitive Emissions from Fuels	2. Oil and Natural Gas		CH4	0.32	1.07	0.44%	0.002831	0.6%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	0.49	0.10	0.04%	0.001618	0.3%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	0.13	0.42	0.17%	0.001085	0.2%	-	-
4B	4. Agriculture	B. Manure Management			CH4	1.90	1.74	0.71%	0.001053	0.2%	-	-
3	3. Solvent and Other Product Use				N2O	0.47	0.25	0.10%	0.000982	0.2%	-	-
6D	6. Waste	D. Other			CH4	0.40	0.66	0.27%	0.000892	0.2%	-	-
4D_o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O			N2O	0.82	0.66	0.27%	0.000827	0.2%	-	-
6A	6. Waste	A. Solid Waste Disposal on Land			CH4	0.22	0.02	0.01%	0.000818	0.2%	-	-
6B	6. Waste	B. Wastewater Handling			N2O	0.81	0.99	0.41%	0.000497	0.1%	-	-
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			SF6	0.00	0.12	0.05%	0.000464	0.1%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	N2O	0.05	0.16	0.07%	0.000432	0.1%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CO2	0.09	0.01	0.01%	0.000328	0.1%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	N2O	0.14	0.07	0.03%	0.000320	0.1%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	1.30	1.46	0.60%	0.000318	0.1%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	0.01	0.08	0.03%	0.000260	0.1%	-	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	0.08	0.13	0.05%	0.000208	0.0%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	CH4	0.00	0.05	0.02%	0.000201	0.0%	-	-
6D	6. Waste	D. Other			N2O	0.08	0.14	0.06%	0.000184	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	0.01	0.05	0.02%	0.000176	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CH4	0.02	0.06	0.03%	0.000161	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	N2O	0.01	0.04	0.02%	0.000110	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	N2O	0.05	0.02	0.01%	0.000107	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	0.05	0.02	0.01%	0.000107	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N2O	0.05	0.08	0.03%	0.000102	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.00	0.02	0.01%	0.000085	0.0%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	0.47	0.48	0.20%	0.000079	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N2O	0.01	0.03	0.01%	0.000073	0.0%	-	-
4B	4. Agriculture	B. Manure Management			N2O	1.52	1.63	0.67%	0.000057	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	N2O	0.00	0.02	0.01%	0.000040	0.0%	-	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	N2O	0.03	0.04	0.02%	0.000039	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CH4	0.04	0.05	0.02%	0.000039	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	CH4	0.00	0.01	0.01%	0.000037	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CH4	0.02	0.01	0.00%	0.000037	0.0%	-	-
6B	6. Waste	B. Wastewater Handling			CH4	0.02	0.03	0.01%	0.000037	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH4	0.01	0.00	0.00%	0.000022	0.0%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CH4	0.01	0.01	0.00%	0.000013	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CH4	0.01	0.00	0.00%	0.000012	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	0.01	0.00	0.00%	0.000012	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	N2O	0.01	0.01	0.01%	0.000010	0.0%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	N2O	0.00	0.00	0.00%	0.000006	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	0.00	0.00	0.00%	0.000005	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	N2O	0.01	0.02	0.01%	0.000005	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0.00	0.00	0.00%	0.000004	0.0%	-	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	0.00	0.00	0.00%	0.000002	0.0%	-	-

(Cont'd next page)

IPCC Source Categories (and fuels if applicable)					Direct GHG	Base Year 1990 Estimate [Gg CO2eq]	Year t Estimate [Gg CO2eq]	Level Assessment	Trend Assessment	% Contribution in Trend	Result level assessment	Result trend assessment
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	N2O	0.00	0.00	0.00%	0.000002	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	N2O	0.00	0.00	0.00%	0.000002	0.0%	-	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CH4	0.00	0.00	0.00%	0.000001	0.0%	-	-
6C	6. Waste	C. Waste Incineration			CO2	0.01	0.01	0.00%	0.000001	0.0%	-	-
6C	6. Waste	C. Waste Incineration			CH4	0.01	0.01	0.00%	0.000000	0.0%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	CH4	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH4	0.00	0.00	0.00%	0.000000	0.0%	-	-
6C	6. Waste	C. Waste Incineration			N2O	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CH4	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	NO	NO	0.00%	0.000000	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO2	NO	NO	0.00%	0.000000	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	NO	NO	0.00%	0.000000	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CH4	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	CO2	NO	NO	0.00%	0.000000	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Other Fuels	CO2	NO	NO	0.00%	0.000000	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	CH4	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Biomass	CH4	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Other Fuels	CH4	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	N2O	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Biomass	N2O	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Other Fuels	N2O	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CO2	NA	NA	0.00%	0.000000	0.0%	-	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CH4	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		N2O	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	CO2	NO	NO	0.00%	0.000000	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	CH4	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	N2O	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CO2	NO	NO	0.00%	0.000000	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CH4	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	N2O	0.00	0.00	0.00%	0.000000	0.0%	-	-
1B2	1. Energy	B. Fugitive Emissions from Fuels	2. Oil and Natural Gas		CO2	NA,NO	NA,NO	0.00%	0.000000	0.0%	-	-
1B2	1. Energy	B. Fugitive Emissions from Fuels	2. Oil and Natural Gas		N2O	NA,NO	NA,NO	0.00%	0.000000	0.0%	-	-
2A	2. Industrial Proc.	A. Mineral Products			CO2	NO	NO	0.00%	0.000000	0.0%	-	-
2A	2. Industrial Proc.	A. Mineral Products			CH4	NO	NO	0.00%	0.000000	0.0%	-	-
2A	2. Industrial Proc.	A. Mineral Products			N2O	NO	NO	0.00%	0.000000	0.0%	-	-
2B	2. Industrial Proc.	B. Chemical Industry			CO2	NO	NO	0.00%	0.000000	0.0%	-	-
2B	2. Industrial Proc.	B. Chemical Industry			CH4	NO	NO	0.00%	0.000000	0.0%	-	-
2B	2. Industrial Proc.	B. Chemical Industry			N2O	NO	NO	0.00%	0.000000	0.0%	-	-
2C	2. Industrial Proc.	C. Metal Production			CO2	NO	NO	0.00%	0.000000	0.0%	-	-
2C	2. Industrial Proc.	C. Metal Production			CH4	NO	NO	0.00%	0.000000	0.0%	-	-
2C	2. Industrial Proc.	C. Metal Production			N2O	NO	NO	0.00%	0.000000	0.0%	-	-
2D	2. Industrial Proc.	D. Other Production			CO2	NO	NO	0.00%	0.000000	0.0%	-	-
2E	2. Industrial Proc.	E. Production of Halocarbons and SF6			CO2	0.00	0.00	0.00%	0.000000	0.0%	-	-
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			PFC	NO	NA,NO	0.00%	0.000000	0.0%	-	-
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			CO2	0.00	0.00	0.00%	0.000000	0.0%	-	-
2G	2. Industrial Proc.	G. Other			CO2	NO	NO	0.00%	0.000000	0.0%	-	-
2G	2. Industrial Proc.	G. Other			CH4	NO	NO	0.00%	0.000000	0.0%	-	-
2G	2. Industrial Proc.	G. Other			N2O	NO	NO	0.00%	0.000000	0.0%	-	-
4C	4. Agriculture	C. Rice Cultivation			CH4	NA,NO	NA,NO	0.00%	0.000000	0.0%	-	-
4D	4. Agriculture	D. Agricultural Soils			CH4	NA,NO	NA,NO	0.00%	0.000000	0.0%	-	-
4E	4. Agriculture	E. Prescribed Burning of Savannas			CH4	NA	NA	0.00%	0.000000	0.0%	-	-
4E	4. Agriculture	E. Prescribed Burning of Savannas			N2O	NA	NA	0.00%	0.000000	0.0%	-	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues			CH4	NA,NO	NA,NO	0.00%	0.000000	0.0%	-	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues			N2O	NA,NO	NA,NO	0.00%	0.000000	0.0%	-	-
4G	4. Agriculture	G. Other			CH4	NA	NA	0.00%	0.000000	0.0%	-	-
4G	4. Agriculture	G. Other			N2O	NA	NA	0.00%	0.000000	0.0%	-	-
6A	6. Waste	A. Solid Waste Disposal on Land			CO2	NO	NO	0.00%	0.000000	0.0%	-	-
6D	6. Waste	D. Other			CO2	NO	NO	0.00%	0.000000	0.0%	-	-

Table 134 Complete Key Category Analysis for 2007 without LULUCF categories.

A1.2 KCA including LULUCF categories

Key Category Analysis 2007 (including LULUCF) IPCC Source Categories (and fuels if applicable)					Direct GHG	Base Year 1990 Estimate	Year t Estimate	Level Assessment	Trend Assessment	% Contribution in Trend	Result level assessment	Result trend assessment
Sorted by NFR code						[Gg CO2eq]	[Gg CO2eq]					
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO_2	0.12	2.44	0.89%	0.007894	1.7%	KC level	KC trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO_2	16.48	21.84	7.94%	0.014772	3.2%	KC level	KC trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO_2	18.74	8.97	3.26%	0.037452	8.0%	KC level	KC trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO_2	14.77	27.13	9.86%	0.039075	8.4%	KC level	KC trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	CO_2	0.00	2.71	0.99%	0.009274	2.0%	KC level	KC trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO_2	60.53	55.85	20.30%	0.029041	6.2%	KC level	KC trend
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO_2	8.70	27.40	9.96%	0.062042	13.3%	KC level	KC trend
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO_2	57.10	27.62	10.04%	0.113058	24.2%	KC level	KC trend
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO_2	2.51	22.54	8.19%	0.067940	14.6%	KC level	KC trend
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO_2	18.74	8.97	3.26%	0.037452	8.0%	KC level	KC trend
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO_2	2.36	3.33	1.21%	0.002803	0.6%	KC level	KC trend
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			HFC	0.00	4.47	1.62%	0.015286	3.3%	KC level	KC trend
3	3. Solvent and Other Product Use				CO_2	1.53	0.86	0.31%	0.002589	0.6%	-	KC trend
4A	4. Agriculture	A. Enteric Fermentation			CH_4	9.80	10.38	3.77%	0.000136	0.0%	KC level	-
4B	4. Agriculture	B. Manure Management			CH_4	1.90	1.74	0.63%	0.000944	0.2%	KC level	-
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N_2O	5.75	5.66	2.06%	0.001550	0.3%	KC level	-
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N_2O	2.73	2.51	0.91%	0.001335	0.3%	KC level	-
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CO_2	18.64	19.03	6.91%	0.002670	0.6%	KC level	KC trend
5B1	5. LULUCF	B. Cropland	1. Cropland remaining Cropland		CO_2	4.33	4.45	1.62%	0.000508	0.1%	KC level	-
5C1	5. LULUCF	C. Grassland	1. Grassland remaining Grassland		CO_2	2.13	1.80	0.65%	0.001595	0.3%	KC level	-
5C2	5. LULUCF	C. Grassland	2. Land converted to Grassland		CO_2	0.08	0.87	0.32%	0.002692	0.6%	-	KC trend
5E2	5. LULUCF	E. Settlements	2. Land converted to Settlements		CO_2	3.30	3.47	1.26%	0.000124	0.0%	KC level	-

Key Category Analysis 1990 (including LULUCF) IPCC Source Categories (and fuels if applicable)					Direct GHG	Base Year 1990 Estimate	Year t Estimate	Level Assessment	Cumulative Total Column E-L	Result level assessment
Sorted by NFR code										
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO_2	16.48	16.48	6.37%	73.49%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO_2	18.74	18.74	7.24%	52.68%	KC level
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO_2	14.77	14.77	5.70%	79.19%	KC level
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO_2	60.53	60.53	23.38%	23.38%	KC level
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO_2	8.70	8.70	3.36%	86.34%	KC level
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO_2	57.10	57.10	22.06%	45.44%	KC level
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO_2	2.51	2.51	0.97%	93.53%	KC level
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO_2	18.74	18.74	7.24%	59.92%	KC level
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO_2	2.36	2.36	0.91%	94.44%	KC level
4A	4. Agriculture	A. Enteric Fermentation			CH_4	9.80	9.80	3.79%	82.98%	KC level
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N_2O	5.75	5.75	2.22%	88.56%	KC level
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N_2O	2.73	2.73	1.06%	92.56%	KC level
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CO_2	18.64	18.64	7.20%	67.12%	KC level
5B1	5. LULUCF	B. Cropland	1. Cropland remaining Cropland		CO_2	4.33	4.33	1.67%	90.23%	KC level
5C1	5. LULUCF	C. Grassland	1. Grassland remaining Grassland		CO_2	2.13	2.13	0.82%	95.27%	KC level
5E2	5. LULUCF	E. Settlements	2. Land converted to Settlements		CO_2	3.30	3.30	1.27%	91.51%	KC level

Table 135 Liechtenstein's key categories in 2007 and in 1990 including LULUCF categories.

In the KCA 2007 including LULUCF categories there are in total 135 categories. 22 of them are key categories, covering 95.3% of the level assessment. Five of the key categories are from the LULUCF sector. The largest category is 5A1 Forest Land remaining Forest Land (6.9%). The other LULUCF key categories are of minor importance: 5B1 Cropland remaining Cropland (1.6%), 5C1 Grassland remaining Grassland (0.7%), 5C2. Land converted to Grassland (0.3%), 5E2. Land converted to Settlements (1.2%).

In the KCA including LULUCF categories for 1990, 16 categories appear as key categories. Four of the key categories are from the LULUCF sector. In contrast to the analysis for 2007 5C2 Land converted to Grassland drops from the list of key categories since its contribution is small.

Please note that the KCA including LULUCF categories shown in the table above is not the same as the “combined KCA without and with LULUCF categories” provided in Table 6. The KCA including LULUCF is a full KCA that includes also LULUCF sources, whereas the “combined KCA with and without LULUCF categories” combines the result of two key category analyses:

- Key categories of all non-LULUCF key categories that result from the KCA without LULUCF plus
- all LULUCF-key-categories that result from the KCA with LULUCF.

Annex 2: Detailed discussion of methodology and data for estimating CO_2 emissions from fossil fuel combustion

CO_2 Emission Factors, net calorific values and densities of fossil fuels

All parameters of fossil fuels are assumed to be constant for the period 1990 to 2007.

Fuel	CO2 Emission Factor 1990-2007			Net calorific values (NCV)		Density
	t CO_2 / TJ	t CO_2 / t	t CO_2 / volume	GJ / t	GJ / volume	t / volume
Hard Coal	94.0	2.47	---	26.3	---	---
Gas Oil	73.7	3.14	2.65t / 1000 lt	42.6	36.0 / 1000 lt	0.845 t / 1000 lt
Residual Fuel Oil	77.0	3.17	3.01t / 1000 lt	41.2	39.1 / 1000 lt	0.950 t / 1000 lt
Natural Gas	55.0	2.56	2.00t / 1000 Nm^3	46.5	36.3 / 1000 Nm^3	0.780 t / 1000 Nm^3
Gasoline	73.9	3.14	2.34t / 1000 lt	42.5	31.7 / 1000 lt	0.745 t / 1000 lt
Diesel Oil	73.6	3.15	2.61t / 1000 lt	42.8	35.5 / 1000 lt	0.830 t / 1000 lt
Propane/Butane (LPG)	65.5	---	---	46.0	---	---
Jet Kerosene	73.2	3.15	2.52t / 1000 lt	43.0	34.4 / 1000 lt	0.800 t / 1000 lt
Lignite	104.0	2.09	---	20.1	---	---
Biofuel (vegetable oil)	89.0	3.35	---	37.6	34.6 / 1000 lt	0.92 t / 1000 lt

Table 136 Parameters of fossil fuels used for the modelling of Liechtenstein's GHG emissions. Data source: FOEN 2008. Information for biofuel see Workbook 3.1 of the Australian National Greenhouse Gas Inventory (ANGHGI 1996)

Annex 3: Other detailed methodological descriptions for individual source or sink categories

A3.1 Agriccultural Livestock Population Data for N2O Emission Calculation

Animals 2007		**Number of places**	**Number of animals**	**kg N per head/year**
Cattle			**5'137**	107.5
Mature dairy and non-dairy cattle		2'593	2'593	114.0
Mature non-dairy cattle		466	466	80.0
Young cattle			2'078	
	Milk fed calf, suckler cow calf, breeding calf and breeding cattle less than one year	1'133		13-25
	Fattening calf (places)	78		8
	Fattening cattle	634		33
Breeding cattle (> 1 year)		951		40-55
Swine			**1'735**	
	Fattening pig places (2)	1'084		13
	Breeding pig places (3)	107		35
Sheep			**3'683**	
	Sheep places (4)	1'842		12
Goats			**319**	
	Goat places (5)	175		16
Horses			**279**	
	Foals < 1 year	3		17
	Foals 1 - 2 years	24		42
	Other horses	251		44
Ponies, Mules and Asses		162	**162**	25
Poultry			**12'224**	
	laying hens	11'357		0.7
	young hens < 18 weeks	1		0.3
	broilers	702		0.4
	turkeys	164		1.4
Total			**23'539**	

(1) N excretion calculated based on milk production according to Walther et al. 1997 and FAL/RAC 2001.

(2) One fattening pig place corresponds to one fattening pig over 25 kg, 1/6 fattening pig place to one young pig below 30 kg.

(3) One breeding pig place corresponds to one sow, 1/2 breeding pig place to one boar.

(4) One sheep place corresponds to one ewe over one year. Other sheep are not included.

(5) One goat place corresponds to one goat over 1.5 years. Goats younger than 1.5 years are not included.

(6) includes ammonia volatilization calculated for each species based on management practice and NO_x emissions of 0.7% of the excreted N.

Table 137 Livestock population data for N_2O emission calculation.

A3.2 Additional Data for N2O Emission Calculation of Agricultural Soils (4D)

2007	Total crop production Crop(O) and Crop(BF) (kg DM)	Nitrogen incorporated with crop residues F(CR) (t N)	N_2O emissions from crop residues (t N_2O)	N fixed per kg crop (kg N/kg crop)	N fixed (kg N)	N_2O emissions from N fixation (t N_2O)
1. Cereals						
Wheat	450'075	3.4	0.1			
Barley	265'659	1.5	0.0			
Maize	283'696	2.4	0.0			
Oats	0	0.0	0.0			
Rye	0	0.0	0.0			
Other (please specify)						
Spelt	21'458	0.2	0.0			
Triticale	62'628	0.7	0.0			
Mix of fodder cereals	0	0.0	0.0			
Mix of bread cereals	0	0.0	0.0			
2. Pulse						
Dry bean	0	0.0	0.0	0.0443	0	0.0
Peas	0	0.0	0.0	0.0330	0	0.0
Soybeans	28'263	1.2	0.0	0.0571	1'899	0.0
Other (please specify)						
Leguminous vegetables	32'400	3.3	0.1	0.0177	3'190	0.1
3. Tuber and Root						
Potatoes	635'184	2.8	0.1			
Other (please specify)						
Fodder beet	20'544	0.2	0.0			
Sugar beet	366'223	3.5	0.1			
5. Other (please specify)						
Silage corn	6'407'808	1.4	0.0			
Green corn	1'089'327	0.2	0.0			
Fruit	9'187	0.0	0.0			
Vine	19'600	0.1	0.0			
Non-leguminous vegetables	685'248	10.7	0.2			
Sunflowers	0	0.0	0.0			
Tobacco	0	0.0	0.0			
Rape	12'884	0.2	0.0			
Total Non-leguminous	10'329'521	27.2	0.5		0.0	0.0
Total Leguminous	60'663	4.5	0.1		5'089.4	0.1
Total	10'390'183	31.7	0.6		5'089	0.1

Table 138 Additional data for N_2O emission calculation of agricultural soils (4D).

Annex 4: CO_2 Reference Approach and comparison with Sectoral Approach, and relevant information on the national energy balance

No supplementary information to the statements given in Chapter 3.6 Comparison of Sectoral Approach with reference Approach.

Annex 5: Assessment of completeness and (potential) sources and sinks of greenhouse gas emissions and removals excluded

No supplementary information to the statements given in Chapter 1.8 Completeness Assessment

Annex 6: Additional information to be considered as part of the NIR submission (where relevant) or other useful reference information

No supplementary information.

Annex 7: Supplementary Information to the Uncertainty Analysis Tier 2

The uncertainty analysis presented in this paragraph is based on the data of the present GHG inventory for 1990 and 2007. The present Monte Carlo Simulation includes all emission source categories, i.e. key categories **and** non-key categories. However, both groups were treated slightly differently for the simulation:

Key categories: For the category 1A Energy Fuel Combustion, the uncertainties of both activity data and emission factors are taken into account for the simulation. For the remaining key categories, only the uncertainty of the emissions is taken into consideration.

Assumptions for probability distribution

IPCC Source Category		Fuel	Gas	Probability distribution		
				AD	EF	Emission
1. CO2 emissions from Fuel Combustion						
1A	1. Energy	Gaseous fuels	CO2	normal	normal	---
1A	1. Energy	Gas oil and LPG	CO2	normal	normal	---
1A	1. Energy	Gasoline	CO2	normal	normal	---
1A	1. Energy	Diesel	CO2	normal	normal	---
1A	1. Energy	Jet Kerosene	CO2	normal	normal	---
1A	1. Energy	Solid fuels	CO2	normal	normal	---
2. Emissions which are not CO2 emissions from Fuel Combustion						
2F	F. Consumption of Halocarbons and SF6		HFC	---	---	normal
4A	A. Enteric Fermentation		CH4	---	---	normal
4D1	D. Agricultural Soils; Direct Soil Emissions		N2O	---	---	lognormal
4D3	D. Agricultural Soils; Indirect Emissions		N2O	---	---	lognormal

Table 139 Probability distribution assigned to activity data, emission factors and emissions (1990 and 2007) of key categories. For the remaining categories, normal probability distributions have been assigned to the emission uncertainties.

Assumptions for correlations between activity data and emissions factors

For modelling of the level uncertainty, the following assumption has been made:

- the activity data of categories “1A Fuel combustion, gasoline” and “1A Fuel combustion, diesel” are positively correlated (r = 0.3). As gasoline and diesel sales are always accounted together (questionary filled by sellers), accounting uncertainty is expected to affect both fuels in the same way: either both are underestimated or both are overestimated (positive correlation).

For modelling of the **trend uncertainty,** the following assumptions have been made:

- the emission factors of each source are strongly and positively correlated (r = 1.0) between 1990 and 2007.
- also, the activity data of each source is positively correlated between 1990 and 2007 (r = 0.5). The correlation is not too strong since the methods for documenting the amounts of fuels sold have been changed at last for gasoline and diesel.

Relation between simulated and inventory values

The Monte Carlo simulation simulates a probability distribution for which all relevant statistical parameters are determined like mean, standard deviation and percentiles. The simulated mean value may slightly differ from the reported CRF value. This occurs because lognormal distributions are applied to some categories.

The discrepancy between simulated and reported values becomes apparent when Figure 5 is compared to Table 11. Note that it is not a relevant issue for the uncertainty analysis but is rather confusing for readers and reviewers who carefully study the numbers. For transparency reasons, the numbers are explained in Table 140.

The absolute percentiles generated by the simulation are expressed as relative numbers (the simulated mean is set to 100%). The relative numbers are then transferred – unchanged – to the mean numbers as reported in the CRF tables, and they are applied to derive the absolute uncertainties (see).

Parmeters	Unit	Emission (excl. LULUCF)	Lower bound 2.5 percentile	Upper bound 97.5 percentile	Lower uncertainty	Upper uncertainty
simulated values				1990		
absolute	Gg CO_2 eq	229.6	208.6	250.7	-21.0	21.2
relative	%	100.0%	90.9%	109.2%	-9.1%	9.2%
values of CRF						
absolute	Gg CO_2 eq	229.6	208.6	250.7	-21.0	21.2
relative	%	100.0%	90.9%	109.2%	-9.1%	9.2%
simulated values				2007		
absolute	Gg CO_2 eq	243.9	229.3	258.8	-14.5	15.0
relative	%	100.0%	94.0%	106.1%	-6.0%	6.1%
values of CRF						
absolute	Gg CO_2 eq	243.5	229.0	258.4	-14.5	15.0
relative	%	100.0%	94.0%	106.1%	-6.0%	6.1%

Table 140 Mean values, 2.5% and 97.5% percentiles of the Monte Carlo simulation and corresponding values of the CRF emissions.

Further Results of the Monte Carlo Uncertainty Analysis

In addition to the results presented in Table 11, Table 141 shows results for the uncertainties of the key categories. The uncertainty of the emission is only a Monte-Carlo simulated result if uncertainty numbers are given in the corresponding columns “uncertainty of activity data” and “uncertainty of emission factors” (e. g. source categories 1A). In the other cases, the uncertainty of the emission is an input data for the Monte Carlo simulation.

IPCC Source category			Gas	Activity Data Year t (2007)		Uncertainty of Activity Data	Emission Factor		Uncertainty of Emission Factor	Emissions Year t	Uncertainty of
						(%)			(%)	Gg CO_2 equivalent)	(%)
1. CO2 emissions from Fuel Combustion											
1A	1. Energy	Gaseous fuels	CO2	1399	(TJ)	5.0	55.0	(t/TJ)	4.6	77	6.8
1A	1. Energy	Gas oil and LPG	CO2	619	(TJ)	20.0	73.6	(t/TJ)	0.6	46	20.0
1A	1. Energy	Gasoline	CO2	756	(TJ)	10.0	73.9	(t/TJ)	1.4	56	10.1
1A	1. Energy	Diesel	CO2	434	(TJ)	15.0	73.6	(t/TJ)	0.5	32	15.0
1A	1. Energy	Jet Kerosene	CO2	1.8	(TJ)	15.0	73.2	(t/TJ)	1.2	0.1	15.0
1A	1. Energy	Solid fuels	CO2	0.13	(TJ)	20.0	94.0	(t/TJ)	5.0	0.01	20.6
2. Emissions which are not CO2 emissions from Fuel Combustion											
2F	F. Consumption of Halocarbons and SF6		HFC	---	---	---	---	---	---	4.47	6.9
4A	A. Enteric Fermentation		CH4	---	---	---	---	---	---	10.38	9.2
4D1	D. Agricultural Soils; Direct Soil Emissions		N2O	---	---	---	---	---	---	5.66	38.3
4D3	D. Agricultural Soils; Indirect Emissions		N2O	---	---	---	---	---	---	2.51	79.6

Table 141 Activity data, emission factors, emissions and their corresponding uncertainties of key categories in Monte Carlo simulation (to be compared with Table 11)

Table 142 shows the results of the Tier 2 uncertainty calculation for all emission source categories, including non-key categories. The lower and the upper limit of the 95% confidence interval is given for each category, as well as the uncertainty introduced on the national total in year t (2007).

A					B	C	D	E	F	G
IPCC Source category					Gas	Base Year Emissions (1990)	Year t Emissions (2007)	Uncertainty in Year t emissions as % of emissions in the category		Uncertainty introduced on national total in Year t
								% below (2.5 percentile)	% upper (97.5 percentile)	%
KEY SOURCES										
1. CO2 emissions from Fuel Combustion										
1A	1. Energy	A. Fuel Combustion		Gaseous fuels	CO2	27.8	76.9	71.9	82.1	2.1
1A	1. Energy	A. Fuel Combustion		Gas oil and LPG	CO2	94.6	45.6	36.6	54.5	3.7
1A	1. Energy	A. Fuel Combustion		Gasoline	CO2	60.5	55.8	50.3	61.4	2.3
1A	1. Energy	A. Fuel Combustion		Diesel	CO2	18.4	31.9	27.2	36.6	1.9
1A	1. Energy	A. Fuel Combustion		Jet Kerosene	CO2	0.08	0.13	0.1	0.2	0.01
1A	1. Energy	A. Fuel Combustion		Solid fuels	CO2	0.09	0.01	0.0	0.0	0.001
2. Emissions which are not CO2 emissions from Fuel Combustion										
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			HFC	0.00	4.5	3.9	5.1	0.2
4A	4. Agriculture	A. Enteric Fermentation			CH4	9.8	10.4	8.5	12.2	0.8
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	5.8	5.7	1.4	9.9	1.7
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	2.7	2.5	0.0	6.4	1.3
NON KEY SOURCES										
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			SF6	NO	0.12	0.1	0.1	0.0
3	3. Solvent and Other Product Use				CO2	1.5	0.86	0.2	1.5	0.3
6C	6. Waste	C. Waste Incineration			CO2	0.01	0.01	0.0	0.0	0.0
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.001	0.02	0.0	0.0	0.0
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0.002	0.00	0.0	0.0	0.0
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constructio	Gaseous Fuels	CH4	0.04	0.05	0.0	0.1	0.0
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constructio	Liquid Fuels	CH4	0.01	0.00	0.0	0.0	0.0
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH4	0.00	0.00	0.0	0.0	0.0
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CH4	0.01	0.01	0.0	0.0	0.0
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	0.49	0.10	0.0	0.2	0.0
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	CH4	0.00	0.05	0.0	0.1	0.0
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	CH4	0.00	0.00	0.0	0.0	0.0
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CH4	0.02	0.06	0.0	0.1	0.0
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CH4	0.02	0.01	0.0	0.0	0.0
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	CH4	0.00	0.01	0.0	0.0	0.0
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	0.01	0.05	0.0	0.1	0.0
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	0.01	0.00	0.0	0.0	0.0
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH4	0.01	0.00	0.0	0.0	0.0
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	0.13	0.42	0.3	0.5	0.1
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CH4	0.00	0.00	0.0	0.0	0.0
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CH4	0.00	0.00	0.0	0.0	0.0
1B2	1. Energy	B. Fugitive Emissions from Fuels	2. Oil and Natural Gas		CH4	0.32	1.07	0.0	1.6	0.2

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4B	4. Agriculture	B. Manure Management			CH4	1.9	1.7	0.8	2.7	0.4
6A	6. Waste	A. Solid Waste Disposal on Land			CH4	0.22	0.02	0.0	0.0	0.0
6B	6. Waste	B. Wastewater Handling			CH4	0.02	0.03	0.0	0.0	0.0
6C	6. Waste	C. Waste Incineration			CH4	0.01	0.01	0.0	0.0	0.0
6D	6. Waste	D. Other			CH4	0.40	0.66	0.3	1.0	0.2
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	0.00	0.00	0.0	0.0	0.0
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N2O	0.05	0.08	0.0	0.1	0.0
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constructio	Gaseous Fuels	N2O	0.01	0.01	0.0	0.0	0.0
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constructio	Liquid Fuels	N2O	0.05	0.02	0.0	0.0	0.0
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	0.00	0.00	0.0	0.0	0.0
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	N2O	0.05	0.16	0.0	0.4	0.1
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	0.47	0.48	0.0	1.2	0.2
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gaseous Fuels	N2O	0.00	0.00	0.0	0.0	0.0
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	N2O	0.00	0.00	0.0	0.0	0.0
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	N2O	0.00	0.02	0.0	0.0	0.0
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	N2O	0.14	0.07	0.0	0.1	0.0
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	N2O	0.01	0.04	0.0	0.1	0.0
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	0.01	0.08	0.0	0.1	0.0
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	0.05	0.02	0.0	0.0	0.0
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	N2O	0.00	0.00	0.0	0.0	0.0
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N2O	0.01	0.03	0.0	0.1	0.0
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	N2O	0.01	0.02	0.0	0.0	0.0
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	N2O	0.03	0.04	0.0	0.1	0.0
3	3. Solvent and Other Product Use				N2O	0.47	0.25	0.1	0.4	0.1
4B	4. Agriculture	B. Manure Management			N2O	1.5	1.6	0.7	2.5	0.4
4D_o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O			N2O	0.82	0.66	0.1	1.2	0.2
6B	6. Waste	B. Wastewater Handling			N2O	0.81	0.99	0.0	2.5	0.5
6C	6. Waste	C. Waste Incineration			N2O	0.00	0.00	0.0	0.0	0.0
6D	6. Waste	D. Other			N2O	0.08	0.14	0.0	0.3	0.1
Total						229.6	243.5	229.0	258.4	6.05

Table 142: Tier 2 Uncertainty calculation and reporting for all sources, including non-key categories.

Annex 8: Supplementary Information the QA/QC System

A8.1 Checklists for QC activities

- Checklist for project manager (PM), project manager assistant (PMA), staff member climate unit (SC), sectoral experts (SE)
- Checklist for national inventory compiler (NIC)
- Checklist for NIR authors (NA)

Quality control system for Climate Reporting Liechtenstein Submission 11 March 2009				
Checklist for sectoral experts and NIR Authors Contact person: Telephone, e-mail:	 Jürg Heldstab (INFRAS) +41 44 205 95 11, juerg.heldstab@infras.ch			
QC activity	**Procedure (description of checks that were carried out)**	**respon-sibles**	**date**	**visa**
General activities (table 8.1 IPCC GPG)	***General procedures***			
1. Check that assumptions and criteria for the selection of activity data and emission	ongoing checks	SE/NIC	Sep-Dec08	JB
	EBP-internal checks, comparison with methods chosen	NA	17.11.08	RBO
	INFRAS-internal checks, comparison with methods chosen	SE	05.12.08	JH
2. Check for transcription errors in data input and reference	check Input-Data for Energy	SE	31.10.08	JB
	plausibility check of the basic input data from the LWA	SE	22.09.08	JB
	check Input-Data for Waste	SE	13.11.08	JB
	check input Data for Agriculture	SE	22.09.08	JB
	check stationary Energy, Ind. Proc., Solvents	NA	17.11.08	RBO
	check Waste	NA	17.11.08	SO
	check mobile Energy.xls: missing values biodiesel	SE	12.11.08	JH
	re-check Energy.xls: NCV ok, time series ok	SE	05.11.08	JH
	Agriculture: Plausibility check of data in background tables Acontec	SE	17.11.08	SG
3. Check that emissions are calculated correctly	Ongoing checks of the calculated emissions in all sectors	SE/NIC	Oct-Dez08	JB
	reached the calculated Energie consumption	SE	12.11.08	JB
	EBP-internal control: Plausibility checks, "Delta-Analysis" combined with KCA, INFRAS-internal control of time series, comparison with February 08 submission.	NA	10.12.08	RBO, SO
	INFRAS-internal checks during generationof tables/figure in Chapter. 2 Trends (independant control by second person Fabia Moret)	SE	20.11.08	JH
4. Check that parameter and emission units are correctly recorded and that appropriate conversion factors are used	check energy-activity-data (input-data)	SE	13.11.08	JB
	check input data format in the sector waste	SE	19.11.08	JB
	check stationary Energy, Ind. Proc., Solvents	NA	12.12.08	RBO
	check Waste	NA	12.12.08	SO
	check mobile Energy, Agriculture	SE	12.11.08	JH
	check Agriculture	SE	19.11.08	SG
	check LULUCF	SE	21.11.08	SG
5. Check the integrity of database files	integrity checked	NIC	25.02.08	JB
6. Check for consistency in data between source categories	consistency checked	NIC	ongoing	JB
	check stationary Energy, Ind. Proc., Solvents	NA	16.12.08	RBO
	check Waste	NA	16.12.08	SO
	check mobile Energy, Agriculture,	SE	12.11.08	JH
	check Agriculture	SE	19.11.08	SG
	check LULUCF	SE	28.11.08	SG
7. Check that the movement of inventory	Processing checked	NIC	ongoing	JB
	check Agriculture	SE	19.11.08	SG
	plausibility check / control of overall emissions from agriculture in CO_2 equivalents, in total and for the source categories for all years	SE	19.11.08	SG
	check LULUCF	SE	21.11.08	SG
8. Check that uncertainties in emissions and removals are estimated or calculated correctly	check stationary Energy, Ind. Proc., Solvents	NA	11.12.08	RBO
	check mobile Energy, Agriculture	SE	12.11.08	JH
	check the correctness of data extrapolation in the LULUCF sector, based on the available land use inventories and the LFI	SE	03.12.08	SG
9. Undertake review of internal documentation	internal documentation checked	SE/NIC	14.01.08	JB
	OEP internal meeting: check on actual state of project, clarification of comprehensive questions	PM/NIC PMA	30.11.08	HK, AG
	proofread NIR	NA	17.12.08	RBO
	proofread NIR	NA	17.12.08	SO
	proofread NIR	NA	29.12.08	JH

continued next page

QC activity	Procedure (description of checks that were carried out)	respon-sibles	date	visa
General activities (table 8.1 IPCC GPG)	*General procedures*			
11. Undertake completeness checks	Completness check for Waste and Energy	SE	11.11.08	JB
	Completness check for all other sectors	SE	12.11.08	JB
12. Compare estimates to previous	check of KCA previous/latest key categories	NA	18.12.08	JH
	plausibility checks of the CRF tables	PMA	14.11.08	AG
	check stationary Energy, Ind. Proc., Solvents	NA	17.11.08	RBO
	check Waste	NA	17.11.08	SO
	check mobile Energy, Agriculture,	SE	21.11.08	JH
	check Agriculture	SE	24.11.08	SG
	check LULUCF	SE	03.12.08	SG
13. Archiving activities	Checked: Documents of submission April 2008 have been archived	PMA	30.01.09	AG
14. Further activities	see Inventory Development Plan, minutes of meetings Inventory Core Group and Review Reports UNFCCC	all	18.06.08	all
Country-specific activities	*Specific procedures*			
20. Where LIE uses Swiss-specific methods: If a change in the Swiss inventory occurs, check whether the change has to be adopted for LIE or not	check Energy (mobile)	SE	21.11.08	JH
	check Agriculture	SE	03.12.08	SG
	check LULUCF	SE	08.12.08	SG
	clarification whether land-use changes between different categories of unmanaged land should be reported and handled differently (set to zero) in the coming years in terms of emissions, plausibility guess	SE	17.12.08	SG/JH
21. Where LIE uses Swiss-specific EF: Where changes in the Swiss EFoccur, check whether the changes are also adequate for LIE or not	check: Energy (stationary), Solvents	NA	05.12.08	RBO
	check Energy (mobile)	SE	01.12.08	JH
	check Agriculture	SE	03.12.08	SG
	check LULUCF	SE	08.12.08	SG
22. Check correctness of KCA, comparison with previous results	plausibility checks	PMA	15.01.08	AG
	EBP-internal plausibility control: caluculation and check of sub-totals,	NA	14.12.08	RO, JH
	cross-check within KCA with/without LULUCF 1990 and 2007: Emissions correct, thresholds correct. Comparison with KCA of Submission Feb 2008	NA	27.11.08	JH
23. Check correctness of uncertainty analysis, comparison with previous results	EBP-internal plausibility checks	NA	11.12.08	RBO
24. Check of transcription errors CRF -> NIR (numbers, tables, figures)	EBP-internal control: Comparison of data in CRF tables with NIR	NA	14.12.08	RBO, SO
	INFRAS-internal control. Comparison of data in CRF tables and NIR. For the transcription of emission data into chapters Exec. Summ., 2. Trends, X.1 Overview (in all sectors) a INFRAS collaborator generates figures and tables, copies them into NIR and adjusts the text correspondingly. These working steps are afterwards checked by another collaborator of INFRAS.	NA NIC	10.11.08 12.11.08	JH JB
25. Check for complete and correct references in NIR	EBP-internal checks	NA	16.12.08	RBO, SO
	INFRAS-internal checks	NA	29.12.08	JH
26. Check for correctness, completeness, transparency and quality of NIR	checked/adapted the correct quotation of LIE statistics for agricultural data (different years, also internal sources)	SE	17.11.08	SG
	unification of terms in the LULUCF chapter, i.e. the altitude categories or the	SE	10.12.08	SG
	recalculated the Swiss mean value of carbon stocks under permanent grass-land on mineral soils (CC31) and introduced in table 111 and chapter 7.5.2	SE	12.12.08	SG
	transparent description which combination categories are considered as managed or unmanaged grasslands respectively (chapter 7.5.1)	SE	03.12.08	SG
	final proofread inventory/NIR, discussion with HK and feedback to JH	PM, PMA	18.02.09	AG, PI
27. Check for completeness of submission documents	final check and submission	PM/ NIC	10.03.09	HK, AG, PI
28. Further activities	Archiving: INFRAS, EBP, Acontec save internally all data individually. NIR in MS-DOC and PDF format are sent to OEP. All tables in MS-EXCEL format are sent to OEP for separate archiving.	NA, NIC	10.03.09 27.02.09	JH, RBO, JB, SO

Table 143 Checklist for QC activities (part in orange of previous page) and for follow-up activities if necessary (this page). The general activities are taken from IPCC GPG, table 8.1, the country specific activities are ad-hoc activities of Good Practice Guidance (IPCC 2000). Abbr.: NA NIR authors, NIC: national inventory compiler (HK is the NIC; note that preliminary feeding/running of the CRF Reporter is delegated to JB as NIC assistant), PM project manager, PMA project manager assistant, SC staff member climate unit, SE sectoral experts.
Member codes: AG Andreas Gstoehl, HE Hanspeter Eberle, HK Helmut Kindle, JB Jürgen Beckbissinger, JH Jürg Heldstab, PI Patrick Insinna, RBO Roman Bolliger, SB Sven Braden, SG Sonja Gehrig, SO Markus Sosmmerhalder.

A8.2 Checklists for QA activities (internal review)

Liechtenstein's National Inventory Report
Review-Formular für das Interne Review Submission Februar 2009

Reviewer	**Andreas Gstöhl, project manager (PM)**
Amt / Firma	AFU
Telefon, E-Mail	00423 236 61 86
Begutachtete(s) Kapitel inklusive Annex, References	Kompletter Bericht

NIR-AutorIn	Jürg Heldstab
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Kommentare des Reviewers (gelb) und Erwiderung der Autorin/des Autors (grün)
Inhaltsverzeichnis: Annex-Auflistung bezüglich Formatierung anschauen. Rest i.O.
Frage zurück an Gstoehl
Executive Summary: Kleine Korrekturen angebracht und ein paar Fragen an die NIR Autoren.
erledigt
Kapitel 1: Diverse kleine Bemerkungen/Fragen. Aktualisierte Version der Kap. 1.7.4 bis 1.8 geprüft und nur kleine redaktionelle Korrekturen. (Kapitel auf S. 35 d) Results: ein Punkt zuviel hinter der Zahl 9.17% sowie Frage, was "cf" in der Klammer (cf. Figure 5) bedeutet.
erledigt
Kapitel 2: Kleine redaktionelle Fragen/Verbesserungsvorschläge. Neue Kommentare bzw. Begründungen (v.a. für Rückgang Brennstoff"verbrauch") geprüft und in Ordnung befunden.
ok
Kapitel 3: Neue Offroad Emissionsfaktoren sind berücksichtigt. Separate Unsicherheitsbetrachtung: wie ist die Herleitung der 10% beim Benzin und 15% beim Diesel? Ich schätze den Fehler bei Benzin <10%. S. 69 bei Erklärung des starken Rückgangs stolpere ich bei den letzten beiden Sätzen. Bitte kurze Erklärung, was ausgesagt werden soll: gehts hier um die Diskrepanz Einkauf vs. effektive Emissionen?
Unsicherheiten 1990 und 2007 sind gleich gross, um Unc. Analysis nicht zu kompliziert zu machen. 10% resp. 15% Unsicherheit scheint für 1990 nicht zu hoch
Kapitel 4: Absatz 4.2.6. Planed Improvements: komme nicht richtig draus. Bitte kurz erklären. HFC aus Entsorgung: wieviel macht das etwa aus? 4.7.6. Planed Improvements: Rückfrage zum INFRAS Vorschlag: Wieviel macht die aktuelle Betrachtung aus? Hab mir mal die Zahl 140t notiert, die wir allenfalls zuviel haben. Lohnt sich Aufwand und Nutzen, bzw. was spricht dafür der Sache genauer nachzugehen? Haben wir konkreten Handlungsbedarf?
erledigt
Kapitel 5: Inhalt bei den Planed Improvements nicht ganz klar. Vgl. Kap. 4.
erlecdigt
Kapitel 6: Kapitel geprüft, keine Korrekturen
ok
Kapitel 7: Letzter Absatz im Kap. 7.2.4: Bitte nochmal kurz Hintergrund erläutern. Kap. 7.3.6, 7.4.6, etc. immer noch auf Stand Submission 2008? Kap. 7.5.6 und 7.6.6: Heisst das, dass das "Versäumnis" vom letzten Jahr noch immer vorliegt und hier einfach anders formuliert ist?
erledigt
Kapitel 8: Im Vorfeld diskutierte Punkte (z.B. Daten Kompostierung Gemeinde Mauren) wurden übernommen.
erledigt
Kapitel 9: Kapitel geprüft, keine Korrekturen.
ok
References: Keine Korrekturen. Annex: Kleine redaktionelle Bemerkungen. Annex 8 aktualisiert.
ok
1) Generell: verschiedene Abbildungen sind in der Berichtsversion "Anpassungen" noch nicht auf das Jahr 2007 aktualisiert. Bitte nochmal durchgehen.
erledigt
2) Wechsel vom Begriff "Source Category" (siehe 3.1.1.) zum Begriff "Sector" konsequent durchziehen.
erledigt

Review durchgeführt	
Datum / Signum	14./15./16./18. Januar 2008; Andreas Gstöhl

Review zur Kenntnis genommen	
Datum / Signum	23.01.2009, JH

Reviewer	Andreas Gstöhl
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Begutachtete(s) Kapitel inklusive Annex, References	Kompletter Bericht

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Kommentare des Reviewers (gelb) und Erwiderung der Autorin/des Autors (grün)
Kapitel 3: Neue Offroad Emissionsfaktoren sind berücksichtigt. Separate Unsicherheitsbetrachtung: wie ist die Herleitung der 10% beim Benzin und 15% beim Diesel? Ich schätze den Fehler bei Benzin <10%. S. 69 bei Erklärung des starken Rückgangs stolpere ich bei den letzten beiden Sätzen. Bitte kurze Erklärung, was ausgesagt werden soll: gehts hier um die Diskrepanz Einkauf vs. effektive Emissionen?
RBO: Erklärung des starken Rückgangs: Ja, es geht um diese Diskrepanz. Wie folgt Verständlichkeit verbessert: Kap 2.3: 1A4: Inhabitants have increased by 22% whereas employment has increased by 40% in the period 1990-2007, which is reflected in a similar increase of energy consumption and GHG emissions by 30.7% until 2006 with several fluctuations caused by warm and cold winter periods. From 2006 to 2007 a pronounced jump downwards of almost one forth is observed. There are two hypotheses that may explain the decrease: A very high price for gas oil in the corresponding period, which gave an incentive for people to reduce fuel consumption and which also caused people to hold off the filling of their oil tanks and – simultaneously – warm winter months at the beginning and at the end of 2007, which is documented by a reduction of 5% to 10% in the heating degree days of Liechtenstein in 2007. (A similar, albeit less significant, phenomenon may be observed in Switzerland, where the prices for gas oil and the climate are similar to Liechtenstein).
Holding off the filling of the residential fuel tanks would mean that to some extent instead of buying new fuel, stocks in residential fuel tanks were depleted. A calculation based on consumption data without taking account those residential stock changes, as it is currently the case for Liechtenstein, may therefore underestimate actual emissions in 2007. Similarly, actual emissions may be overestimated in following years, when residential tanks might be refilled. Next year's fuel consumption data will probably show which of the reasons explain the decrease in fuel consumptiom from 2006 to 2007.
Kap 3.3.2: The significant decrease of gas oil consumption between 2006 and 2007 may be due to two reasons, as explained in chapter 2.3: high prices of fossil fuels and warm winters. The former might lead to stock changes in residential tanks, which would entail an underestimation of actual emissions in 2007 and an overestimation in subsequent years, when stocks might be refilled. Next year's fuel consumption data will probably show which of the reasons explain the decrease in fuel consumptiom from 2006 to 2007.
Kapitel 4: Absatz 4.2.6. Planed Improvements: komme nicht richtig draus. Bitte kurz erklären. HFC aus Entsorgung: wieviel macht das etwa aus? 4.7.6. Planed Improvements: Rückfrage zum INFRAS Vorschlag: Wieviel macht die aktuelle Betrachtung aus? Hab mir mal die Zahl 140t notiert, die wir allenfalls zuviel haben. Lohnt sich Aufwand und Nutzen, bzw. was spricht dafür der Sache genauer nachzugehen? Haben wir konkreten Handlungsbedarf?
RBO: Zu Absatz 4.2.6 planned improvements: Habe zweiten Satz jetzt herausgestrichen, da der erste Satz bereits alles sagt, in etwas allgemeiner Form. Es geht um zwei Sachen: 1. Zahlen Bevölkerung CH sind leicht anders in CH NIR, soll bereinigt werden. 2. der hier für verwendete EF von Liechtenstein für 2007 ist wie folgt bisher berechnet: (Emissionen CH 2006 / Bevölkerung CH 2007). In Zukunft sollte das für das neuste Jahr nach dem Muster sein: EF LIE 2007 = (Emissionen CH 2006 / Bevölkerung CH 2006)
Kapitel 5: Inhalt bei den Planed Improvements nicht ganz klar. Vgl. Kap. 4.
RBO: analog zu Kap. 4
Kapitel 6: Kapitel geprüft, keine Korrekturen
Kapitel 7: Letzter Absatz im Kap. 7.2.4: Bitte nochmal kurz Hintergrund erläutern. Kap. 7.3.6, 7.4.6, etc. immer noch auf Stand Submission 2008? Kap. 7.5.6 und 7.6.6: Heisst das, dass das "Versäumnis" vom letzten Jahr noch immer vorliegt und hier einfach anders formuliert ist?
Ja
Kapitel 8: Im Vorfeld diskutierte Punkte (z.B. Daten Kompostierung Gemeinde Mauren) wurden übernommen.
okay
Kapitel 9: Kapitel geprüft, keine Korrekturen.
References: Keine Korrekturen. Annex: Kleine redaktionelle Bemerkungen. Annex 8 aktualisiert.

Review durchgeführt	
Datum / Signum	14./15./16./18. Januar 2008; Andreas Gstöhl

Review zur Kenntnis genommen	
Datum / Signum	27.1.2009, RBO

Reviewer	**Patrick Insinna, staff memeber climate unit OEP**
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Begutachtete(s) Kapitel inklusive Annex, References	Gesamtes Dokument

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Kommentare des Reviewers (gelb) und Erwiderung der Autorin/des Autors (grün)
Amtskürzel einheitlich auf Grundlage von englischen Bezeichnungen gestellen (betroffene Kapitel markiert)
ok
Einzelne Jahreszahlen (2006/2008) im Dokument aktualisiert
ok
Prozentangabe 1A4a in Executive Summary um eine Dezimalstelle geaendert, um auf exakten Gesamtwert zu kommen.
ok
Anmerkung zur Beschreibung der Mone Carlo Analyse in der Einleitung
ok
Kleinere redaktionelle Anmerkungen in Kapitel 2.
ok
Aktualiserte Fassung von Kapitel 7.9 muss noch gelesen werden.
findet im Feb statt
Abbildung 135 (Annex 7, Seite 199) nicht korrekt formatiert - Kontrolle.
Formatierung korrigiert
Aktuelle KP LULUCF Tabellen in Annex 9 übernehmen
erledigt
Inhalte des Annex 10 müssen jährlich aktualisiert werden. In welche Checkliste sollen wir das übernehmen?
erledigt

Review durchgeführt	
Datum / Signum	14./15./16./19. Januar 2009; Patrick Insinna

Review zur Kenntnis genommen	
Datum / Signum	23.01.2009, JH

Reviewer	**Sven Braden, staff member climate unit OEP**
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Begutachtete(s) Kapitel inklusive Annex, References	Executive Summary, Kapitel 1 und 2, Annex 9 und 10

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Kommentare des Reviewers (gelb) und Erwiderung der Autorin/des Autors (grün)
einen Rechtschreibfehler korrigiert, Überprüfung der Textkonsistenz und Verständlichkeit, i.O.
ok

Review durchgeführt	
Datum / Signum	19. Januar 2009; Sven Braden

Review zur Kenntnis genommen	
Datum / Signum	23.01.2009, J.Heldstab; 27.01.2009, R. Bolliger

Liechtenstein's National Inventory Report
Review-Formular für das Interne Review Submission Februar 2009

Reviewer	**Jürgen Beckbissinger, assistant of NIC, sectoral expert**
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Begutachtete(s) Kapitel	Kapitel, 1.4., Kap.9 und enstprechende Verweise
inklusive Annex, References	Kommentare

NIR-AutorIn	Jürg Heldstab
Firma	INFRAS
Telefon, E-mail	+41 44 205 95 11

Kommentare des Reviewers (gelb) und Erwiderung der Autorin/des Autors (grün)
Grundsätzlich: Sämtliche Bemerkungen wurden direkt als Kommentare in den NIR-Entwurf eingetragen. Nur wenig übergeordnete Kommenatre
ok
Emissions from 6B Waste Water Handling 6C Waste Incineration and 6D Other are reported. Es werden auch die Emissionen von 6A rapportiert.
erledigt
1.4.2. Specific Assumptions for the Year 2007 / Energy. Es ist nur der Sektor 1A3b betroffen
nachfragen am 26.1.09
1.4.2. Specific Assumptions for the Year 2007 / Ind. Process. Betroffen sind nur die Sektoren 2A5 und 2A6 nicht jedoch die Sektoren 2F
nachfragen am 26.1.09
1.4.2. Specific Assumptions for the Year 2007 / Agriculture. In dieser Sub wurden für 4A, 4B und 4D die aktuellen 2007 CH Daten verwendet / nicht aufführen
nachfragen am 26.1.09

Review durchgeführt	
Datum / Signum	22.1.2009 / Bb

Review zur Kenntnis genommen	
Datum / Signum	23.01.2009, JH

Table 144 Checklists for QA activity internal review.

Annex 9: Voluntary Supplementary Information for Article 3 paragraph 3 of the Kyoto Protocol: Kyoto Tables

No supplementary information in addition to Chapter 7.9

Annex 10: Information required under Art. 7 paragraph 2 of the Kyoto Protocol: National Registry and Commitment Period Reserve (CPR)

A10.1 Introduction

Under the terms of Art. 7 of the Kyoto Protocol, each Party included in Annex I shall provide the necessary supplementary information in its National Inventory Report (NIR) to demonstrate compliance with Art. 3 of the Kyoto Protocol. Decision 15/CMP.1 is – inter alia – focusing on the reporting requirements for changes in the national registries. Additionally decision 15/CMP.1 refer to Art. 5, para 1, defining the national Guidelines for national systems. Each Party shall describe the changes that have occurred in the system as well as in the registry, compared with the information reported in its last submission. The changes described are in comparison with the Initial Report (IR) submitted in December 2006.

A10.2 Changes in the National System

The national inventory system remains unchanged compared to the description given in the Initial Report under the Kyoto submitted in December 2006 (OEP 2006a, 2007b).

A10.3 Registry administrator

The name and contact information of the registry administrator designated by the Party to maintain the national registry:

The postal address of the registry has changed and two additional persons have joined the registry staff.

Registry Administrator	Contacts
Office of Environmental Protection (OEP) P.O. Box 684 Dr. Grass-Strasse 12 9490 Vaduz Principality of Liechtenstein phone: +423 236 75 96 fax: +423 236 61 99 email: registry@aus.llv.li website: http://www.llv.li/amtsstellen/llv-aus-emissionshandel_en.htm	Main Contact Patrick Insinna Email: patrick.insinna@aus.llv.li Alternative Contact Andreas Gstoehl Email: andreas.gstoehl@aus.llv.li Alternative Contact Helmut Kindle Email: helmut.kindle@aus.llv.li

A10.4 Consolidated system

The names of the other Parties with which the Party cooperates by maintaining the national registries in a consolidated system:

No changes compared to IR 2006. Liechtenstein still cooperates with Switzerland and Monaco for the setting-up and operation of the IT-Platform (hardware and software) for the National Registry. Switzerland is responsible for the technical hosting of the registries of these Parties on servers physically located in Switzerland. The three National Registries are maintained as independent systems with independent registry administrators. The National Registry is based on the Seringas™ registry software, which was developed by the French Caisse des Dépôts et Consignations, CDC. Further developments, updates and releases of the software are undertaken in cooperation with all Seringas™ licensees.

A10.5 Database structure and capacity

A description of the database structure and capacity of the national registry:

According to Decision 13/CMP.1, paragraph 18 „any two or more Parties may voluntarily maintain their respective national registries in a consolidated system, provided that each national registry remains distinct“. This consolidated solution was implemented by Liechtenstein together with Monaco and Switzerland. The latter acting as the technical host with servers physically located in the Swiss Federal Office of Information Technology, Systems and Telecommunication (FOITT). The three Parties' registries are running in parallel but maintained as independent systems with independent registry administrators. The Information and Communication Technology (ICT) architecture is illustrated in Figure 27.

French software application SERINGAS from the developer „Caisse des Depôts et Consingnations (CDC) has been implemented using a Microsoft SQL Server relational data base management system with a dedicated conceptual data model developed by CDC (Figure 28).

The total capacity of the registry is only limited by the maximum size of the Microsoft SQL Server. By March 2009, 22 accounts have been installed and activated.

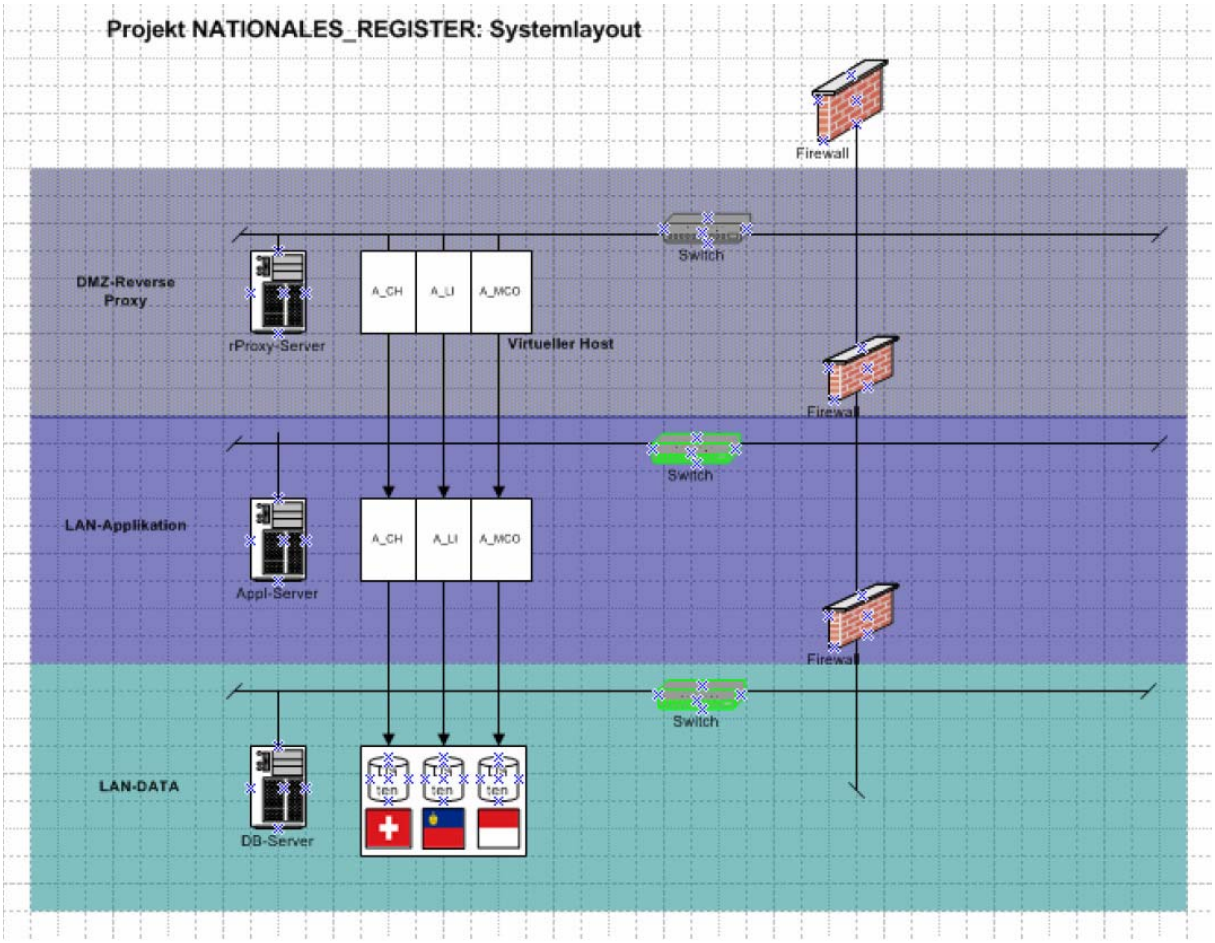

Figure 27 Information and communication technology (ICT) architecture for the consolidated registry system of Switzerland, Liechtenstein and Monaco. Figure kindly provided by the Federal Office of Information Technology, Systems and Telecommunication (FOITT).

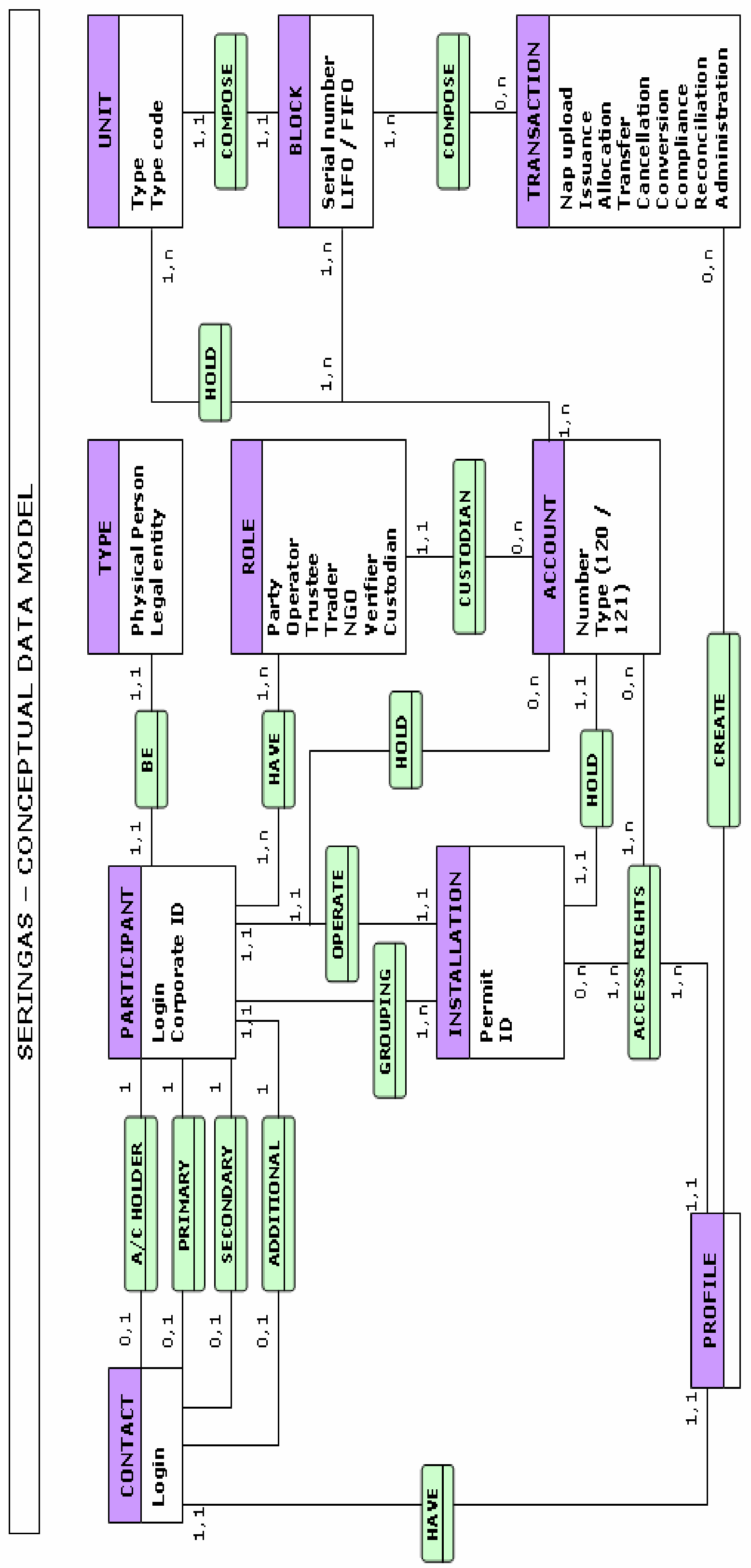

Figure 28 Conceptual Data Model developed by CDC. Figure taken from the „Registry Administrator User Guide Version 4“, page 19.

A10.6 Conformity with Data Exchange Standards (DES)

A description of how the national registry conforms to the technical standards for data exchange between registry systems for the purpose of ensuring the accurate, transparent and efficient exchange of data between national registries, the clean development mechanism registry and the transaction log (decision 19/CP.7):

Liechtenstein's National Registry is in conformity with the DES in the relevant version to ensure the correct treatment and reception of information by the ITL. Software version 4.06. and 4.2 (including all relevant patches of version 4.0.6) respectively were used for interoperability tests according to Annex H of the DES, version 1.1.002, between the national registry of Liechtenstein and the International Transaction Log (ITL) on 5. September 2007. With the final Independent Assessment Report (IAR) dating from 7. December, the ITL Administrator confirmed the successfully completed initialization process.

Further, the requirements mentioned in IR 2006 concerning account numbers, serial numbers of units including project identifier and transaction numbers (Annex F) as well as concerning the list and electronic format of information transmitted electronically when transferring, acquiring, issuing, cancelling or retiring AAUs, CERs, ERUs or RMUs to other national registries or to the CDM registry and/or the ITL (Annex I) are still fulfilled.

A10.7 Prevention of discrepancies

A description of the procedures employed in the national registry to minimize discrepancies in the issuance, transfer, acquisition, cancellation and retirement of ERUs, CERs, tCERs, lCERs, AAUs and/or RMUs, and replacement of tCERs and lCERs, and of the Stepps taken to terminate transactions where a discrepancy is notified and to correct problems in the event of a failure to terminate the transactions:

To prevent discrepancies between national registries and the ITL, the SERINGAS Software applies a number of internal checks before submitting transactions to the ITL.

General checks	Equivalent check in ITL/CITL
Transaction identifier check: Transactions identifier proposed by the registry must be unique. Transaction identifier received by the registry must be unique.	3001 **and more***
Transaction status check: Completed, terminated, accepted, rejected or cancelled status are final status, thus, once a transaction has completed, terminated, accepted, rejected or cancelled status, it can not change its status anymore	3003, 3004, 3007, 3008, 3009, 3013, 3014, 3015, 3016

Transaction status evolution check: The registry propose a transaction with status = “proposed” If the transaction status comes back with “checked with discrepancies”, then the registry terminate the transaction If the transaction status comes back with “checked with no discrepancies”, then the registry complete the transaction	3005, 3006, 3011
Unit check: a unit is compulsory to create a transaction, and only one unit per transaction (except for cancellation and replacement transaction)	5004, 5057
The source account check: all transactions must have an active source account (except for Issuance transaction). The source account for a transaction can only be from type 100, 120 and 121. More restrictions can be added, depending on the transaction type. Only one account can be selected	4011, 4012, 4014, 7406 **and more**
The destination account check: all transactions must have an active destination account; only one account destination can be selected.	5154, 7208, 5204, 5253 **and more**
Quantity check: The quantity of a transaction must not by greater than the quantity of the source account (except for issuance transaction as it has no source account). The quantity of a transaction must be greater than 0	4016 **and more**
Period check: the applicable period of the unit is compulsory to create a transaction, and only one can be selected (except for issuance, the period is calculated by the system)	**No equivalent**
Unit blocks check: the unit block of a transaction is flagged as “reserved” until the transaction has a final status (Completed, terminated, accepted, rejected or cancelled)**.** A block flagged as “reserved” can not be used for another transaction.	4010
The destination registry check: for all transactions, the destination registry is the same as the source registry, except for external transfers and excess issuance cancellation transactions.	4006
Project checks: project is compulsory for transactions involving ERU, CER, tCER and lCER.	**No equivalent**

* **“<ITL/CITL code> and more”** means that the registry makes the same checks as the ITL/CITL which provide for that reason with a particular <ITL/CITL code>, but this code does not cover all checks made by the registry, thus, there’s no right equivalent in the CITL/ITL codes for the appropriate registry checks.

Specific transaction checks **Issuance Transaction (01-00)**	**Equivalent check in ITL/CITL**
Issuance unit check: only AAU and RMU can be issued by the registry	5001, 5002, 5003
Issuance period check: The applicable and the commitment period are calculated from the system date: if the system date is in 2008 to 2012, then the applicable and the commitment period is 1. if the system date in 2013 to 2017, the then the applicable and the commitment period is 2	5005, 5006, **and more**
Issuance of serial number check: The serial number must be unique, can not have the same serial number for AAU and RMU	5007, **and more**
Issuance acquiring account check: the issuance acquiring account must be 100-2-0	5017, **and more**
Issuance LULUCF activity check: the LULUCF activity is compulsory when the registry issue RMU	**No equivalent**

Specific transaction checks **Issuance of allowances (10-52)**	**Equivalent check in ITL/CITL**
Issuance of allowances unit check: only AAU can be choose for this transaction, as the issuance of allowances is treated as a conversion of AAU into EUA	7205, 7219 **and more**
Issuance of allowances period check: the period of the allowances is the same period as the AAU used for the issuance	7205
Issuance of allowances serial number check: The serial number must be the same as the AAU used for the issuance	**No equivalent**
Issuance of allowance source account checks: the source account must be 100-2-0	**No equivalent**
Issuance of allowance destination account checks: the destination account must be 100-4-0	7202 **and more**

Specific transaction checks **Allocation transaction (10-53)**	**Equivalent check in ITL/CITL**
Allocation units check: only allowances (EUA) can be used for allocation	No equivalent
Allocation source account check: the source account is 100-4-0	7360, **and more**
Allocation destination account check: the destination account must be account type 120	7206
Allocation year check: the allocation year is compulsory	**No equivalent**

Specific transaction checks **Correction to allowances (10-55)**	**Equivalent check in ITL/CITL**
Correction to allowances unit check: only allowances (EUA) can be used a correction to allowances transaction	**No equivalent**
Correction to allowances source account check: the source account is 100-4-0	**No equivalent**
Correction to allowances destination account check: the source account is 100-2-0	**No equivalent**

Specific transaction checks **Voluntary cancellation (04-00)**	**Equivalent check in ITL/CITL**
Voluntary cancellation unit check: all Kyoto units and EUA are useable for voluntary cancellation.	**No equivalent**
Voluntary cancellation source account check: only holding accounts can be used as source account for cancellation, with the exception of 100-3-0	**No equivalent**
Voluntary cancellation destination account check: only account type 230 is allowed as destination account for voluntary cancellation transactions.	5153 **and more**

Specific transaction checks **Domestic transfers (10-00)**	**Equivalent check in ITL/CITL**
Domestic transfer unit check: all Kyoto units and EUA are useable for domestic transfers	**No equivalent**
Domestic transfer destination account check: the destination account can only be holding accounts (type 100, 120 or 121) except 100-4-0; only one destination account can be entered.	7407

Specific transaction checks **External transfers, outgoing (03-00)**	**Equivalent check in ITL/CITL**
External transfers, outgoing unit check: all Kyoto units and EUA are useable for outgoing external transfers	**No equivalent**
External transfer, outgoing destination account check: the destination account can only be holding accounts (type 100, 120 or 121); only one destination account can be entered.	**No equivalent**
Domestic transfer, outgoing destination registry check: the destination registry can not be source registry.	4007

Specific transaction checks External transfers, incoming (03-00)	Equivalent check in ITL/CITL
External transfers, incoming unit check: all Kyoto units and EUA are useable for incoming external transfers	**No equivalent**
External transfer, incoming destination account check: the destination account can only be holding accounts (type 100, 120 or 121), and the account number must exists in the acquiring registry.	**No equivalent**

Specific transaction checks Conversion of AAU and RMU into ERU (02-00)	Equivalent check in ITL/CITL
Conversion units check: only AAU and RMU can be used for a conversion transaction	5056
Conversion source account check: the source account can only be national holding accounts (type 100).	5052
Conversion destination account check: the destination account is the same as the source account	**No equivalent**
Conversion project check: a project is compulsory for a conversion transaction. The project has to be created before the conversion transaction.	**No equivalent**

Specific transaction checks Surrendering (10-02)	Equivalent check in ITL/CITL
Surrendering units check: only EUA, CER and ERU converted from AAU can be used for a surrendering transaction	7356
Surrendering source account check: the source account can only be operator holding accounts (type 120).	7354
Surrendering destination account check: the destination account has to be 100-3-0	7202
Surrendering year check: the surrendering year is compulsory	**No equivalent**

Specific transaction checks **Cancellation and replacement (10-41)**	**Equivalent check in ITL/CITL**
Cancellation and replacement destination account check: the destination account can only be a national holding account (type 100)	7202, 7407
Cancellation and replacement transaction date check: Cancellation and replacement transaction can only be made on the 1st of May	**No equivalent**
Cancellation and replacement quantity check: the quantity replaced is calculated with the percentage entered in the settings of the transaction. The quantity “cancelled” is all EUA of holding accounts except 100-3-0	**No equivalent**
Cancellation and replacement transaction procedure: move all EUA of the previous period from holding accounts, by transferring them into a national holding account and converting them into AAU (“cancellation” process), then convert AAU (from the account 100-8-0) of the current period into EUA and transfers the EUA from the current period to the holding accounts (“replacement”). The quantity is of the replacement is calculated from the percentage set for the transaction.	7205, 7219, 7360, 7402, 7406

Specific transaction checks **Retirement(05-00)**	**Equivalent check in ITL/CITL**
Retirement unit check: All Kyoto units can be used. Allowances (EUA) are not useable.	7365 **and more**
Retirement transaction date check: retirement transactions can be made only on the 30th of June	
Retirement source account check: the retirement source account can only be national holding account (type 100)	7360 **and more**
Retirement destination account check: the destination account can only be a retirement account (type 300)	5252

Notification Checks Net source cancellation (04-00)	Equivalent check in ITL/CITL
Net source cancellation notification Identifier check: the notification identifier is compulsory, and fixed by the notification	5158
Net source cancellation unit check: only AAU, RMU, CER, ERU and EUA can be used for a net source cancellation transaction.	5156
Voluntary cancellation destination account check: only account type 210 is allowed as destination account for voluntary cancellation transactions.	5153

Notification Checks Non compliance cancellation (04-00)	Equivalent check in ITL/CITL
Non compliance cancellation notification Identifier check: the notification identifier is compulsory, and fixed by the notification	5159
Net source cancellation unit check: only AAU, RMU, CER, ERU and EUA can be used for a net source cancellation transaction.	5156
Voluntary cancellation destination account check: only account type 220 is allowed as destination account for voluntary cancellation transactions.	5153

Notification Checks Expiry date replacement (06-00)	Equivalent check in ITL/CITL
Expiry date replacement notification Identifier check: the notification identifier is compulsory, and fixed by the notification	5216, 5217
Expiry date replacement unit check: only AAU, RMU, CER, tCER and EUA can be used for a replacement of tCER. Only AAU, RMU, CER can be used for a replacement of lCER. The unit to be replaced is given by the notification and is compulsory for this transaction. Once the unit is replaced, it is flagged as replaced.	5206, 5207, **and more**
Expiry date replacement destination account check: only account type 411 is allowed as destination account for replacement of tCER. Only account type 421 is allowed as destination account for replacement of lCER.	5202, 5203, 5213, 5214
Expiry date replacement quantity check: the quantity fixed by the notification and can not be changed.	5209

Notification Checks **Reversal of storage cancellation (04-00)**	**Equivalent check in ITL/CITL**
Reversal of storage cancellation notification Identifier check: the notification identifier is compulsory, and fixed by the notification	5160
Reversal of storage cancellation unit check: only lCER of the project described in the notification can be used for a reversal of storage cancellation transaction.	**No equivalent**
Reversal of storage cancellation destination account check: only account type 250 is allowed as destination account for this transaction.	5153

Notification Checks **Reversal of storage cancellation (06-00)**	**Equivalent check in ITL/CITL**
Reversal of storage replacement notification Identifier check: the notification identifier is compulsory, and fixed by the notification	5218, 5220
Reversal of storage replacement unit check: only AAU, RMU, ERU, CER, EUA and lCER of the project described in the notification can be used for a reversal of storage cancellation transaction. The unit to be replaced is lCER and is compulsory for this transaction. Once the unit is replaced, it is flagged as replaced.	5206, 5207, 5215
Reversal of storage replacement destination account check: only account type 422 is allowed as destination account for this transaction.	5203
Reversal of storage replacement quantity check: the quantity fixed by the notification and it can be changed. The quantity is the same for replacing units and replaced units.	5209

Notification Checks **Non submission of certification report cancellation (04-00)**	**Equivalent check in ITL/CITL**
Non submission of certification cancellation notification Identifier check: the notification identifier is compulsory, and fixed by the notification	5161
Non submission of certification cancellation unit check: only lCER of the project described in the notification can be used for a non submission of certification cancellation transaction.	**No equivalent**
Non submission of certification cancellation destination account check: only account type 250 is allowed as destination account for this transaction.	5153

Notification Checks Non submission of certification report cancellation (06-00)	Equivalent check in ITL/CITL
Non submission of certification replacement notification Identifier check: the notification identifier is compulsory, and fixed by the notification	5219, 5220
Non submission of certification replacement unit check: only AAU, RMU, ERU, CER, EUA and lCER of the project described in the notification can be used for a reversal of storage cancellation transaction. The unit to be replaced is lCER and is compulsory for this transaction. Once the unit is replaced, it is flagged as replaced.	5206, 5207
Non submission of certification replacement destination account check: only account type 423 is allowed as destination account for this transaction.	5203
Non submission of certification replacement quantity check: the quantity fixed by the notification and it can be changed. The quantity is the same for replacing units and replaced units.	5209

Notification Checks Excess issuance for CDM project cancellation (03-00)	Equivalent check in ITL/CITL
Excess issuance for CDM cancellation notification Identifier check: the notification identifier is compulsory, and fixed by the notification or received by mail	**No equivalent**
Excess issuance for CDM cancellation destination account check: only account type 240 is allowed as destination account for this transaction.	**No equivalent**
Excess issuance for CDM cancellation destination registry check: only CDM registry is allowed for this transaction	5152

Notification Checks Carry-over (07-00)	Equivalent check in ITL/CITL
Carry-over notification Identifier check: the notification identifier is compulsory, and fixed by the notification.	5310
Carry-over unit check: only AAU, ERU converted from AAU and CER can be carried over. The commitment period is increased by one period.	5303, 5305, 5306, 5307
Carry-over source account check: only holding account type can be used for the carry-over transaction.	5302
Carry-over destination account check: the destination account must be the same as the source account.	**No equivalent**

Notification Checks Expiry date change (08-00)	Equivalent check in ITL/CITL
Expiry date change notification Identifier check: the notification identifier is compulsory, and fixed by the notification.	5453
Expiry date change unit check: only unit fixed by the notification is used for the transaction.	5454

Table 145 List of internal checks; taken from the document “Seringas internal checks before submitting transactions to ITL”, 15. December 2008.

A10.8 Determent of unauthorized manipulations

An overview of security measures employed in the national registry to prevent unauthorized manipulations and to prevent operator error and of how these measures are kept up to date:

User identification and authentification

Every user of the registry system is identified by a distinctive Login name and authenticated by a personal password composed of a minimum of 10 characters including at least one number. The validity of the password is limited on 60 days and have to be renewd accordingly. The new password must be different from the last 10 password and must not contain neither the surname or name nor the login of the user. Plain text of the password can not be viewed by third persons or even the registry administrator as it is tored by 1-way coding.

Profile Management

Every user is designed to a determined profile depending on his/her role defined in the application form and implemented by the system administrator. Currently there are seven profiles available:

- P1 = System administrator (Registry administrator)
- P2 = Registry administrator
- P3 = Account consultant
- P4 = Primary authorized contact
- P5 = Secondary authorized contact
- P6 = Guest
- P7 = Verified allowances management (Verifier)
- P8 = Verified allowances validation (Competent authority)

Authorized functionalities for each profile are managed as shown in Table 146.

Access Protection

Apart from the measures within the software for the identification and authentication of authorised users, the following technical and organisational measures are in place, to prevent third parties access to the data:

- SSL-based encoding of the data transmission in the WEB and user authentication
- to gain entry to the system,
- Employment of continuously updated virus-scanner software on the servers
- and the clients of the registry administration,
- Continuous security updates of the system software
- Network infrastructure with hardware firewalls
- Continuous check of the firewall logs for attack attempts,

Authorised functionalities	**System administrator**	**Registry Administrator**	**Account consult**	**Primary authorized contact**	**Secondary authorized contact**	**Guest**	**Verified allowances management (Verifier)**	**Verified allowances validation (Competent authority)**
Add account	x	x						
Add contact	x	x		x				
Add installation	x	x						
Add operation	x	x		x	x			
Add participant	x	x		x				
Add processing unit	x	x						
Add profile	x							
Add unit	x	x						
Advanced search	x	x	x	x	x	x	x	x
Advanced search to document text	x	x	x	x	x	x	x	x
Categories of activities management	x							
Change main participant	x	x						
Compliance status	x	x						
Consult account	x	x		x	x			
Consult contact	x	x	x	x	x			x
Consult installation	x	x	x	x	x			x
Consult NAP detail	x	x						
Consult NAP Table	x	x						
Consult transaction	x	x	x	x	x			
Consult participant	x	x	x	x	x		x	x
Consult processing unit	x	x		x	x			

Authorised functionalities	System administrator	Registry Administrator	Account consult	Primary authorized contact	Secondary authorized contact	Guest	Verified allowances management (Verifier)	Verified allowances validation (Competent authority)
Consult profile	x	x	x	x	x			
Consult unit	x	x		x				
Consult reports	x	x	x	x	x		x	x
Consult verified allowances	x	x	x	x			x	x
Create contact	x	x						
Create participant	x	x		x	x			
Create processing units	x	x		x	X			
Create installation	x	x						
Create account	x	X						
Create transaction	x	x		x	x			
Create unit	x	x						
Create profile	x	x						
Create verified allowances	x						x	
Disconnections	x	x	x	x	x			x
Delete account	x	x		x				
Delete contact	x	x		x				
Delete installation	x	x						
Delete participant	x	x		x				
Delete processing unit	x	x		x	x			
Delete profile	x	x						
Delete Transaction	x	x						
Delete unit	x	x						
Enter verified emissions	x	x					x	x
Installation load from xml file	x							
Modify account	x	x		x	x			
Modify contact	x	x		x	x			
Modify installation	x	x		x	x			
Modify participant	x	x		x	x			
Modify password	x	x	x	x	x		x	
Modify processing unit	x	x		x	x			
Modify profile	x							
Modify unit	x	x						
NAP load from xml file	X							

Authorised functionalities	System administrator	Registry Administrator	Account consult	Primary authorized contact	Secondary authorized contact	Guest	Verified allowances management (Verifier)	Verified allowances validation (Competent authority)
Operator load from xml file	X							
Password management	X	x		x	x			
Validate verified emissions	X	x						x

Table 146 Authorized functionalities for profiles.

A10.9 Public Reports

A list of the information publicly accessible by means of the user interface to the national registry:

For each account the following reports are available on the public area of the national registry:

1) List of legal entities holding an account in the national registry
2) List of installations in line with the European emissions trading directive
3) List of accounts opened in the national registry
4) Annual summary of quantity of units per type of operation performed in the national registry
5) Compliance status of installations concerning the declaration of verified emissions, grouped by operators
6) Summary statement on the quantity of allowances surrendered by an operator for compliance
7) Report on consolidated position of all installations verified emissions compared with total allowances surrendered
8) Report on the assessment of operator's compliance, grouped by operators
9) List of non-compliant installations
10) Verified emissions table

Additionally, FAQs, international texts (Kyoto Protocol, Marrakesh Accords etc.), and details of the national allocation plan are publicly available by means of the user interface.

A10.10 Internet address

The URL of the interface for the national registry of Liechtenstein is:

www.emissionshandelsregister.li and alias

www.emissionstradingregistry.li

A10.11 Safeguard and Recovery Plan

A description of measures taken to safeguard, maintain and recover data in order to ensure the integrity of data storage and the recovery of registry services in the event of a disaster:

The planned measures taken to safeguard, maintain and recover data in the event of a disaster first presented in the IR 2006 are now implemented:

	Description	**Frequency**	**Retention Period**	**Storage**
System data	Full Backup	Weekly	3 months	Tape, offsite
	Incremental backup	Daily	1 week	Tape, offsite
Application DB	Online backup of the data base on a daily basis	Daily	3 months	Tape, offsite
	Creating transaction logfiles	Hourly	1 week	Local system disk on the data base server. This device is separated from the device holding the DB.
Transaction Logfiles	Transaction logfiles will be subject to the system data backup			

Table 147 Backup strategy of National Registry (Source: Initial Report of Switzerland).

A10.12 Test procedures

The results of any test procedures that might be available or developed with the aim of testing the performance, procedures and security measures of the national registry undertaken pursuant to the provisions of decision 19/CP.7 relating to the technical standards for data exchange between registry systems:

Interoperability tests based on Annex H of the DES version 1.1.002 were performed on 5. September 2007 and passed successfully. Additionally, the Remote Tests between the national registry of Liechtenstein and the Community Independent Transaction Log (CITL) focusing on issues relevant for EU-ETS (Allocation Plan Details; Issuance of EUAs, etc) were carried in line with the ETS Testing Plan Version 4 out and completed successfully.

A10.13 Commitment period reserve (CPR)

According to the Annex of decision 11/CMP.1, each Party included in Annex I shall maintain, in its national registry, a commitment period reserve which should not drop below 90 per cent of the Party's assigned amount calculated pursuant to Article 3, paragraphs 7 and 8, of the Kyoto Protocol, or 100 per cent of five times its most recently reviewed inventory, whichever is lowest. In line with these specifications, Liechtenstein reported its commitment period reserve to be 950,061 CO_2 eq based on the assigned amount, which is consistent with the initial review report 2006 (FCCC/IRR/2007/LIE).

Liechtenstein considers that the „most recently reviewed inventory" refers to the inventory 2007 presented in the current NIR. The inventory is understood to be calculated without LULUCF emissions/removals.

In order to determine which of the two methods to calculate the commitment period reserve results in the lower value, the results of both methods are indicated in Table 148

Method 1		Method 2	
Assigned amount calculated pursuant to Art. 3, para. 7 and 8 of the Kyoto protocol (five times 92% of 1990 emissions), see Table 13 [Gg CO2 equivalent]	1'055.623	2007 emissions without LULUCF, see Table 13, [Gg CO2 equivalent]	243.478
90% of the assigned amount [Gg CO2 equivalent]	950.061	100% of five times the 2007 emissions without LULUCF [Gg CO2 equivalent]	1217.389

Table 148 Calculation of Liechtenstein's commitment period reserve 2007.

The CPR remains unchanged since method 1 still results in the lower value and is therefore used to calculate the minimum amount of the CPR. **The commitment period reserve of Liechtenstein should therefore not drop below 950.061 Gg CO_2 equivalent (0.950061 million tonnes CO_2 equivalent).**