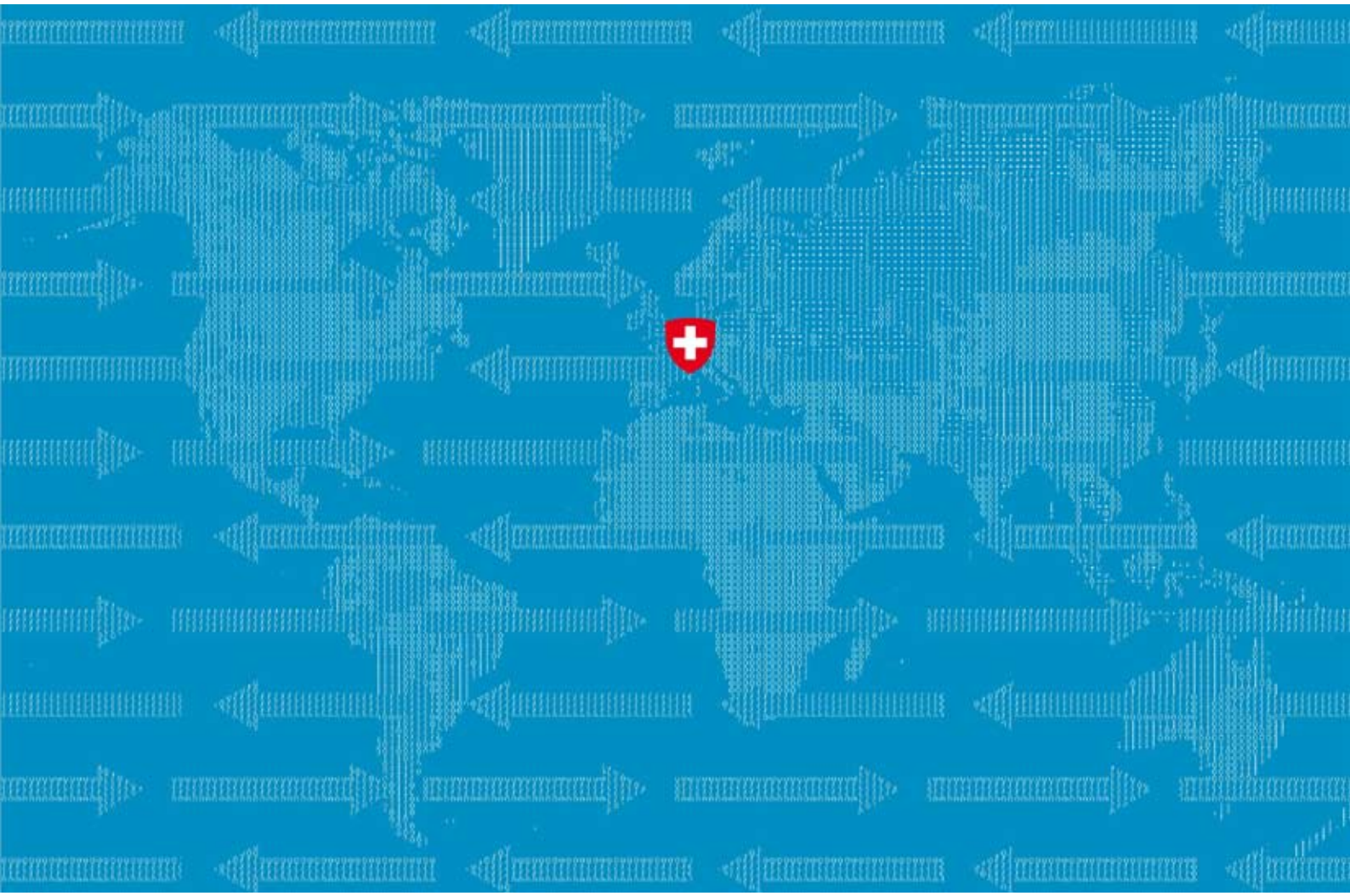
Switzerland's Fifth National Communication under the UNFCCC

Second National Communication under the Kyoto Protocol to the UNFCCC



Schweizerische Eidgenossenschaft
Confédération suisse
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Swiss Confederation

Imprint

Editor Federal Office for the Environment (FOEN). FOEN is an office of the Federal Department of Environment, Transport, Energy and Communications (DETEC).

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Citation FOEN (Ed.), 2009: Switzerland's Fifth National Communication under the UNFCCC, Bern.

Download PDF http://www.climatereporting.ch/NC5. No printed edition.

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Foreword

Given the new and ever stronger scientific evidence on climate change, a long-term commitment and sustained international efforts are urgently required. There is a lot at stake and consequences of inaction will become more and more severe. Every nation should thus strive to contribute to the solution of this global challenge to the best of its abilities. Switzerland is highly committed to do its share. It supports international efforts to tackle climate change and promotes cooperation for a more sustainable future.

In its 5th National Communication, Switzerland demonstrates the progress made over the past four years and the efforts made to keep to the commitments of the Framework Convention on Climate Change and the Kyoto Protocol. Switzerland had to step up its efforts over the past years to stay within reach of the target set out in the Kyoto Protocol – and further efforts will be needed in the future.

The Federal Council has put forward a draft bill that outlines targets of the Swiss climate policy until 2020. The proposal builds on the diverse portfolio of measures that has been established over the past years, but with tightened rules in order to achieve further emission reductions. Apart from national mitigation goals, the draft also includes the development and coordination of a national adaptation strategy to prepare for and hedge against future risks.

Climate change is neither a problem that was caused by a single nation, nor will it be solved by a single nation. However, it is the responsibility of every nation to contribute towards the common goal. Concerted action will make a difference!

Bruno Oberle
Director
Federal Office for the Environment (FOEN)

December 2009

1 Executive Summary

1.1 Introduction

This is Switzerland's fifth national communication (NC5) under the UN Framework Convention on Climate Change and the second communication under the Kyoto Protocol. The report is in accordance with UNFCCC's reporting guidelines on national communications (FCCC/CP/1999/7) and the annotated outline for fifth national communications of Annex I parties under the UNFCCC, including reporting elements under the Kyoto Protocol.

The fourth national communication was submitted on 2.12.2005, and reviewed by the expert review team (ERT) from 5.-10.06.2006. Results of the in-depth review have been taken into account, by *inter alia*,

- integrating a description of the national registry (section 3.5)
- providing information on measures minimizing adverse effects (section 4.6)
- developing complete "with additional measures" and "without measures" scenarios and including these into chapter 5 for estimating the total effects of policies and measures
- clearly defining "new and additional financial resources" in section 7.1

1.2 National circumstances

Political profile

Switzerland is a confederation, with a federal government, a bicameral parliament and a federal supreme court. The territory consists of 26 cantons (states), each of which has its own government, parliament and cantonal courts. Responsibilities are shared between the federal authorities and the cantons., however subsidiarity plays an important role in Switzerland. This is reflected in constitutional law, which states that unless legislative power is explicitly assigned to the confederation, the cantons are sovereign, i.e. entitled to legislate in an area of policy.

International relations

Switzerland is a member of several international organisations like e.g. the UN, OECD, the World Bank Group, and the European Environmental Agency. It is not a member of the European Union (EU), but most new and amendments to existing Swiss laws have been made compatible with EU legislation. Bilateral agreements coordinate a wide range of policy areas between Switzerland and the EU.

Population and urbanisation

At the end of 2008, the population of Switzerland accounted for 7.7 million with a density of 186 persons per km^2. Approximately 20% of the permanent residential population were foreign nationals. Population growth - more than 13% in the period 1990-2008 - results mainly from immigration and increasing life expectancy. More than two thirds of the Swiss population live in cities or metropolitan areas – half of which in the urban agglomerations of the five major cities. While the number of households is increasing (+36% since 1980), the number of persons per household is decreasing. The energy reference area in Switzerland has been increasing steadily since 1990 and accounted for over 680 million m^2 in 2008.

Geography and climate

Switzerland covers an area of 41'300 km^2, comprising 31% forest and woodland, 37% cropland and pastureland, 7% built-up and 25% unproductive land. With the Alps acting as climatic divide, conditions such as average temperature and precipitation vary significantly across Switzerland, depending mainly on altitude and location. Long-term observations indicate a marked shift towards a warmer climate – particularly since 1970. Variable winter temperatures are an important control on energy consumption, and leave a strong imprint on annual CO_2 emissions.

Economic profile

Switzerland's economy is largely dependent on the tertiary sector, which contributes over 70% to the GDP and employs 75% of Switzerland's workforce. GDP per capita has increased by 38% since 1990 and accounted for over CHF 67'000 in 2007. The unemployment rate has been fluctuating since 1990 between 2% and 5%. Furthermore, the Swiss economy strongly depends on foreign trade, which represents a very high share of GDP. Main trading partner is the European Union accounting for 62% of exports and 79.5% of imports.

Sector characteristics

Energy: Energy use in Switzerland totalled 900'040 TJ in 2008, i.e. 4% above the previous year. Main drivers for this increase were colder weather conditions, positive economic development and further increase in population. 80% of primary energy supply was imported whereas 20% was sourced domestically. 55.1% of total final energy consumption relied on oil, 23.5% electricity and 12.3% gas. The remaining 9.1% comprised wood, waste, coal and several renewable forms of energy. Electricity generation in Switzerland is dominated by hydroelectric power plants (56.1%) and nuclear power plants (39%). Switzerland is trading electricity with several western and central European countries. Energy productivity (energy consumption in relation to GDP) has remained constant in recent decades, however, since 2005, real GDP and final energy consumption started to diverge due to an increase in energy efficiency and outsourcing of production sites to other countries.

Transport: The share of road transport is still increasing (for passenger as well as for freight transport). However, public transport covered almost 20% of total passenger kilometres in 2006. In the freight transport sector, over 40% of total tonne kilometres were transported by rail in 2006. Both in the passenger and in the freight transport sector, the modal split between rail and road is rather high compared to other European countries.

Industry: Structural transformation is continuing in Switzerland, with the service sector growing faster than the industry sector. The secondary sector in Switzerland increased its production by 50% between 1990 and 2007, but greenhouse gas emissions decreased slightly, showing a decoupling of economic growth and greenhouse gas emissions. Manufacturing industries are the largest emitters among all economic activities (27%).

Agriculture and forestry: 24% of the area of Switzerland is used by farmers. Another 13% are alpine pastures (including cultivation of land and animal husbandry). 70% of the agriculturally productive land was used as natural grassland and pasture land in 2007. Hence, dairy products and meat are the most significant output of this sector. Agriculture is responsible for roughly 10% of total GHG emissions in Switzerland, the most important sources being methane from digestion and rumination of animals followed by the emissions of nitrous oxide from agricultural soils. Switzerland elected to account for activities related to forest management under article 3.4 of the Kyoto Protocol. A third of Switzerland is covered by forests, and the forest area has increased by 5% since 1995. National programmes promote ecologically and economically effective wood use, with the intention to increase the use of wood as a substitute for fossil fuels rather than enhancing the forest sink capacity.

Waste: The total amount of waste generated in Switzerland increased by 34% between 1990 and 2007 and accounted for 5.46 million tonnes in 2007 (718 kg per person). Thereof, 2.68 million tonnes were incinerated and 2.78 million tonnes were recycled.

1.3 Information on GHG inventory, the national system and the national registry

Aggregated greenhouse gas emissions 2007

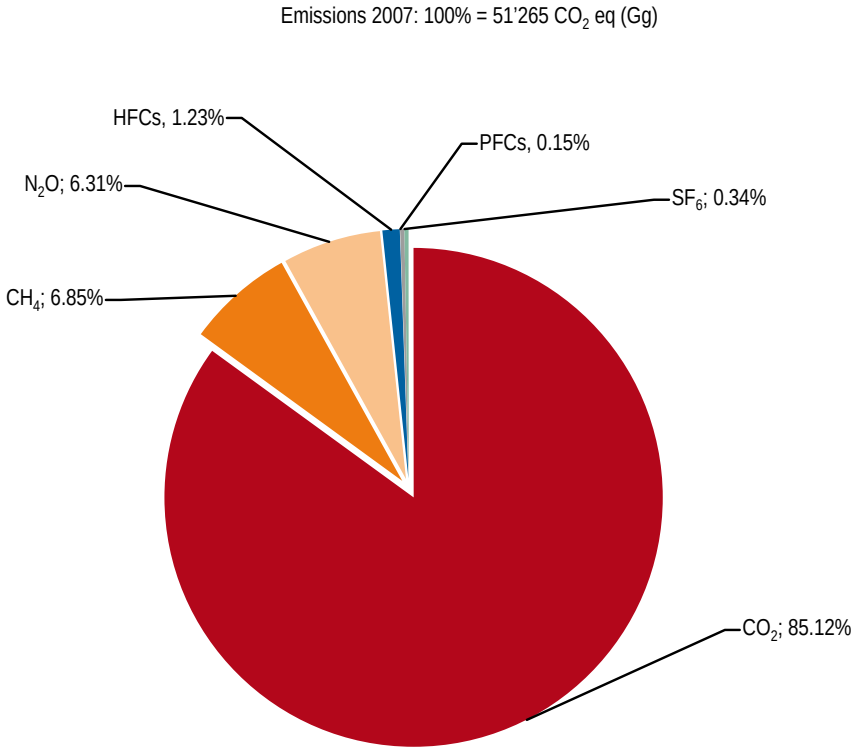
In 2007, Switzerland emitted 51'265 Gg CO_2 equivalent (excluding LULUCF), or 6.73 tonnes CO_2 equivalent per capita. With a share of 85% (Fig. 1), the largest contributor gas was CO_2 with 43'636 Gg (5.73 tonnes per capita), and the most important source was the energy sector with 41'966 Gg CO_2 equivalent. Tab. 1 shows emissions by gas and sector in Switzerland 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.

Emission trends 1990-2007

Energy (source category 1): There is no significant trend in the total emissions over the period 1990–2007. Year-to-year variations of total emissions are mainly caused by changing winter temperatures and their effect on CO_2 emissions from fuel combustion. In 2007, total GHG emissions (excluding LULUCF) were -2.7% lower than in 1990. Including LULUCF, emissions increased slightly by 0.5% from 1990 to 2007. As CO_2 persistently forms the major part of total GHG emissions (1990: 84.4% and 2007: 85.1%, respectively), its relative trend between 1990 and 2007 runs largely parallel to total GHG emissions excluding LULUCF (Fig. 2). As shown in Fig. 3, the largest share of emissions originated from the energy sector (source category 1). Due to Switzerland's electricity production structure (largely hydroelectric and nuclear power plants), the energy industries sector (source category 1A1) plays only a minor role (6.8%), whereas emissions from the transport sector (source category 1A3) contribute 31.9%.

Industrial processes (source category 2): In line with economic development, overall emissions in the industry sector showed a decreasing trend in the nineties and a rebound between 1998 and 2005.

Fig. 1 > Contribution of gases to Switzerland's GHG emissions (excl. LULUCF) in 2007



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Solvent and other product use (source category 3): NMVOC emissions, the main source of indirect CO_2 emissions of the sector, have diminished between 1990 and 2004 due to their limitation brought by the Ordinance on Air Pollution Control and due to the introduction of the VOC tax in 2000. Emissions from solvent and other product use make up less than 0.5% of total Swiss greenhouse gas emissions in 2007.

Agriculture (source category 4): Declining populations of cattle and swine and reduced fertilizer use have led to a decrease in greenhouse gas emissions from 1990 until 2004. Since then, CH_4 emissions have slightly increased again due to higher livestock numbers (mainly cattle). Agriculture contributed 10.4% to the total greenhouse gas emissions in 2007.

Tab. 1 > Switzerland's GHG emissions in CO_2 equivalent (Gg) by gas and sector in 2007

Emissions 2007		CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total	Share
		CO_2 equivalent (Gg)							
1	Energy	41'358	279	330				41'966	81.9%
2	Industrial Processes	2'086	7	83	630	77	175	3'058	6.0%
3	Solvent Use	177	0	54				231	0.5%
4	Agriculture	0	2'829	2'516				5'346	10.4%
6	Waste	15	396	252				663	1.3%
Total (excluding LULUCF)		43'636	3'511	3'235	630	77	175	51'265	100.0%
5	LULUCF	-655	2	6				-647	-1.3%
Total (including LULUCF)		42'982	3'513	3'241	630	77	175	50'617	98.7%
	International Bunkers	*3'919*	*1*	*38*				*3'959*	

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Fig. 2 > Relative trend of Switzerland's GHG emissions (excl. LULUCF) by gas (base year 1990 = 100%) The increase in synthetic gases (not shown) amounts to 362%.

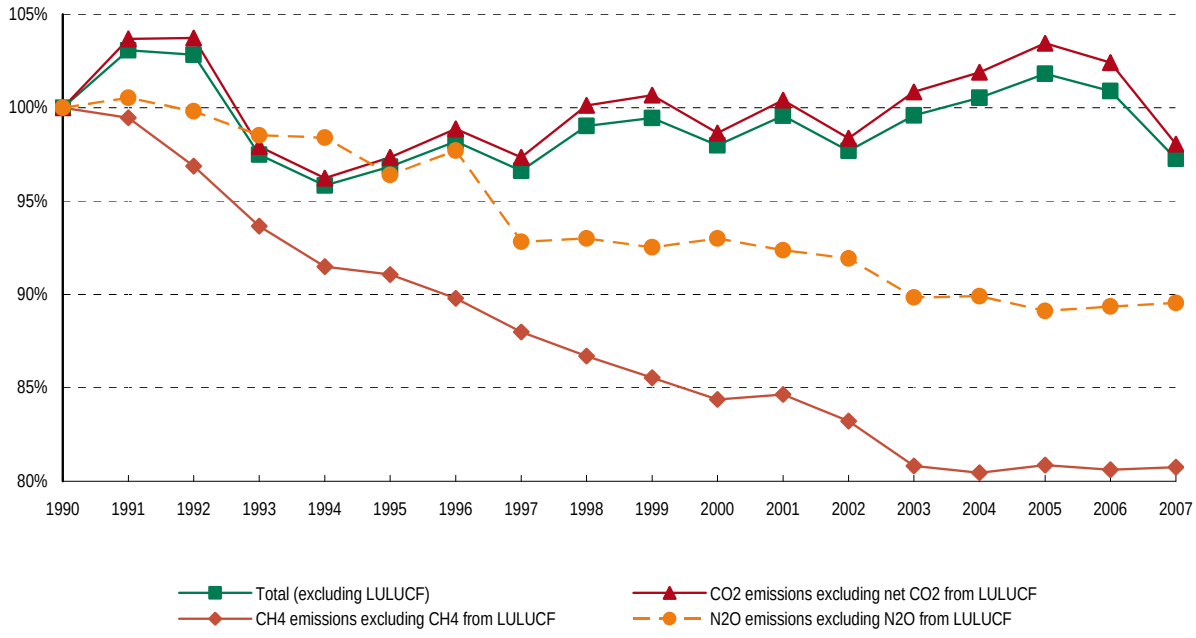

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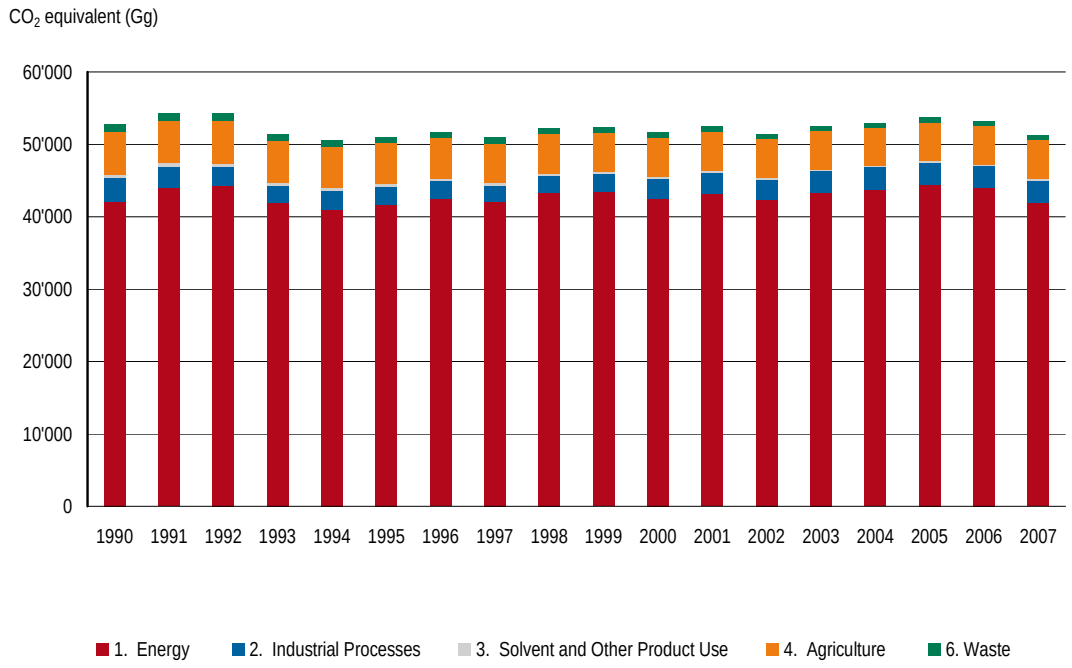
Fig. 3 > Switzerland's GHG emissions (excluding LULUCF) in CO_2 equivalent (Gg) by sectors



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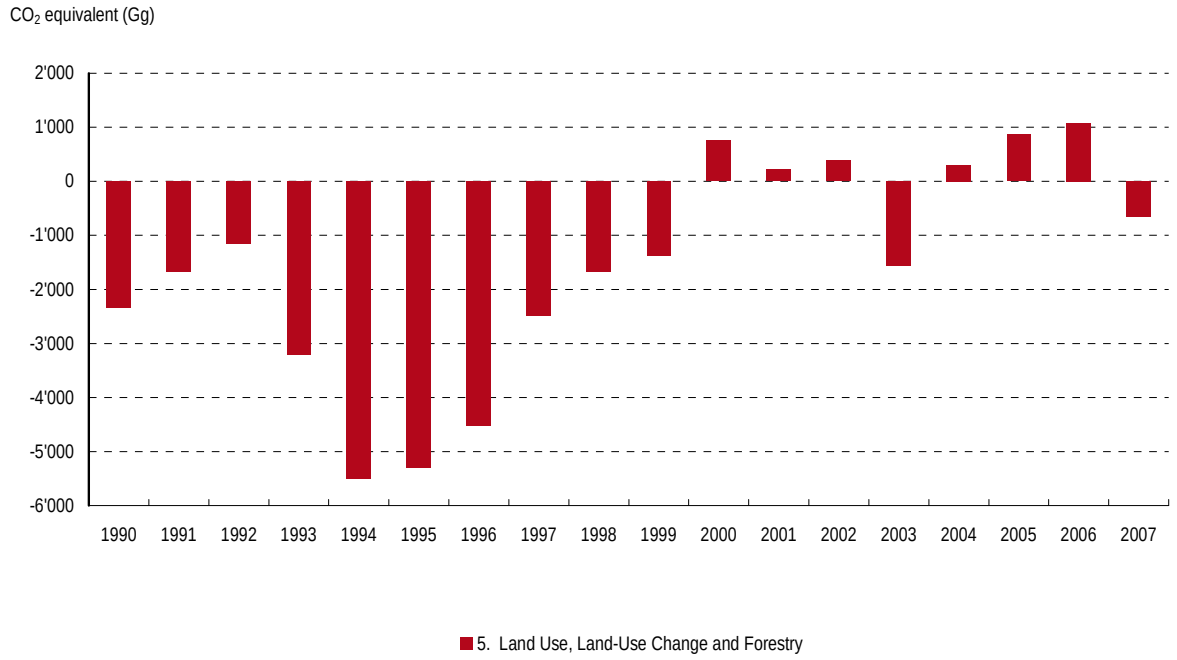
Land Use, Land-Use Change and Forestry (source category 5): The LULUCF sector in Switzerland is dominated by biomass dynamics in forests. As shown in Fig. 4, removals were higher than emissions prior to the year 2000. Since then, the forest carbon sink seems to diminish. In 2007, the LULUCF sector was a net CO_2 sink of the order of 1% of total greenhouse gas emissions.

Waste (source category 6): Total emissions from the waste sector decreased steadily throughout the period 1990-2003. Since 2000, emissions have been reduced further by a change in legislation: Disposal of combustible municipal solid wastes in landfills has been banned, leading to a decrease in methane emissions from landfill sites and an increasing amount of municipal solid waste being incinerated in waste incineration plants, with emissions reported under energy industries (source category 1A1) rather than waste (source category 6). Altogether, waste-related emissions including emissions from waste management activities reported in source categories 1A, 4D and 6 have increased since 1990 by 19%.

Emission trends for indirect greenhouse gases and SO_2: Emission trends for indirect greenhouse gases show a very pronounced decline. From 1990 to 2007, a strict air pollution control policy and the implementation of a large number of emission reduction measures led to a decrease of -50% to -70% in emissions of air pollutants. The main reduction measures were abatement of exhaust emissions from road vehicles and stationary combustion equipment, taxation of solvents and sulphured fuels, and voluntary agreements with industry sectors. The energy sector was by far the largest source of indirect greenhouse gas emissions, with the only exception being NMVOC, where solvent and other product use (source category 3) accounted for 24.3% of the total in 2007.

Fig. 4 > Net CO_2 equivalent balance of sector Land Use, Land-Use Change and Forestry (LULUCF)

Positive values refer to emissions, negative values refer to removals.



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Data for activities under article 3, paragraphs 3 and 4 of the Kyoto Protocol (KP-LULUCF)

Switzerland has decided to account for forest management under the elective voluntary activities of article 3, paragraph 4 of the Kyoto Protocol. In accordance with decision 16/CMP.1 (FCCC/KP/CMP/2005/8/Add.3), credits from forest management are capped in the first commitment period. For Switzerland, the cap is set at 1.83 Mt CO_2 (0.5 Mt C) per year, or 9.15 Mt CO_2 for the whole commitment period. Tab. 2 provides an overview of sources and sink activities between 2000 and 2007.

National inventory system

The Swiss national inventory system (NIS) is developed and managed under the auspices of the Federal Department of the Environment, Transport, Energy and Communications (DETEC). It is hosted by a DETEC agency, the Federal Office for the Environment (FOEN). As stipulated in the Ordinance on the Internal Organization of DETEC of 13.12.2005, the FOEN has the lead within the federal administration regarding climate policy and its implementation. Fig. 5 provides a schematic overview of the institutional setting of the NIS.

Key category analyses (KCA)

The key category analyses are performed according to the IPCC good practice guidance. Level and trend assessments are made using tier 1 and tier 2 methods. For 2007, 32 out of a total of 134 categories (without LULUCF) have been identified as key. 17 of the key categories are in the energy sector, accounting for 45.7% of the sum of all level assessments. Agriculture (sector 4) accounts for 38.9% of that sum. The analysis shows that these two sectors have the highest impact on inventory uncertainty. The other key categories are from industrial processes (sector 2, 3.7%), solvent and other product use (sector 3, 1.6%), and waste (sector 6, 5.2%). Including LULUCF categories in the KCA, four additional categories out of the LULUCF sector are key categories: 5A1 forest land remaining forest land (the largest LULUCF category), contributing 7.5% to the sum of all level assessments (weighted with their uncertainty). The other 3 LULUCF key categories (5A2, 5B1, 5E2) together contribute 4.3% to the sum.

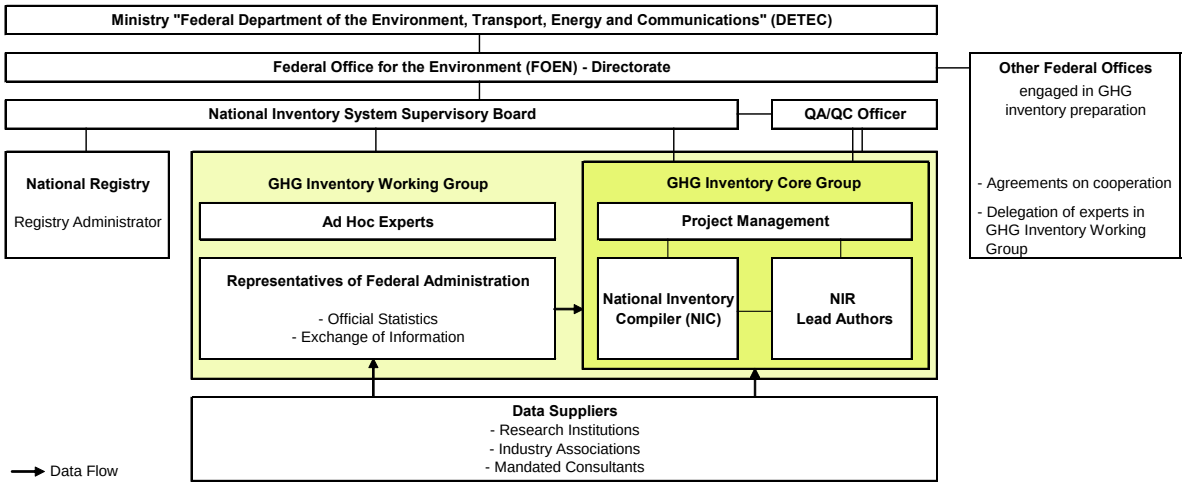
Tab. 2 > Overview of net CO_2 equivalent emissions and removals for activities under article 3, paragraphs 3 and 4 of the Kyoto Protocol, 2000-2007

Positive values refer to emissions, negative values refer to removals

GREENHOUSE GAS SOURCE AND SINK ACTIVITIES	Net CO_2 equivalent emissions and removals (Gg)							
	2000	2001	2002	2003	2004	2005	2006	2007
A. Article 3.3 activities	18.78	29.63	46.96	8.99	-6.69	-17.10	26.80	8.66
A.1. Afforestation and reforestation	-50.22	-52.68	-55.15	-57.61	-60.07	-63.29	-65.69	-67.73
A.1.1. Units of land not harvested since the beginning of the commitment period	-50.22	-52.68	-55.15	-57.61	-60.07	-63.29	-65.69	-67.73
A.1.2. Units of land harvested since the beginning of the commitment period	0	0	0	0	0	0	0	0
A.2. Deforestation	69.00	82.31	102.11	66.60	53.38	46.19	92.49	76.39
B. Article 3.4 activities	-372.83	-905.49	-738.39	-2'695.34	-822.76	-338.06	-87.31	-1'741.70
B.1. Forest management incl. biom. burning	-372.83	-905.49	-738.39	-2'695.34	-822.76	-338.06	-87.31	-1'741.70
- growth of liv. biom.	-12'950.12	-13'946.89	-13'492.10	-12'610.33	-11'748.55	-10'901.07	-12'234.35	-13'409.85
- cut and mortality	13'830.08	14'295.67	14'144.82	11'445.76	11'065.46	11'538.57	11'999.80	1'2499.35
- dead wood pool	-1'253.20	-1'254.68	-1'395.73	-1'537.11	-139.90	-976.09	146.09	-833.84
- sum FM without biom. burning	-373.24	-905.91	-743.01	-2'701.68	-822.99	-338.59	-88.45	-1'744.34
B.2. Cropland management (if elected)	NA	NA	NA	NA	NA	NA	NA	NA
B.3. Grazing land management (if elected)	NA	NA	NA	NA	NA	NA	NA	NA
B.4. Revegetation (if elected)	NA	NA	NA	NA	NA	NA	NA	NA
SUM Art. 3.3 and 3.4	-354.05	-875.86	-691.43	-2'686.35	-829.45	-355.16	-60.51	-1'733.04

NA = not applicable

Fig. 5 > Institutional setting of the national inventory system



FOEN (2006h, 2009)

Recalculations

Several recalculations were performed in the past, driven by the permanent improvement process of the inventory. Meanwhile, the inventory has reached a consolidated state. Data suppliers and members of the inventory core group have to apply for recalculations to the inventory project management. The project management itself may consider the recalculation of data on the basis of review results. It will assess the rationale for any recalculation and submit a proposal for its implementation to the NIS supervisory board.

Quality management system

The GHG inventory is managed according to a quality management system (QMS) that was established following an audit in 2004. The QMS is designed to comply with the quality objectives of the good practice guidance of IPCC (2000), i.e. to ensure and continuously improve transparency, consistency, comparability, completeness, accuracy, and confidence in national GHG emission and removal estimates. Based on these quality criteria, the objective of Switzerland's inventory system is to produce yearly high quality inventories that fully comply with the reporting requirements of the UNFCCC and the Kyoto Protocol. The NIS quality management system complies with the ISO 9001:2000 standard and has been certified by the Swiss Association for Quality and Management Systems.

Procedures for official consideration and approval of the inventory

The inventory project management submits the national inventory report (NIR) and the CRF tables to the NIS supervisory board for consideration. The chair of the NIS supervisory board presents the inventory to the FOEN directorate for official approval.

National registry

Switzerland uses the Seringas™ registry software (developed by the French Caisse des Dépôts et Consignations). Further developments, updates and releases of the software are undertaken in cooperation with all Seringas™ licensees. As of today, the same software is used by the Czech Republic, France, Liechtenstein, Monaco, Poland, Portugal, Slovakia and Russia. In addition, Switzerland cooperates with Liechtenstein and Monaco and hosts the registry of these parties on Swiss servers.

The Swiss national registry conforms to the technical standards for data exchange as specified in the UNFCCC data exchange standards (DES) for registry systems under the Kyoto Protocol. It is connected to the ITL and fully operational since December 2007. The daily reconciliations confirm the integrity of the database.

1.4 Policies and measures

General policy context

The overarching context for environmental and climate policy is the federal constitution of the Swiss Confederation where, prominently in the opening paragraphs, sustainable development is listed as one of the main objectives of the country. In pursuit of this commitment, Switzerland has established an Interdepartmental Sustainable Development Committee (ISDC), which defined the priorities for action and oversees implementation and monitoring of progress. The intention is to make sustainability assessments an integral part of decision making and policy evaluation. In the field of climate policy, many topics fall in the responsibility of various federal departments and offices. The Federal Council has therefore appointed the Swiss Interdepartmental Committee for Climate Policy (SICCP) to facilitate a coherent Swiss climate policy compliant with the UN framework convention on climate change.

As Switzerland has ratified the Kyoto Protocol, the national greenhouse gas emission target is set to 8% below emissions in 1990 over the period from 2008-2012. In national legislation (the CO_2 Act), Switzerland has translated this reduction commitment into national targets for energy related CO_2 emissions. A second important piece of legislation bearing on compliance with commitments under the Kyoto Protocol is the Federal Act on the Protection of the Environment. It provides measures to mitigate emissions from waste disposal (CH_4), synthetic gases (HFC, PFC, SF_6) and GHG precursors.

Implementation of measures to reach the national emission targets are divided between different authorities. While the strategic decisions and the overall framework are made by the federal authorities, the concrete legislation and its implementation remains within the competences of the cantons. This is reflected in the complex and diverse cantonal and federal legislative frameworks that are relevant to the overall Swiss climate policy. Consequently, also the funding of measures is divided between federal, cantonal and private entities, depending on the individual measures.

Institutional arrangements with regards to flexible mechanisms

The national secretariat for the flexible mechanisms (designated national authority under the CDM and designated focal point under JI) was established and announced to the UNFCCC in 2004 and 2007 respectively. Activities relating to the implementation of the flexible mechanisms as well as enquiries concerning the mechanisms and the examination and approval of project proposals are coordinated by an interdepartmental working group of the SICCP.

The use of the flexible mechanisms is governed by rules defined at the international level (UNFCCC, CDM executive board, JI supervisory committee). The Swiss government does not intend to purchase certificates from CDM/JI projects. The major user of the flexible mechanisms is likely to be the private Climate Cent Foundation. Additionally, some activities by entities included in the Swiss emissions trading scheme are expected. In principle, all natural or legal persons are allowed to participate in the mechanisms. An ordinance concerning the requirements for CDM/JI projects, as well as the amount of certificates from abroad to be used for compliance (supplementarity), was adopted by the Federal Council in June 2005.

So far, the Swiss designated national authority has issued 709 letters to CDM projects: 175 letters of approval to Swiss or Swiss-based entities and 534 letters of authorization for participation in already registered projects mainly to foreign entities. The issuance of authorizations to foreign entities is mainly due to the early connection of the Swiss registry to the international transaction log (ITL) of the UNFCCC.

Sectoral and Cross-sectoral policies and measures

The policies and measures presented in the fourth national communication have been upheld and developed over the past years. Some of the planned policies have been implemented in the mean time and make part of the Swiss policy portfolio for compliance with the Kyoto Protocol.

- Introduction of "climate cent" on fuels for transport (0.015CHF/litre) levied by mineral oil importers to fund the Climate Cent Foundation on 1.10.2005
- Second term of SwissEnergy programme 2006-2010 (follow-up to Energy 2000 and SwissEnergy 2000-2005)
- Federal decree on compulsory compensation of all CO_2 emissions from gas power stations (currently limited until 31.12.2010, but parliamentary discussion for including compensation conditions into revised CO_2 Act ongoing)
- Introduction of levy on heating fuels on 1.1.2008 (12 CHF/t CO_2), increased to 36 CHF/t CO_2 as of 1.1.2010
- Action plans "Energy efficiency" and "Renewable energy" adopted
- Addendum to the contract with the Climate Change Foundation to deliver additional CO_2 credits within and outside Switzerland
- Swiss Interdepartmental Committee for Climate Policy SICCP, inaugurated in April 2008
- Promotion of natural gas and biofuels via reduced tax rates from 1.7.2008 (with the proviso of a favourable ecological balance of the biofuel)
- Earmarking of CO_2 tax revenues to fund building programme (passed by the parliament in June 2009)

Environmental policy

Swiss environmental policy is addressing a wide spectrum of issues within Switzerland, ranging from pollution of air, water and soil, to protecting stratospheric ozone or to reducing and managing waste. Some of these policy areas are linked directly or indirectly to Swiss greenhouse gas emissions. The main instruments for implementation are the definition of legally binding emission limits, introduction of levies on potentially damaging substances or practices, as well as the obligation of environmental compatibility assessments for particular facilities and installations.

Climate policy

The centrepiece of Swiss climate policy is the CO_2 Act that came into force in May 2000. It limits CO_2 emissions from fossil fuel use for heating and transport to 10% below 1990 levels over the period from 2008-2012. The overall target is further divided into a reduction target of 15% on heating and process fuels and 8% on transport fuels. The primary instruments to reach the targets are

- voluntary actions in various areas
- subsidiary CO_2 levy for heating and process fuels as well as transport fuels
- measures in other policy areas that are relevant to climate change mitigation
- emissions trading and complementary use of flexible mechanisms (cap and trade)

Within the CO_2 Act, the Federal Council is obliged to propose further reduction targets for the time after 2012. It has put a climate policy proposal forward for parliamentary discussion in August 2009 including:

- reduction of emissions by 20% below 1990 in 2020 (possibly 30%, depending on other nations' commitments)
- continuation of CO_2 levy on heating fuels
- intensified efforts to promote energy efficiency and use of renewable energy in the building sector, subsidized with up to CHF 200 million from the CO_2 levy
- introduction of CO_2 emission limits for new cars, compatible with EU regulations; compensation of parts of the CO_2 emissions from the transport sector by domestic or international projects; option to introduce a CO_2 levy on transport fuels if other measures in the transport sector prove insufficient
- full compensation of emissions from combined cycle power plants
- further development of national emissions trading scheme with a view to link it to the EU scheme
- national coordination of adaptation measures in Switzerland

Energy policy

According to the federal constitution, the federal government and the cantons are obliged to use their competences to ensure an adequate, broad-based, secure, economical and ecological energy supply, and the economical and efficient use of energy. The policies and measures in the energy sector are addressing three priority areas: The building sector, the transport sector and the regulatory framework concerning renewable energy (in particular electricity). Policies and measures are allocated to various interlinked programmes and frameworks, both at federal and cantonal level. Most relevant are:

- The SwissEnergy programme, with the target for 2010 to reduce fossil fuel consumption by 10% compared to 2000, to limit the increase in electricity consumption to 5% compared to 2000, and to increase the percentage of electricity from renewable sources by 1% and of heat from renewable sources by 3%.
- Regulations in the electricity market and opening of the market in two stages.
- Cantonal energy directors adopting new building codes (SIA 380/1 2007).
- Action plans for energy efficiency and renewable energies.
- Short-term measures to curb the economic downturn that intensify existing initiatives in the energy sector.

Transport policy

Switzerland has developed an integrated strategy for transport policy, focusing on better coordination between transport modes, and paying greater attention to environmental problems. This strategy has been strengthened in recent years with a broader integration of transport policy into spatial development and the general sustainability context. The main thrust of the resulting policies lies in promoting a shift towards more sustainable modes of transport, planning and providing infrastructure that supports such a shift, and by passing legislation that reduces emissions and promotes low-emission technologies.

Passenger transport: Switzerland has an excellent rail infrastructure that is permanently maintained, modernized and improved. The first phase of a major expansion of rail transport capacity RAIL 2000 was completed in 2004. It marked a milestone for Swiss public transport, as rail service levels increased by 12%. At the same time, work is progressing on the New Rail Link through the Alps. A first tunnel (Lötschberg) opened in 2008, the second is expected to open in 2017 (St. Gotthard). The tunnels are increasing the capacity and attractiveness for both transalpine freight and passenger transport from Switzerland and northern Europe to Italy.

Funding for development and maintenance of road infrastructure is provided through the infrastructure fund, which has been launched in 2008. Amongst others, Switzerland runs an agglomeration programme aimed at providing financial resources for infrastructure projects that promote public and non-motorized transport in suburban regions and agglomerations out of this fund. Switzerland has developed further programmes aimed at specific parts of the transport sector like leisure transport, non-motorized transport, traffic telematics and a service centre for innovative mobility. These programmes are complemented with regulations and recommendations at the technical level, such as emission standards, environmental labels for motor vehicles, promotion of biofuels and measures at the cantonal and communal level.

Freight/heavy goods transport: Switzerland's freight transport policy rests on article 84 of the federal constitution, which requires that transalpine freight transport shifts from road to rail. The central policy element to reach this target is the heavy vehicle fee (HVF) combined with measures to improve competitiveness of international rail transport. The HVF is applied to passenger and freight transport vehicles of more than 3.5 tonnes gross weight. The fee is calculated according to three criteria: the kilometres travelled on Swiss roads, the highest authorized gross weight, and the pollutants emitted by the vehicle, according to EURO classes. Additional measures to support modal shift of freight traffic from road to rail include for example the modernisation of rail infrastructure by 2030, the further increase of the productivity and competitiveness of rail transportation or bringing down slot prices and providing additional intermodal services.

Aviation: With respect to climate change, Swiss aviation policy is focused on international aviation, as the share of Switzerland's domestic aviation emissions is very small. Switzerland joined the International Civil Aviation Organization (ICAO), the European Civil Aviation Conference (ECAC), and the European Aviation Safety Agency (EASA). Switzerland adopted European civil aviation legislation within the framework of the bilateral transport agreement between Switzerland and the EU. Within the ECAC, EASA and ICAO, Switzerland strives for internationally coordinated measures to limit GHG emissions from aviation. Switzerland applies and promotes airport emissions charges systems and works towards stricter internationally accepted emission standards for new aircraft engines. With respect to market based measures, Switzerland is studying how civil aviation could be integrated in an emissions trading system compatible with European aviation policy. The Federal Council evaluates to what extent revenues from current taxes on kerosene in domestic aviation could be used to finance environmental protection measures relating to aviation.

Industry

Switzerland has not developed specific policies in the industry sector, apart from the policies related to synthetic gases (described below). Industrial emissions of CO_2 are controlled under the CO_2 Act, with the main instruments being the CO_2 levy, the conditional exemption from the CO_2 levy, and the emissions trading amongst companies exempt from the CO_2 levy.

The Ordinance on Chemical Risk Reduction provides for measures to control emissions of persistent substances with a high global warming potential (HFCs, PFCs, SF_6, NF_3, HFEs) in almost all sectors. The use of synthetic gases has strongly increased, and in 2007 they represented around 1.7% of anthropogenic GHG emissions in Switzerland. The effort made since 2003 to control synthetic GHG emissions under the generic name of "substances stable in the air" has shown its first positive effects, with stable emissions since 2004. The regulation limits the use of substances stable in the air to those applications where there is no alternative. Where their use is unavoidable, it aims at reducing emissions as far as possible, and it endorses binding agreements developed by the industry.

Agriculture
According to the Swiss greenhouse gas inventory, agriculture contributed approximately 5.35 million tonnes CO_2eq in 2007, corresponding to roughly 10% of total Swiss emissions. Total emissions from the agriculture sector decreased by 10% from 1990 until 2007. Methane emissions decreased by 7%, while nitrous oxide emissions decreased by 12% over the same period. The reduction is mainly a result of the reduced livestock (cattle declined from 1.86 million to 1.57 million) and of a reduced application of mineral nitrogen fertilizers (reduction from 75'000 tonnes to 57'900 tonnes)

The reform of Swiss agricultural policy led to a reduction of regulated prices in favour of product-independent direct payments for maintaining and cultivating agricultural land according to ecological standards. Lately, a new programme has been launched which subsidizes measures for more efficient use of natural resources in the agricultural sector. Currently, a climate strategy for the agriculture sector is being developed. This strategy will address both the mitigation and adaptation potential. It covers actions aimed at reducing the greenhouse gas intensity of agricultural production and possible measures to adapt agricultural production to climate change. A free trade agreement between Switzerland and the EU for the agrarian and food sector is pending.

Land-use change and forestry
Switzerland has a long-standing tradition of preserving both forest area and forest as a natural ecosystem. The Forests Act prescribes sustainable forest management, prohibits clearing, and bans deforestation unless it is replaced by an equal area of afforested land or an equivalent measure to improve biodiversity. A national forest programme, outlining an action plan for 2004–2015, specifies five priority objectives:

- The forest's protective function is guaranteed
- The economic viability of the forestry sector is improved
- The value-added chain for wood is strengthened
- Biodiversity is conserved
- Forest soils, trees and drinking water are not threatened

Swiss forest policy aims at reducing CO_2 emissions by substituting fossil fuels rather than enhancing sink capacity in the forests. The sink potential of Swiss forests is dwindling, because of largely old forests. The aged forests have decreasing productivity and wood quality, so that a large proportion of mature trees are likely to be harvested in the near or more distant future. As stated in the initial report to the UNFCCC, Switzerland will be accounting for forest management under article 3.4 of the Kyoto Protocol. However, parliament rejected a proposal that would have allowed forest owners to trade carbon credits based on the sink capacity of their forests.

Waste management
In Switzerland, combustible waste, (municipal solid waste, combustible construction waste and sewage sludge) is incinerated in the 29 Swiss municipal solid waste incinerator plants (MSWI), all but one of which produce heat and/or electricity. As these plants have to guarantee waste disposal, they cannot control the waste input in order to reduce their CO_2 output. Therefore, their only possibilities of indirectly reducing CO_2 emissions are increasing the energy efficiency of the incineration plants and optimising the metal recovery from the incineration residues.

1.5 Projections and the total effect of measures

The projections have been completely revised and are no longer comparable to those given in NC4. For all sectors, new or updated models have been used to calculate future trends. Emissions for scenarios "without measures", "with measures", and "with additional measures" have been estimated as recommended by the UNFCCC and are presented in Fig. 6.

Scenario "without measures" The scenario "without measures" estimates the evolution of greenhouse gas emissions from 1990 to 2020 in the absence of measures relating to climate and energy policy that have been taken since 1990. It is based on a reference scenario ("with measures") from which the estimated emissions savings are subtracted. Obviously, a major uncertainty lies in determining if and to what extent the effects are attributable to these measures rather than technological progress. This is taken into account by using additionalities ranging from 30% to 100%.

Scenario "with measures" For the commitment period 2008 – 2012, a special short-term econometric model is used, which is updated annually to take the most actual data available into account. The scenario "with measures" includes the mitigating effects of the SwissEnergy programme and the energy action plans, the building renovation programme and revised building codes, the CO_2 levy on heating fuel, the incentives on biofuels, the heavy vehicle fee, voluntary agreements to enhance energy efficiency and reduce CO_2 emissions, and the wood action plan. Measures implemented to reduce CH_4 and N_2O emissions mainly in the energy and agricultural sectors are taken into account, as well as expected reductions in HFC emissions due to technological developments in refrigeration and air conditioning. For PFCs and SF_6 no major changes are expected. The resulting emission estimates are shown in Fig. 7 and Fig. 8.

Scenario "with additional measures" The proposal of the Federal Council for a revision of the CO_2 Act sets reduction targets (-20% and possibly -30%) and presents the necessary measures for the post-Kyoto period 2012-2020. These measures are considered "additional measures", however, their implementation is subject to parliamentary discussion and possibly a referendum. Planned measures are the continuation of the CO_2 levy, the building programme, a cap-and-trade system for energy-intensive companies, emission standards for new cars, a deposit on synthetic greenhouse gases and the use of the flexible mechanisms to partially compensate for emissions from the transport sector. The expected domestic emission reductions are of the order or -14% for the -20% target, and -18% for the -30% target. Supplementary reduction will be achieved by use of the flexible mechanisms through the compensation requirements imposed on fossil transport fuels.

Fig. 6 > Total GHG emissions from 1990 to 2020 for different scenarios

The lines correspond to the domestic emissions. Use of the flexible mechanisms to purchase emission certificates is part of the Swiss mitigation strategy. The combined effect of domestic and supplementary emission reductions is marked with the bold bars in 2010 and 2020.

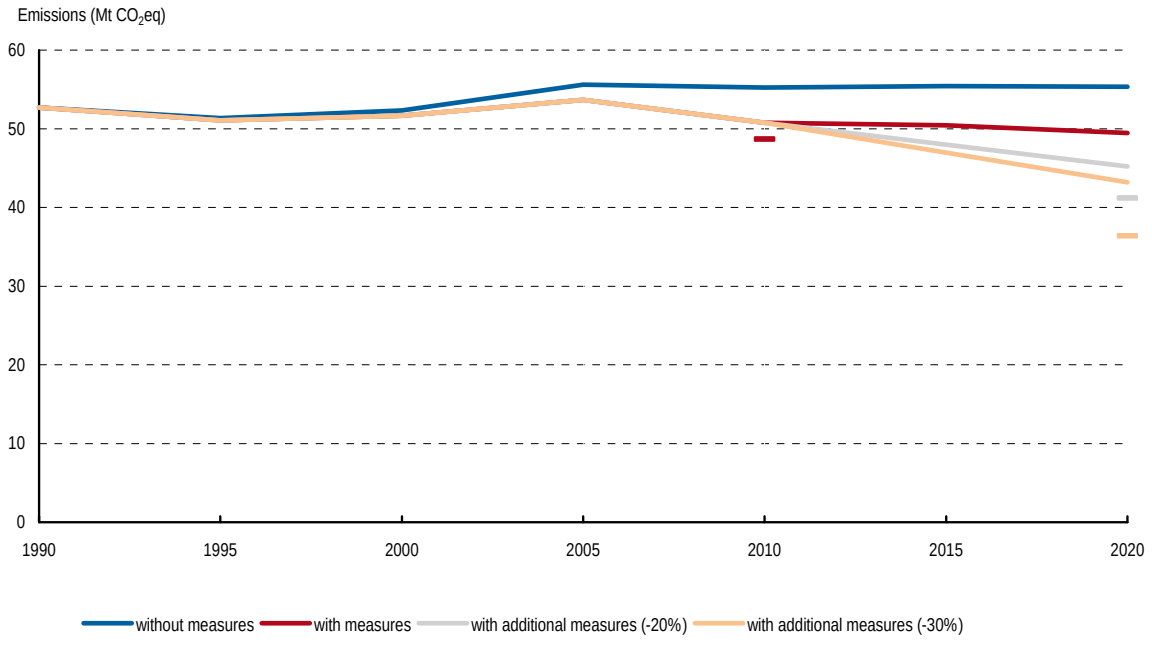


Fig. 7 > CO_2 equivalent emissions from 1990 to 2030, based on scenario "with measures".

Emissions in million tonnes CO_2 equivalent

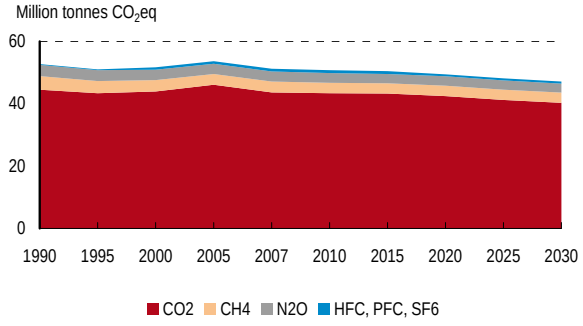
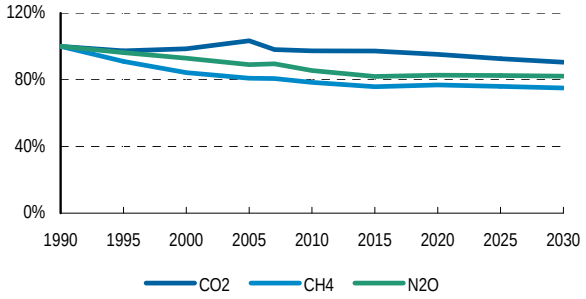


Fig. 8 > Emissions relative to 1990, based on scenario "with measures". Synthetic gases not shown.

Index 1990 = 100%



Kyoto Protocol target

Under the Kyoto Protocol, Switzerland's target for GHG emissions in the first commitment period is 48.57 million tonnes CO_2 equivalent per year – a reduction of 8% below 1990 levels. Switzerland decided to account for forest management (Art. 3.4 KP), and Switzerland will use the flexible mechanisms. However, no public funds are assigned for this purpose. CO_2 credits are solely acquired by the private sector, such as the Climate Cent Foundation. The most recent projections (Tab. 3) show that the Kyoto target can be reached.

Tab. 3 > Kyoto target

Gross and net GHG emissions during the commitment period 2008-2012	
Kyoto Protocol emissions (million tonnes CO_2 equivalent)	
Kyoto target (assigned amount units per year, average 2008–2012)	48.57
Total projected gross GHG emissions (average 2008–2012)	50.86
Use of Kyoto mechanisms (CDM)	*-2.2*
Forest Management (Art. 3.4 KP)	*-0.35*
Net GHG emissions	*48.31*

FOEN (2009e)

1.6 Impacts, vulnerability assessment and adaptation

A recent report of the Swiss Advisory Body on Climate Change (OcCC) provides an assessment of the observed and expected impacts of climate change on Switzerland and the vulnerability of various ecological and socio-economic systems. Recent data confirms a warming trend with an observed increase in mean annual temperature of 1.6 °C between 1864 and 2008. Over the last 100 years, mean annual temperatures increased by 0.12-0.19 °C per decade, with a substantially accelerated warming in recent decades. According to the mean estimate, average temperatures will rise by another 1.8 °C in winter and 2.7 °C in summer between 1990 and 2050. The most visible change in the Alps resulting from global warming is the retreat of glaciers, which showed a volume loss of 12% since 1999. According to the OcCC report, the area covered by alpine glaciers will diminish by about three quarters in case of a medium warming by 2050.

The observed trends in precipitation are less distinct than in temperature. For a number of stations a significant increase in precipitation is found in winter and spring (+2.7 to +3.1% per decade). For summer and autumn no significant trends are detectable. Based on regional climate scenarios, an increase in mean winter precipitation of 8% compared to 1990 is expected north of the Alps by 2050 (11% south of the

Alps), and a decrease of 17% in summer (19% south of the Alps). This will have a marked impact on the hydrological cycle: On the Central Plateau and in the very south of Switzerland, small and medium water-courses will dry up more frequently and natural replenishment of groundwater will decrease accordingly. Apart from changes to the average precipitation rate, increased intensity of storms and reduced snowfall and snow cover duration are expected in the coming decades. This is particularly relevant for alpine areas, tourism and forestry due to the risk of more frequent floods, landslides and debris flows.

The warming trend and changing precipitation patterns are expected to have significant effects on ecosystems. The Biodiversity Monitoring Switzerland reports that impacts of climate change are already being observed, for instance, typical alpine vascular plants have shifted uphill over the past few years. Generally, climate change is expected to affect species composition, distribution, their cycles, synchronicity, the overall genetic diversity and the provision of ecosystem services. It will enhance the vulnerability of forests and impair their protective, productive and social functions. For agriculture, a moderate warming of 2°C to 3°C might increase productivity, however, if temperature rose beyond that level, the increase in heat waves and drought periods would prove problematic for the cultivation of land and for livestock husbandry.

Various sectors of the Swiss economy are likely to be affected by progressing climate change. In particular, the tourism industry will be hard hit, as the potentially beneficial effects for summer tourism will not compensate for the loss of income in mountain resorts during winter due to scarcity of snow. Hydroelectric power stations may be affected by altered run-off and sediment transport regimes, and insurance companies may face increased losses due to winter storms and floods. Natural hazards and extreme weather events potentially pose a growing risk to infrastructure and human health. Heat waves and elevated tropospheric ozone levels are cause for serious concern, as evidenced by the impacts of the heat wave in 2003. Additionally, it remains to be seen to what extent vector-borne diseases spread due to changing climatic conditions.

Swiss national adaptation strategy During the last years, awareness has risen that adaptation to climate change needs an integrated approach involving all stakeholders on all institutional levels. This has triggered work on a coordinated national adaptation strategy. A survey of the Federal Office for the Environment has led to an initial list of measures to be taken into account in the context of the national adaptation strategy and has identified important information gaps. The development of a national adaptation strategy requires:

- improved assessment and planning tools, high-resolution observational data and climate scenarios
- sectoral/regional assessments of climate change impacts, risks and opportunities
- definition of adaptation goals
- prioritising of possible fields of action based on a comprehensive risk assessment
- formulation of sectoral strategies in high-priority areas

Switzerland intends to include adaptation in its future climate legislation, in parallel with efforts aimed at greenhouse gas emissions reductions. The current status of adaptation strategies is listed in Tab. 4.

Tab. 4 > Vulnerability assessment and current adaptation strategies

Vulnerable area	Vulnerability	Adaptation
Society and economy as a whole	Damage, casualties and disruptions caused by more frequent/intense extreme events; irreversible changes in climatic and hydrological conditions with unforeseeable consequences for environment, economy and society	National adaptation strategy to assure a coherent, coordinated approach; development of high-resolution climate models for assessment of impacts at regional/local scale; integration of climate change in strategy on natural hazards; improved preparedness for natural hazards
Water management / Water resources	Increased risk of floods and water shortages, making current lake level regulation schemes obsolete; lack of methodology for the development of quantitative water management plans; insufficient legislation for integrated water resource management (IWRM); loss of coolant capacity due to higher temperature of rivers and lakes	Research projects to improve the data base for assessment of potential impacts and planning of adaptive measures at the sectoral level; review of water management provisions (water reservoirs, managed lakes; code of practice for water use); recommendations and guidelines for IWRM.
Biodiversity	Loss in species diversity with consequences for e.g. food, medicine; degradation of ecosystem services, e.g. pollination, soil fertility, water purification	Fostering resilience of ecosystems, restoring habitat connectivity to enable adaptation of species, safeguarding genetic diversity (gene pool), improving databases, elaboration of a new national biodiversity strategy
Forests and forestry	Reduced productivity and larger damage from pests and forest fires	Guidelines for adaptive forest management (promotion of near-natural silviculture); research on site-specific adaptive measures; extension of early warning systems for pests and forest fires
Agriculture	Reduced productivity and larger damage from pests; decreasing yield stability due to extreme events; increasing damages of infrastructure	Development of a climate strategy for agriculture; breeding/selection of plants and animals; adaptation of cultivation methods and farm management (e.g., water management and irrigation, diversification, insurance)
Hydropower generation	Slight decrease of production; increased transport of sediment and other solid material in rivers	Evaluation of the need for the development of a long-term strategy for adaptive measures
Tourism	Decreasing snow-reliability at lower altitudes; changes in natural scenery; locally reduced ground stability, increased natural hazards; new opportunities for summer tourism	Short-term: "corrective" measures to assure usability of skiing areas. Long-term: adjustment of the offer to changing conditions (e.g., concentration, diversification); climate-proof investments
Human health	Increased mortality during heat waves; spread of vector-borne diseases	Information campaigns/weather alert systems; extension of existing monitoring systems to new risks
Infrastructure	Increasing risk of severe damage through extreme events; heat impairing living and working conditions in buildings	Adaptation of construction standards; exterior wall design (shadowing), air-conditioning/ventilation, minimisation of waste heat in buildings
Insurance business	Unfavourable trend in development of insured damage cost and future loss potential from extreme events; uncertainties with regard to the impact of climate change on the development of losses	"Prospective underwriting"; new products to deal with more severe loss events; use of incentives to promote risk-adapted behaviour of insurance-takers; support of preventive measures to safeguard insurability

1.7 Financial resources and transfer of technology

Within the Swiss federal government, two agencies are responsible for policy formulation and implementation in the area of development cooperation and cooperation with eastern Europe and the CIS: The Swiss Agency for Development and Cooperation (SDC) deals with technical cooperation, financial aid and humanitarian aid, and the State Secretariat for Economic Affairs (SECO) is responsible for measures related to trade and economic development. Both agencies assume a co-responsibility for the international financial institutions. For multilateral contributions to developing countries and countries in transition, also the Global Environment Facility (GEF) plays a major role. The GEF is managed by the Federal Office for the Environment (FOEN). SDC's contributions related to climate change are made within its Global Programme Climate Change (GPCC) that operates at political, multilateral and regional levels and covers climate change mitigation as well as adaptation. SECO provides macro-economic support, private sector promotion, trade promotion and infrastructure financing. For these purposes, SECO has partnered with the World Bank, Regional Development Banks, UNIDO, UNCTAD, ITC, ITTO and other specialised organisations, including from the Swiss private sector.

"New and additional" financial resources

Switzerland's contribution to funds under the UNFCCC and its Kyoto Protocol that are managed by the Global Environmental Facility (GEF) are listed in Tab. 5.

Tab. 5 > Financial contributions to the UNFCCC climate funds managed by the GEF

	Contributions (CHF)			
	2005	2006	2007	2008
Least Developed Countries Fund	700'000	700'000	1'000'000	1'000'000
Special Climate Change Fund (Adaptation)	650'000	900'000	500'000	500'000
Special Climate Change Fund (Technology Transfer)	650'000	400'000	0	0

FOEN (2009 internal document)

Assistance to developing country parties that are particularly vulnerable to climate change

The overall goal of SDC's Global Programme Climate Change in adaptation is to support developing and threshold countries in reducing their susceptibility to unavoidable climate change and minimising the social and economic costs. Most activities of SDC in this field are linked to sustainable management of soils, water and forests and envisage the most vulnerable countries and communities. Furthermore, Switzerland has been very active in disaster risk reduction and has developed methods and tools to better integrate disaster risk reduction into project planning and project management. Several climate related projects of multilateral institutions are supported by SDC, such as UNDP's climate change capacity development for policy makers in developing countries, the World Bank's study "Economics of Adaptation to Climate Change" or the knowledge management platform Climate-L.org, which is provided by IISD in cooperation with the UN Chief Executives Board for Coordination Secretariat. SECO, on the other hand, is supporting the Commodity Risk Management (CRMG) of the World Bank by co-founding pilot projects on weather insurance for farmers that are based on weather indices.

Provision of financial resources (incl. under Art. 11 KP)

From 2005 to 2008, Switzerland's official development assistance amounted to CHF 8.3 billion (between 2 and CHF 2.2 billion per year), whereof approximately 25% have been provided through multilateral assistance (core contributions and programmes) and 75% through bilateral assistance projects. Contributions to climate-related aid in bilateral ODA is estimated at approx. 70 million CHF per year, while contributions to multilateral institutions were of the order of 300 million CHF per year. However, as most projects pursue a holistic approach, it is difficult to assign contributions to climate change alone.

Activities related to transfer of technology

Alongside public sector activities, the Swiss private sector plays an important role in terms of technology transfer. In many fields of environmentally sound technologies, Swiss companies are leading in the development, diffusion and implementation of state-of-the-art solutions and pursue climate-related activities in the order of several billion CHF per year, supported by the Swiss export promotion agency Business Network Switzerland.

The main responsibility of Switzerland's **public sector activities** with regard to technology transfer lies within SECO's "Economic Cooperation and Development" division, which is responsible for planning and implementing economic and trade policy measures with developing countries, eastern European and central Asian states as well as the new EU member states. The focus on its activities is on mitigation of greenhouse gases mostly in sectors with high mitigation effects. Activities focus on:

Carbon market: SECO is supporting capacity building activities related to CDM projects and promotes emissions trading and market-based instruments.

Promoting energy efficiency: SECO provides financial incentives, improves the framework conditions and offers professional consultancy services to make use of know-how and capital in the private sector. Mainly together with UNIDO, SECO has contributed to promote energy efficiency, e.g. through the creation of a global network of National Cleaner Production Centres.

Promoting renewable energy sources: SECO provides attractive framework conditions and financial incentives to facilitate the use of hydropower, solar energy and biogas in order to help securing energy supply but also decreasing the use of fossil fuels and related emissions.

Sustainable use of natural resources: SECO supports the formulation of global mechanisms that create financial incentives to protect the rainforest as an important carbon sink. Furthermore, SECO has been an official partner of the World Bank's Forest Carbon Partnership facility since its launch in 2007. To date around USD 8.2 million have been contributed in order to set up control systems, reinforce training programmes and pilot projects.

Apart from **SDC's** activities in the field of adaptation, its Global Programme Climate Change is also supporting mitigation actions in developing and emerging countries in order to follow a sustainable development path with low greenhouse gas emissions and less dependence on fossil fuels. With regard to energy efficiency in buildings, Switzerland has developed considerable technological and scientific expertise.

1.8 Research and systematic observation

Climate research is spread over many institutions and funded through national and international funding bodies. Swiss researchers actively participate in various international research programmes. In 2007, about 240 projects received funding from the National Science Foundation and about 120 from the EU, with an average funding of CHF 130'000 per project and year.

Switzerland has established two National Centres of Competence in Research (NCCR), which are concerned with climate change issues. **NCCR Climate** started its third 4-year period in April 2009. It addresses issues of natural climate variability, predictability, and resulting impacts on biological and socio-economic systems by combining the contributions from relevant disciplines into an integrated network of competence. Two national centres for climate research have emerged from the NCCR Climate initiative: The Oeschger Centre for Climate Change Research (OCCR) at the University of Bern and the Centre for Climate Systems Modelling (C2SM) at the ETH Zürich. **NCCR North South** focuses on international research cooperation. It contributes to an improved understanding of different syndromes of global change, of the pressures these syndromes exert on different resources, and of the responses of social groups and society as a whole.

Research that is directly funded by government institutions falls into one of the federal research programmes. These programmes provide the conceptual framework and set research priorities in the relevant policy area. Energy research policy is laid down in the four-year federal **energy research** programme of the Swiss Federal Office of Energy. The focus for the years 2008-2011 lies on the rational use of energy, renewables, nuclear energy, and energy policies and economics. Energy research continues to be guided by the vision of a 2'000 W per capita society. National priorities in **transport research** are external costs, sustainable modes of transport and road infrastructure. **Agriculture research** is focusing on farming practices that contribute to climate change mitigation or that are more adaptable to future climate conditions. **Forest research** targets sustainable forest management and the preservation of the protective function of forests against natural hazards.

Switzerland has a long tradition of **systematic climate observation**. Temperature and precipitation series of more than 150 years, the world's longest total ozone series, glacier measurements dating back to the end of the 19th century and the 100-year anniversary of the Physical Meteorological Observatory Davos are only a few of the highlights of Switzerland's contribution to global and regional climate monitoring. The implementation of systematic climate observation in accordance with the requirements of the UNFCCC and the Kyoto Protocol (Global Climate Observing System GCOS), is coordinated by the Swiss GCOS Office at the Federal Office of Meteorology and Climatology MeteoSwiss. It includes all climate-relevant measurements that are made by federal offices, research institutes and universities in Switzerland. Furthermore, the Swiss GCOS Office ensures communication with the corresponding international bodies. Switzerland hosts international data, calibration and quality assurance centres and participates in the GCOS Cooperation Mechanism (GCM), which supports the improvement of climate observing systems in developing and emerging countries

In the atmospheric domain, observation networks include surface, upper air and atmospheric composition measurements. These national networks are linked to international programmes and observing systems such as for example to the GCOS Surface Network (GSN), the GCOS Upper Air Network (GUAN) or the WMO Global Atmosphere Watch (GAW) programme. In the terrestrial domain, continuous measurements of the cryosphere (glacier, permafrost, snow cover), the water cycle, and the biosphere provide a basis for assessing the impacts of climate change on the Alpine environment and its consequences (e.g. for agriculture, energy production, ecosystems).

1.9 Education, training and public awareness

Switzerland has a long tradition on raising public awareness for environmental issues. According to a recent study on the public perception and knowledge with regard to environmental issues, climate change represents one of the top three concerns of Swiss citizens, only outweighed by concerns regarding health-care costs and the funding of the state pension scheme. The prominence of climate change issues may be related to the concerted effort of leading climate researchers in communicating their results to the general public.

Federal, state, and local authorities as well as the private sector contribute to various activities related to education, training and public awareness. Information platforms and websites have been launched by the Federal Office for the Environment, the Swiss Federal Office of Energy, MeteoSwiss, OcCC and various cantonal environmental authorities. The platforms either provide information on climate change related topics or deal with climate-related enquiries from the general public. These channels are supplemented by a wide spectrum of magazines, reports and newsletters published by federal agencies, media releases as well as talks and public appearances at exhibitions and meetings.

Training and further education in the energy sector is the joint responsibility of the Swiss Federal Office of Energy and the Conference of Cantonal Energy Directors, as no trade or industry association exists that systematically focuses on the economical and ecological use of energy resources. The initiative "continuing education in energy efficiency and renewable energy" is a core element of the energy action plans and aims to build up technical know-how to better exploit the energy saving potential and the use of renewable energies in the building sector through education programmes of the cantons, professional associations as well as technical schools and universities of applied sciences.

The scientific advisory bodies ProClim (*www.proclim.ch*) and OcCC (*www.occc.ch*) are prominent organisations that regularly publish the latest information on climate change research. The aim of ProClim is to provide a holistic view on climate change, including the physical climate system, biogeochemical processes and the human dimensions of global change. Furthermore, it is an important platform for nationwide networking amongst people and institutions. OcCC's role is to formulate recommendations on questions regarding climate and global change for politicians and the federal administration. The two bodies are involved in translating and distributing the summaries of the IPCC reports. Various other initiatives are supported by federal agencies mostly in collaboration with research groups of Swiss universities such as the freely available e-learning environment based on the hiking trail in Engadine, developed by the Swiss Federal Institute of Technology in Zürich (*www.klimaweg.ethz.ch*).

Private sector initiatives Swiss companies are undertaking voluntary efforts (partly within the WWF Climate Group) to reduce the carbon footprint of production processes and products. The Energy Agency for the Economy assists companies in reducing CO_2 emissions, increase energy efficiency and tap the potential of cost-efficient and climate-friendly measures. Furthermore, the Swiss Association for Environmentally Conscious Management (ÖBU) highlights the challenges and potential new business opportunities related to climate change. An ever increasing number of activities and events aimed at increasing public awareness and consciousness towards climate change, its challenges and potential measures for mitigation or adaptation are sponsored by various companies and associations.

2 National circumstances

2.1 Political profile

Administrative structures
Switzerland is a confederation, with a federal government, a bicameral parliament and a Federal Supreme Court. The territory consists of 26 cantons (states), each of which has its own government, parliament and cantonal court. Responsibilities are shared between the federal authorities and the cantons.

The federal government consists of the seven members of the Federal Council, together with the Federal Chancellor, and is elected by the United Federal Assembly for a four-year term. The federal administration comprises the Federal Chancellery and seven Federal Departments (for details, see *http://www.bk.admin.ch/dokumentation/02070/index.html?lang=en*).

The Swiss parliament has two chambers which, when in joint session, are known as the United Federal Assembly. This is the country's legislative authority. The National Council, through its 200 members, represents the population of the country as a whole – the individual cantons are represented in proportion to the number of their inhabitants. The Council of States represents the 26 cantons – 20 cantons are represented by two members while six half-cantons each send one representative to the 46-strong chamber.

Subsidiarity plays an important role in Switzerland. This is reflected in constitutional law, which states that unless legislative power is explicitly assigned to the confederation, the cantons are sovereign, i.e. entitled to legislate in an area of policy. This fundamental principle helps to protect minority interests, above all those of the French-, Italian- and Romansh-speaking parts of Switzerland. Another important aspect is fiscal federalism. Each canton has its own budget and sets its own level of direct taxation. Despite a system of financial equalization amongst cantons, substantial differences remain in the level of taxation of both households and companies.

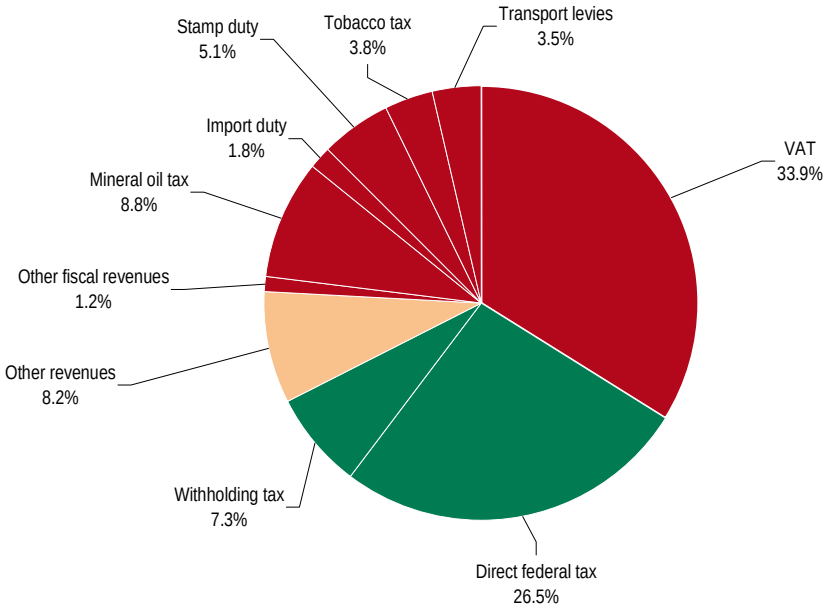
Cooperation is an important principle, both vertically across the hierarchic levels of authorities and horizontally within a level of authority. In matters where the federal authorities are responsible for legislation, the role of the cantons is to implement and enforce such legislation. Very often, the cantons have substantial leeway to take local or regional conditions into account. At a lower level, similar autonomy is granted to the municipalities by the cantons. At the same time, cantons cooperate horizontally and have agreements that facilitate harmonized, effective implementation in a number of policy areas.

The legislative system comprises several hierarchical levels. All legislation must ultimately comply with the constitution. Laws of different kinds (federal acts and federal decrees) implement constitutional matters. Regulation at both of these levels is subject to the approval of the electorate, which is not the case for ordinances, through which the government alone implements the contents of laws.

Federal revenue and expenditure
Fig. 9 and Fig. 10 show the present structure of federal revenue and expenditure. Federal revenue accounted for around CHF 58 billion in 2007 whereof 58% derived from indirect taxes (highlighted in red) and 34% from direct taxes (highlighted in green).

Fig. 9 > Breakdown of federal revenue in 2007

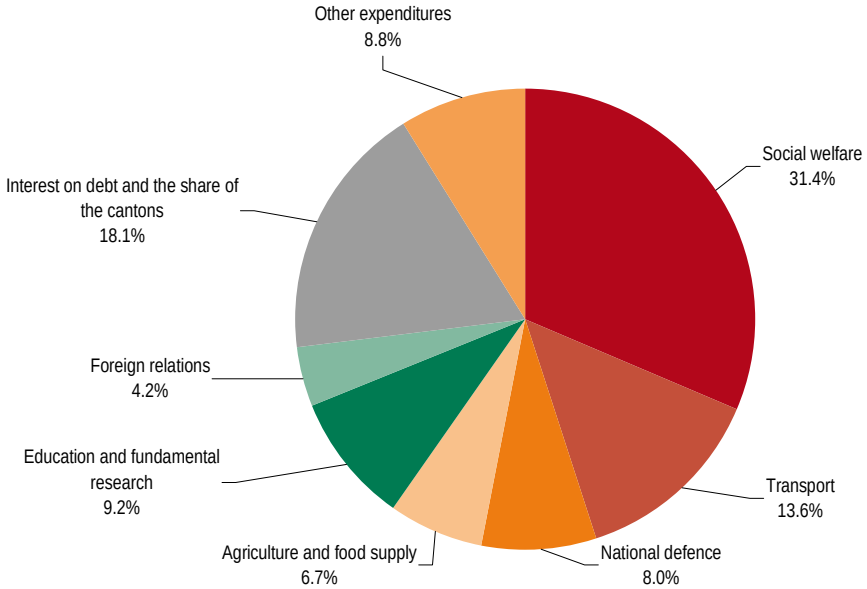
Total federal revenue in 2007 accounted for CHF 58 billion. Direct taxes are shown in green, indirect taxes in red.



FCh (2009)

Fig. 10 > Breakdown of federal expenditure in 2007

Total federal expenditure in 2007 accounted for CHF 54 billion.



FCh (2009)

Political organisation of Switzerland: The people, the supreme political authority

Switzerland is a representative democracy, with strong formal and informal elements of direct democracy. According to the federal constitution, the Swiss people are sovereign and ultimately the supreme political authority. Virtually all important decisions have to be approved by the electorate. This includes all Swiss adults who are eligible to vote – some 4.9 million citizens, i.e. around 60% of the resident population. Those under the age of 18 and foreign nationals have no political rights at federal level. Switzerland is virtually the only country in the world where the people have such extensive decision-making power. The longstanding democratic tradition, but also the comparatively small size of the population are crucial for the operation of this particular system of government. At federal level, Swiss nationals can **elect**, **vote**, request for **popular initiatives** and take a **referendum**. At cantonal and municipal level, similar rights exist; however, they are not uniform all across Switzerland.

Every four years, the people **elect** the 200 members of the National Council. All Swiss citizens over the age of 18 may take part in elections, both actively and passively. In other words, they may cast their votes and stand for election themselves. Federal civil servants standing for election are required to choose between their position in the federal administration and elected office.

The electorate is regularly asked to cast their **vote** in popular ballots. Voters are generally called on four times a year to vote on federal proposals. On average these votes involve three to four proposals that may be adopted or rejected; although in exceptional cases, there may be more than twice that many. Votes are held on people's initiatives and referendums. Often, cantonal and communal ballots are held at the same time.

By means of a **popular initiative**, citizens can seek an amendment to the constitution (at the cantonal level also an amendment to a law). Popular initiatives may comprise a general proposal or contain detailed regulations. In most cases, a proposal must be accepted by a majority of the electorate and of the cantons if it is to become part of the constitution. This requirement for a "double" majority (population and cantons) mainly serves to protect the interests of less populous rural cantons.

The second formal instrument of direct democracy is the **referendum.** This allows citizens to veto decisions made by parliament. The referendum may be mandatory or optional. It is possible to have a referendum concerning regulations at the level of the constitution, formal laws, international treaties, and generally binding federal decrees that are put into effect as a matter of urgency. Both popular initiatives and referendums also exist at the cantonal level. The petition is an informal instrument of public participation and is non-binding.

The cantons and other interested parties (e.g. business, trade unions, NGOs etc.) are included in a consultation process whenever government (the Federal Council) proposes a significant change in the constitution, in a law or an ordinance. This comprehensive consultation process is a very important phase in the legislative procedure in Switzerland. The aim is to include expert knowledge and to consider proposals of particular interest groups, where possible. This process allows to estimate and improve the success chances of the proposals in an eventual referendum. Although the outcome of the consultation process is formally non-binding, it is of great importance and reflects an established principle of consensus, which is typical of policy-making and of political culture in Switzerland. However, this political participation process also leads to a relatively prolonged policy-making process which needs to be appreciated in the context of the policies and measures described in section 4.

International relations

Switzerland is a member of several international organizations (e.g. the OECD, the World Bank Group and all UN specialized agencies). In March 2002, the Swiss population also voted for UN membership, and since September 2002, Switzerland has been a full member of the United Nations.

Although not a member state of the European Union (EU), Switzerland has a strong relationship with the EU and European policy is a high priority of Swiss foreign policy. The legal basis of this close cooperation is formed by bilateral agreements (Integration Office 2009), and most new and amendments to existing Swiss laws have been made compatible with EU legislation. Relations between Switzerland and the EU have developed over decades. The bilateral agreements have been extended step by step. Important stages of this European policy have been assessed and approved by the people in referendums. Switzerland became a member of the European Environmental Agency (EEA), one of the most important agencies for European cooperation in environmental issues.

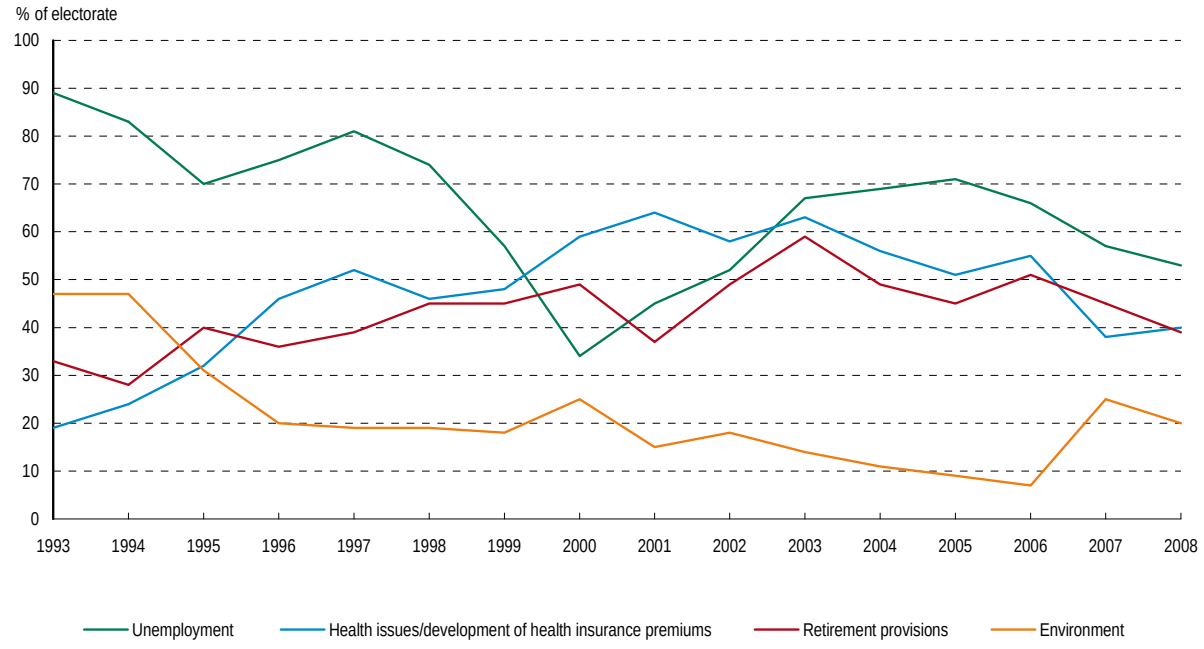
2.2 Perceptions of political problems

In the year 2008, 53% of the Swiss considered unemployment as one of the five major problems Switzerland is facing, followed by concerns regarding the public health system and associated increase of health insurance premiums, and the prospects of retirement pensions. Fig. 11 shows the development of these three issues and the concern about environmental issues from 1993 until 2008. Due to structural and cyclical changes in national and international labour markets, unemployment began to rise at the beginning of the 1990s and became a major public concern during that decade. Development of unemployment rates are shown in section 2.6.

In relation to the three major concerns, environmental issues are perceived to be less important. However, if respondents were asked about future fears, the environment is thought to be in a much worse state in ten years than today and therefore, it accounts for the second most important issue that we will face in future. Furthermore, over the last five years, increasing importance is assigned to achieving political goals with regard to GHG emissions.

Fig. 11 > Perception of political problems

"What do you consider the five most important problems of Switzerland? " Multiple answers were possible.



GfS (2003) and (2008)

2.3 Population, building stock and urban structure

According to the Swiss Federal Statistical Office (FSO 2009a), Switzerland had a population[1] of 7.7 millions with a density of 186.4 persons per km^2, and more than two thirds of the Swiss population living in cities or metropolitan areas at the end of 2008. Fig. 12 shows the increase in population from 1960 to the end of 2008.

Population growth is mainly the effect of immigration and increasing life expectancy. 25% of children born in Switzerland in 2008 were foreign nationals.

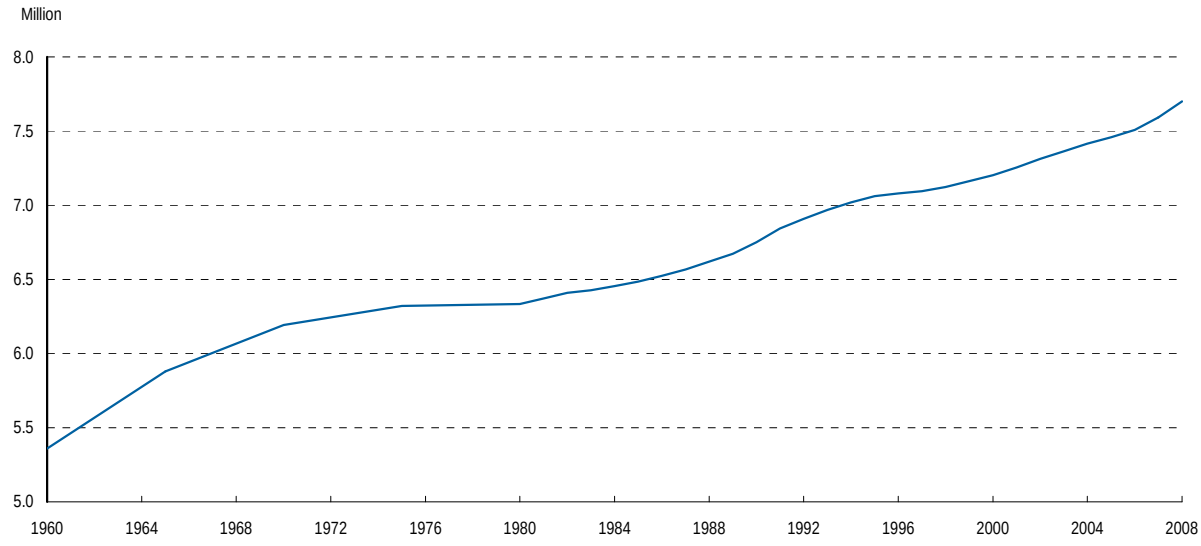
Age structure: Fig. 13 shows the demographic structure of Switzerland in 2008 by age, sex and nationality. Foreign nationals account for about 23% of the permanent Swiss residential population. A growing proportion of the population is of retirement age, while the share of persons below the age of 20 has been declining since the 1970s.

Languages: Switzerland has four official languages (German, French, Italian, and Romansh). In 2007, German was spoken by 63.7%, French by 20.4%, Italian by 6.5% and Romansh by 0.5% of the inhabitants. The most common foreign languages are Serbo-Croatian (9%), Albanian, Portuguese, Spanish, English, Turkish and other Slavic languages.

Expansion of urban areas: One third of the Swiss population lives in the urban agglomerations of the five major cities of the country (Zürich, Geneva, Basel, Bern and Lausanne). Another third lives in smaller urban areas, while the remaining third has settled in rural areas. Since the early 80's, the share of population living in urban areas slightly declined (from 74.5% to 73.4%) (FSO 2009c).

Fig. 12 > Population

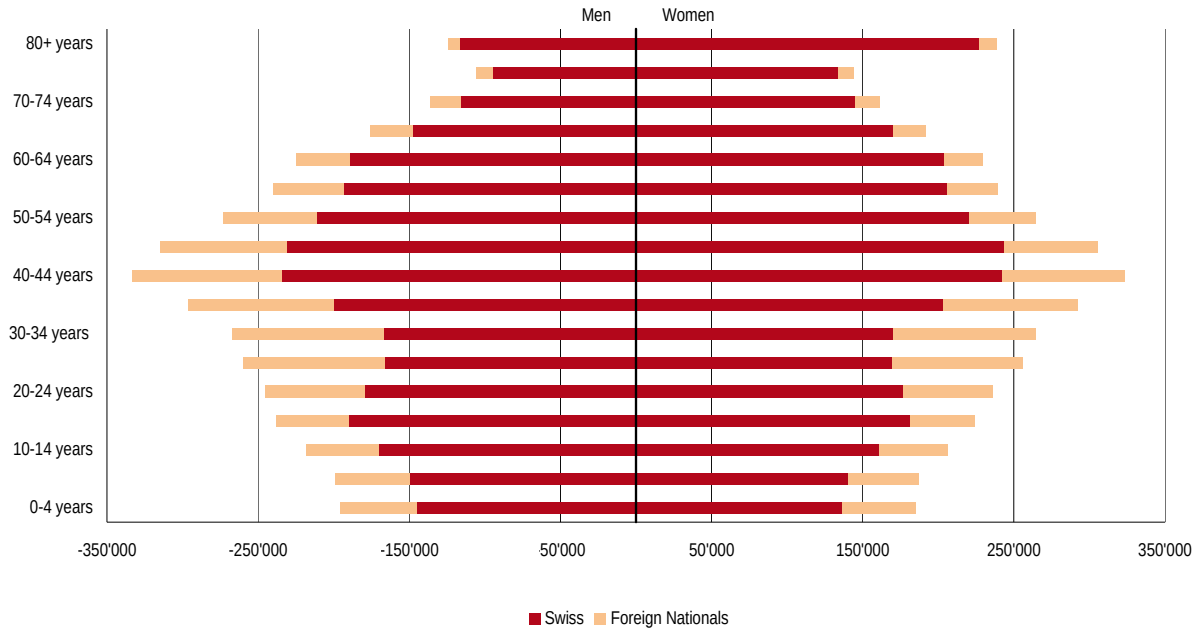
Permanent residential population at year end between 1960 and 2008. At the end of 2008, Switzerland had 7.7 million permanent residents, of which 3.8 million men and 3.9 million women. Approximately 20% of the permanent residential population were foreign nationals.



SFOE (2004b) and FSO (2009a)

[1] The GHG emissions per capita were calculated based on preliminary numbers of SFOE 2008, which were slightly different.

Fig. 13 > Age structure in Switzerland in 2008



FSO (2009b)

Homeownership rates: Homeownership rates in Switzerland stay relatively low. Only 34.6% of the permanent residents in Switzerland live in their own apartments (data for 2000), the majority stays in rented accommodation. Since 1970, the percentage of homeowners has slightly increased (FSO 2009c), however, it still represents the lowest rate in all European countries. With regard to modernising of buildings, the low homeownership rates represent a significant hurdle.

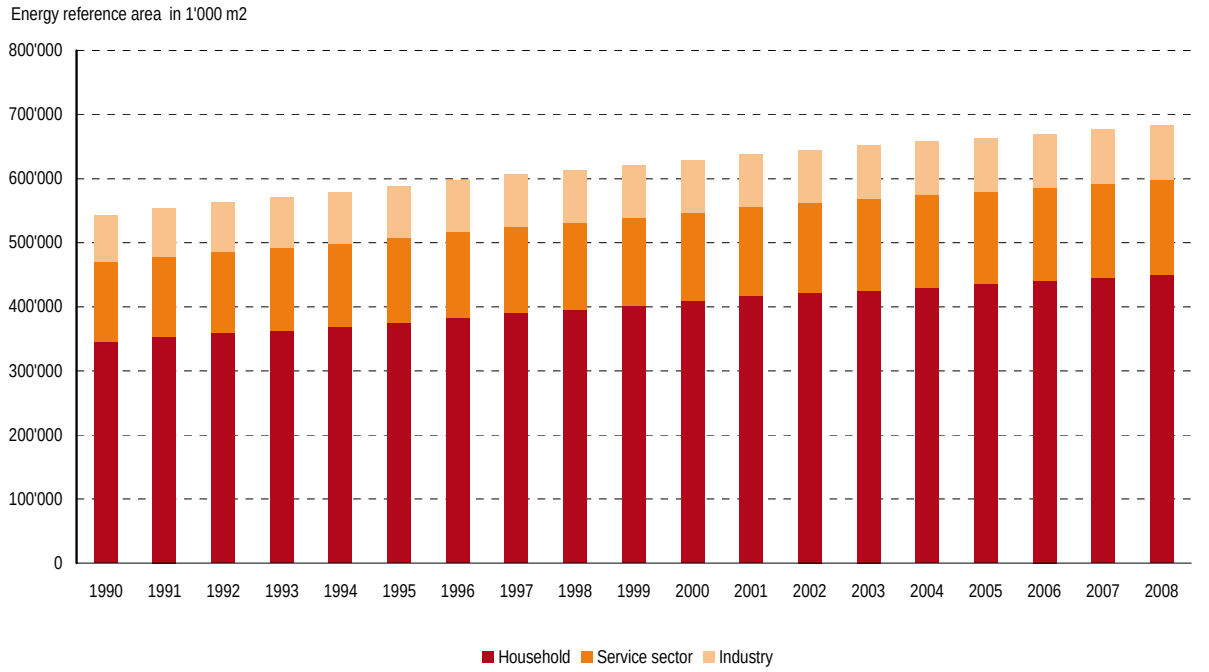
Household size and housing: The number of households is increasing (+36% between 1980 and 2007), while the number of persons per household is decreasing. In 2000, the average person had 44 m^2 of living space, which is about 14% more than in 1990 (FSO 2009c).

Development of energy reference area: Total energy reference area in Switzerland is steadily increasing since 1990 and accounted for over 680 million m^2 in 2008 (Fig. 14). Residential buildings account for the major share of energy reference area. In comparison, industry accounts for only around 12% of heated floor area.

The increase and structure of the Swiss population, building stock as well as urban structure also influence parameters such as for example, mobility behaviour, income, or land consumption discussed in the following sections 2.6 - 2.13.

Fig. 14 > Energy reference area in Switzerland between 1990 and 2008

Energy reference area of households increased by around 30% between 1990 and 2008.



Wüest and Partner (2009) on behalf of SFOE

2.4 Geography

Switzerland is located between 45°49' and 47°48' north and from 5°57' to 10°30' east. It covers an area of 41'300 km^2, comprising 31% forest and grove, 37% cropland and pastureland, 7% built-up and 25% unproductive land (situation in the mid-1990s) (Fig. 15). The size of the built-up area more than doubled between 1950 and 1990 and has continued to expand ever since, mainly at the expense of agricultural land (Fig. 16). Over the last 70 years the degree of landscape fragmentation has risen by 88% and the degree of urban sprawl by 112%. Total settlement area in Switzerland increases by 0.9 m^2/s, with currently no indication of a change in this trend. In 2007, nearly 3.5% of the total surface area of Switzerland was strictly protected.

Fig. 15 > Types of land use

Land use types in Switzerland between 1992 and 1997.

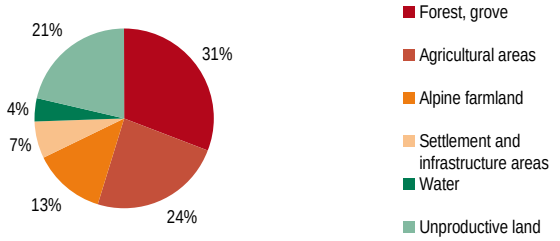
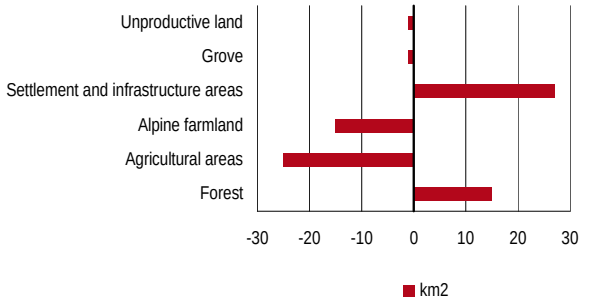


Fig. 16 > Land use change

Annual changes in land use between 1979/85 and 1992/97.



FSO/FOEN (2008) and FSO (2009c)

The location in the heart of Europe and in the centre of the European Union leads to substantial imports and exports of goods and services, and to transit freight flows through Switzerland. Swiss topography is defined by the Alps. According to the snow and avalanche research institute SLF (*www.slf.ch*) around 50% of the Swiss surface area is higher than 1000 meters above sea level and around 25% higher than 2000 meters above sea level. This means, that around one third of the precipitation occurs as snow. Furthermore, around 4% of the surface area of Switzerland is covered by water bodies. Both topographic attributes are influencing climate patterns in Switzerland (refer to 2.5). Observed and expected changes of the richness of Swiss biodiversity are outlined in section 6.1.6, its vulnerability in section 6.2.1. Furthermore, the Alps serve as a natural barrier to traffic moving in the north-south direction, i.e. between northern Europe and Italy. A number of tunnels allow for large-scale road and rail traffic to cross the Alps. Two new railway tunnels designed to facilitate transalpine traffic and increase transit capacity have been under construction over the past years – the Lötschberg base tunnel which opened in December 2007 and the Gotthard base tunnel which is expected to open in 2017. As Switzerland has no mineral resources, the country historically has no heavy industry (refer to 2.6).

2.5 Climate trends

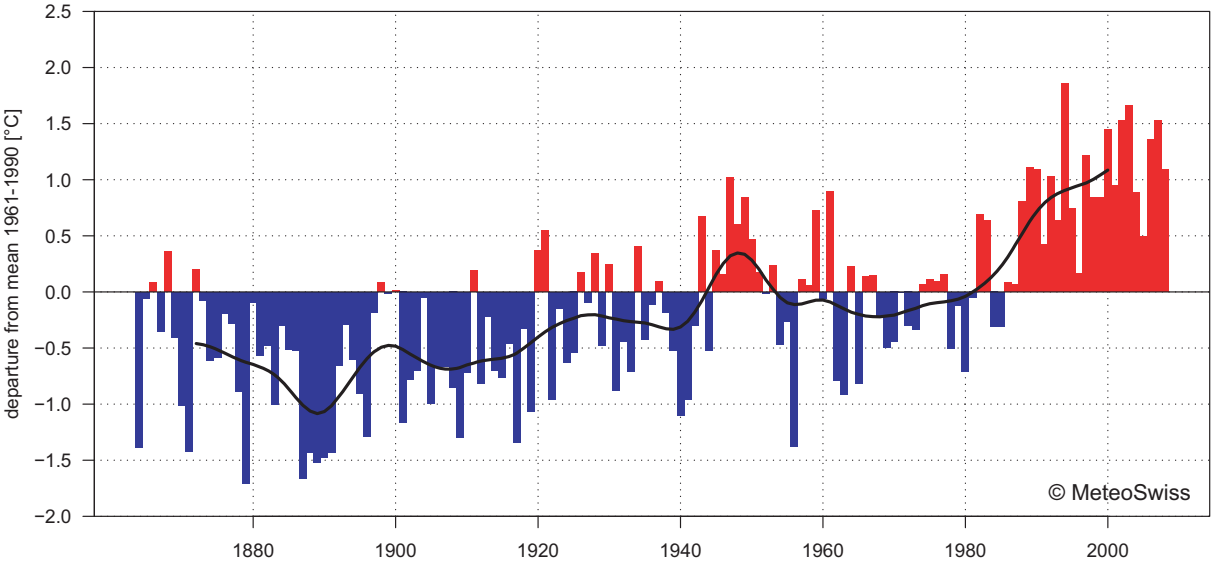
Climatic conditions, average temperature and precipitation patterns vary significantly across Switzerland, depending mainly on altitude and location. The Alps – running from south-west to east – act as a climatic divide. Measurements indicate a marked shift towards a warmer climate – particularly since the 1970s. Changes in precipitation are less clear, e.g. for annual mean precipitation no significant trends are found in the 20th century (OcCC 2008). For expected future developments and impacts thereof see section 6.1.

Temperature
Fig. 17 shows the annual temperature anomaly in Switzerland with respect to 1961-1990 average conditions. Annual temperature has increased by +1.6°C between 1864 and 2008 which corresponds to a linear temperature trend of about +0.11°C per decade.
Temperature trends have accelerated substantially for more recent time periods (Fig. 18). Over the last 100 years (1909-2008), annual temperature has increased by about 0.12-0.19°C per decade with no pronounced differences between geographical locations (north-south, low-high). The trend magnitude is similar for all seasons with a slight tendency to somewhat higher values in summer and autumn (up to 0.24°C per decade). Annual temperature trends for the last 70 years (1939-2008) are 0.11 to 0.25°C per decade, between 0.23 and 0.41°C per decade for the last 50 years (1959-2008) and between 0.41 and 0.66°C per decade for the last 30 years (1979-2008). This is roughly two (last 100 years) to three (last 30 years) times the globally averaged temperature trend (IPCC AR4 WG1, p.249-250) and in agreement with the trends in other parts of western and central Europe. In the last 30 years, the trends were largest (highly significant) in spring (0.69 to 0.98°C per decade) and summer (0.46 to 0.77°C per decade) whereas less pronounced and mostly insignificant in winter (0.18 to 0.54°C per decade) and especially in autumn (-0.07 to 0.48°C per decade). Within the period of 1958 to 2003 the seasonal frost line (0^{o}C) has risen from approximately 600 m in the 1960s to approximately 900 m in the 1990s (by approximately 200 m per degree of warming) (Scherrer and Appenzeller 2006).

Since there is a considerable yearly variation in weather conditions, this has to be taken into account when interpreting the year-to-year changes in energy consumption and CO_2 emissions. Heating degree days (HDD) are a measure of weather conditions in winter. HDD are calculated as the sum of the daily differences between the mean outdoor temperature and the indoor temperature (20°C) for outdoor temperatures below 12°C. Fig. 19 shows the index of heating degree days from 1970 to 2008. The index value for 2008 is 104.5.

Fig. 17 > Mean annual temperature anomalies in Switzerland 1864-2008

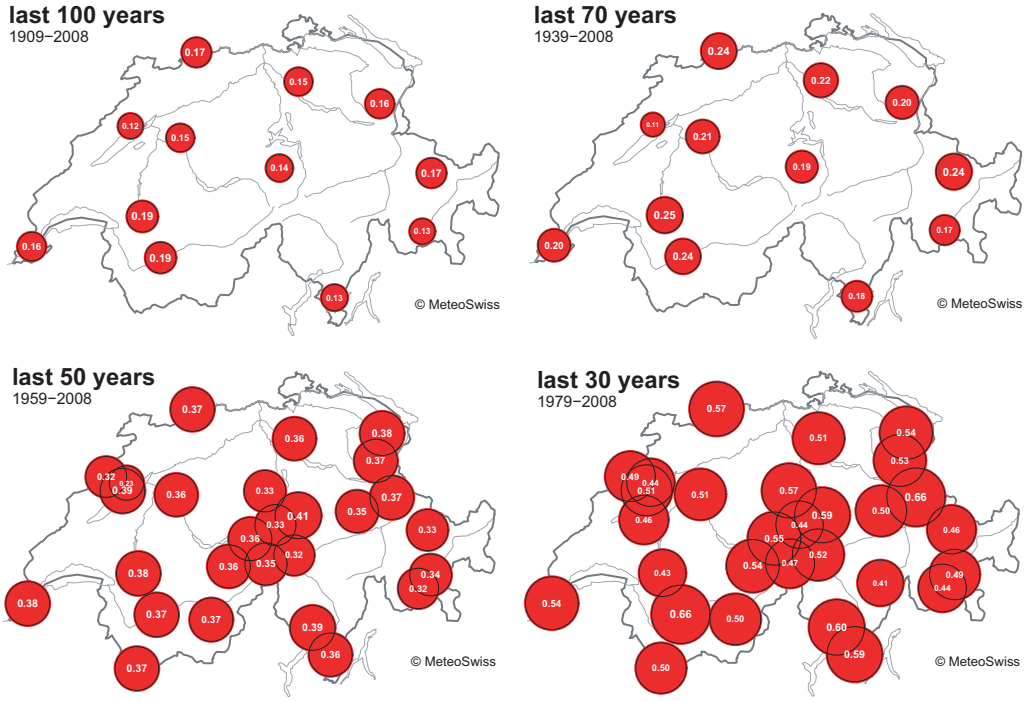
Annual temperature anomalies in Switzerland shown as deviation from the mean of 1961-1990. The years with positive anomalies (warmer) are shown in red and those with negative anomalies (cooler) in blue. The black line represents 20-year Gaussian low pass filtered data.



MeteoSwiss

Fig. 18 > Observed annual temperature trends in Switzerland

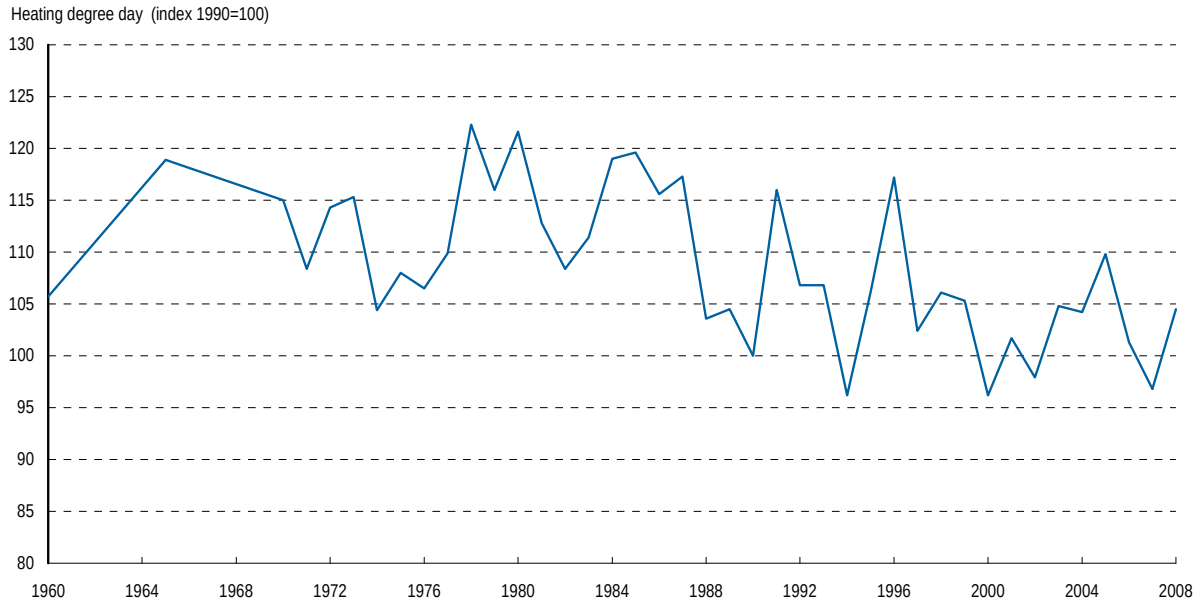
Observed annual temperature trends in Switzerland for homogenized station data. Shown are trends in °C/decade of the last 100 (1909-2008, top left), last 70 (1939-2008, top right), last 50 (1959-2008, bottom left) and last 30 years (1979-2008, bottom right). All trends are statistically significant (5% significance level).



MeteoSwiss

Fig. 19 > Index of heating degree days between 1960 and 2008, 1990=100

Heating Degree Days (HDD) are a measure of weather conditions in winter. HDD are calculated as the sum of the daily differences between the mean outdoor temperature and the indoor temperature (20°C) for outdoor temperatures below 12°C. The index value for 2008 is 104.5



SFOE (2009)

Precipitation

For the last 100 years, most stations show no significant trends in annual precipitation (1909-2008, significance level: 5%). For some stations, significant increases in precipitation are found in winter and spring (+2.7 to 3.1% per decade) (OcCC 2008). No significant trends are found for summer and autumn. Precipitation trend characteristics for shorter time periods (last 50 and 30 years) show some differences to the long-term characteristics. Annual precipitation in the last 50 years (1959-2008) is increasing at most stations, and significantly for about a third of the stations of the Swiss Plateau (+2.4 to 6.2% per decade). Predominantly increasing, but mostly statistically insignificant trends are also found in spring, summer and autumn. In winter, decreasing precipitation trends are prevailing although none of them is statistically significant. For the last 30 years (1979-2008) annual precipitation trends are insignificant. Most of the station trends for the seasons are insignificant too. Winter is an exception, with roughly half of the stations showing significant decreases (-9 to -26% per decade). In summer, increases dominate but the majority of them are statistically insignificant. In terms of precipitation strength and occurrence, significant increases are found for winter. In autumn, statistically significant increases are found only for heavy precipitation, whereas precipitation frequency and spell-length show little systematic change (Schmidli and Frei 2005).

Extreme events

Occurrence numbers of floods, debris flows and landslides did not show any significant tendency over the past decades (Fig. 20). Flooding was the most frequent type of extreme event occurring since 1972 (60–95% of all loss events). However, despite comparable occurrence rates, damages due to extreme weather events have been growing in recent years. It is highly likely that climate change contributes to increased intensity and wider geographical distribution of meteorological extreme events. However, the contribution of climate change to extreme weather events is not sufficiently understood (PLANAT 2007). Analysis of impacts due to extreme weather events, such as e.g. damaged wood (Fig. 21) is discussed in section 6.

Fig. 20 > Number of loss events (floods, debris flows, landslides) between 1972-2006

The major share of damages due to extreme weather events is caused by floods. Other incidents of weather-related hazards are much less frequent.

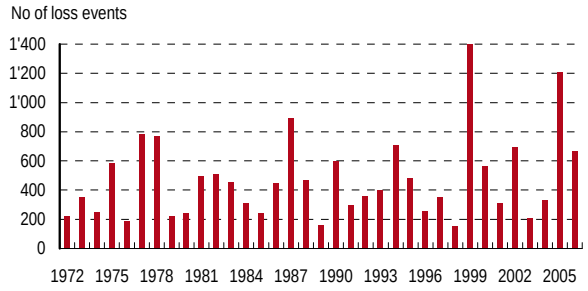
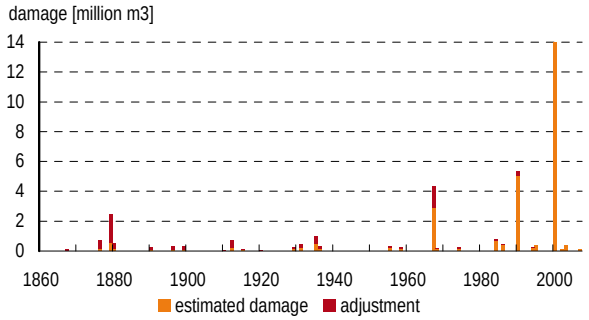


Fig. 21 > Damaged timber due to winter storms

Damaged timber due to storms with forest damage exceeding 70'000 m^3. Red additions represent adjustments due to increased stocks.



WSL (2008) and Usbeck et al. (2009)

2.6 Economy

Main characteristics

Switzerland's economy is largely dependent on the tertiary sector, which is contributing over 70% to the GDP (Fig. 22). Since the 1960s, the proportion of the total workforce employed by the industrial and commercial sector has fallen from half to less than a quarter. Since 1960 the proportion employed in the primary sector had dropped from 15% to 4% in 2008. At the same time, almost 73% of employees make their living in the services and administration sector (Fig. 23).

Switzerland's key economic data

Switzerland's real GDP remained constant in the early 1990s, but has been increasing since 1995, except for 2003. In 2007, it increased by 3.3% compared to the previous year. Fig. 24 shows real GDP trends in relative terms for the period from 1990 to 2007. GDP per capita (in current prices) is also steadily increasing (38% since 1990) and accounted for over CHF 67'000 in 2007 (Fig. 25).

Traditionally a country with low unemployment, Switzerland experienced a dramatic increase in unemployment from the beginning of the 1990s, basically as a consequence of the overall economic slowdown. Apart from foreign nationals (both male and female), the category most affected by this development was Swiss women. As Fig. 26 shows, the total rate of unemployment has peaked twice since 1991 – at 4.2% in 1997 and at 4.5% in 2005. Total unemployment reached 3.5% (tentative values) in 2008 and is forecast to increase during 2009 due to the worldwide financial crisis and economic downturn. In parallel with rising unemployment, aggregate government spending of all three administrative levels has exceeded revenues since 1990, which has led to increasing debt (Fig. 27). Following a relatively stable period between 1998 and 2003, the revenues have exceeded the expenditures since 2004.

During the 1990s low economic growth and the worldwide recession increased public spending ratio in Switzerland. Since then, public spending ratio has been stabilized and in 2007 Switzerland had one of the lowest public spending ratio of 33.4% in the OECD comparison (Fig. 28).

Fig. 22 > GDP contribution of economic sectors

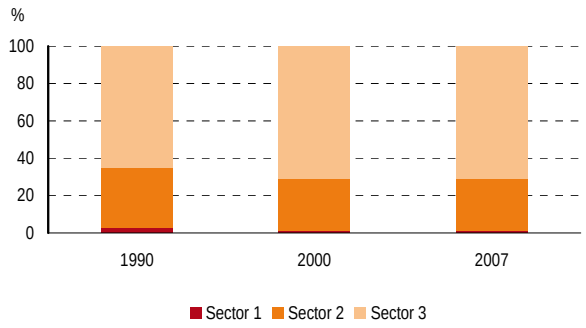
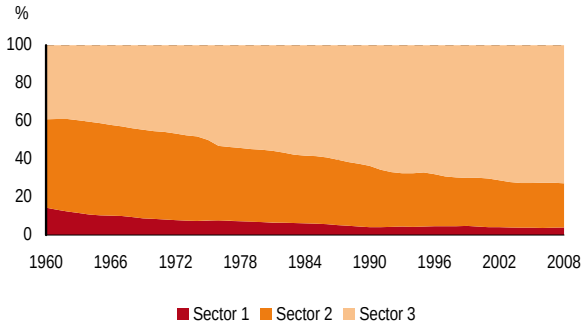


Fig. 23 > Workforce by sector



FSO (2009e) and FOEN/FSO (2009)

Fig. 24 > Percentage change of real GDP

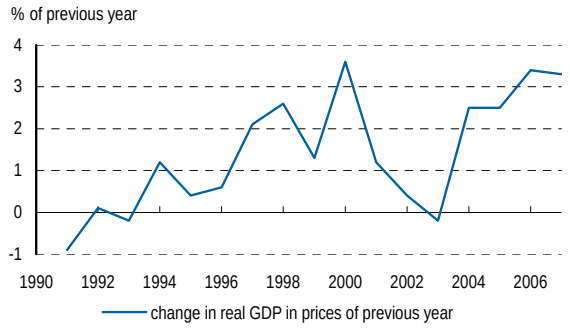
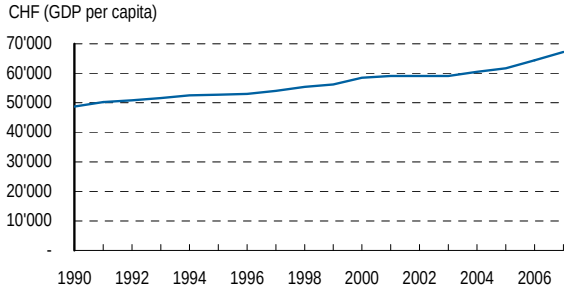


Fig. 25 > GDP per capita between 1990 and 2007



FSO (2009g)

Fig. 26 > Unemployment rate

Rates of unemployment between 1991 and 2008. The value for 2008 is tentative, disaggregated figures not yet available.

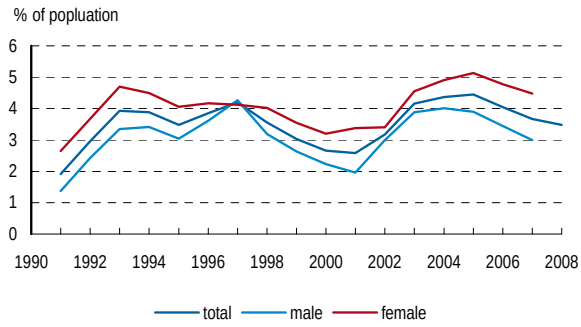
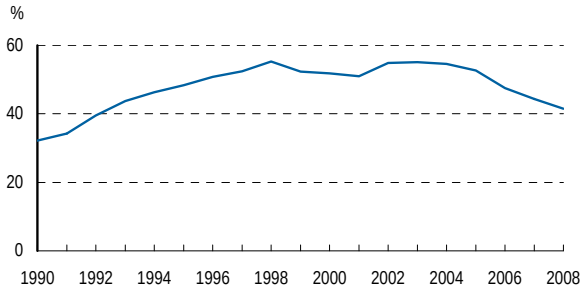


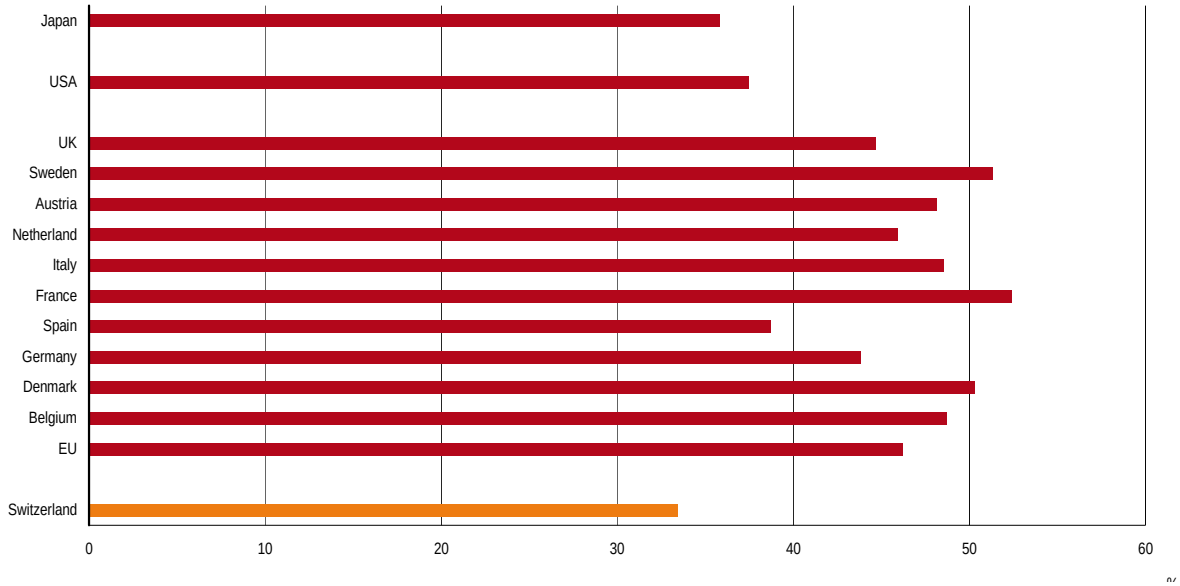
Fig. 27 > Public dept quota

Public debt of all administrative levels in percentage of the Swiss GDP between 1990 and 2008. Values for 2007 and 2008 are estimations.



FSO (2009d) and FFA (2009a)

Fig. 28 > Public spending ratio (federal expenditure/GDP in current prices) in OECD countries in 2007



FFA (2009b)

Industry Sector

Switzerland has virtually no mineral resources. The country's economy is dependent on foreign trade, representing a very high proportion of GDP. Fig. 29 shows development of trade balance in % of GDP (10.3% in 2007). The main export sectors are the pharmaceuticals industry, micro technology, high technology, biotechnology, banking and tourism (FSO 2009c). The major trading partners account for 77.9% of Swiss exports and 88.1% of its imports in 2007. Germany is by far the most important trading partner for Switzerland, accounting for around CHF 62 billion imports and CHF 42 billion exports in 2007 (Fig. 30). Trade volumes with Italy and France are substantial, with almost equal amounts of imports and exports. Trade with the United States is heavily biased towards exports.

Switzerland imports bulk raw materials and exports high-quality goods. In 2007, the value of one tonne of exported goods was up to three times higher than that of the same amount of imports. The relatively small size of its domestic market is another factor which has encouraged Swiss manufacturers to look to foreign markets to make investments in research and development worthwhile. Most important import and export goods are chemicals, machines and electronics, and instruments and watches (Fig. 31).

Fig. 29 > Trade balance in % of GDP

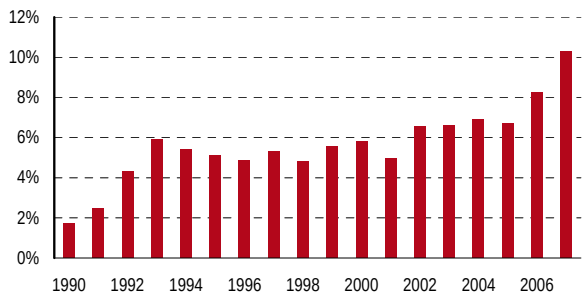
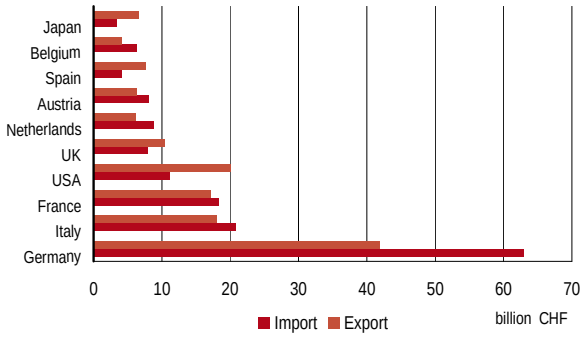


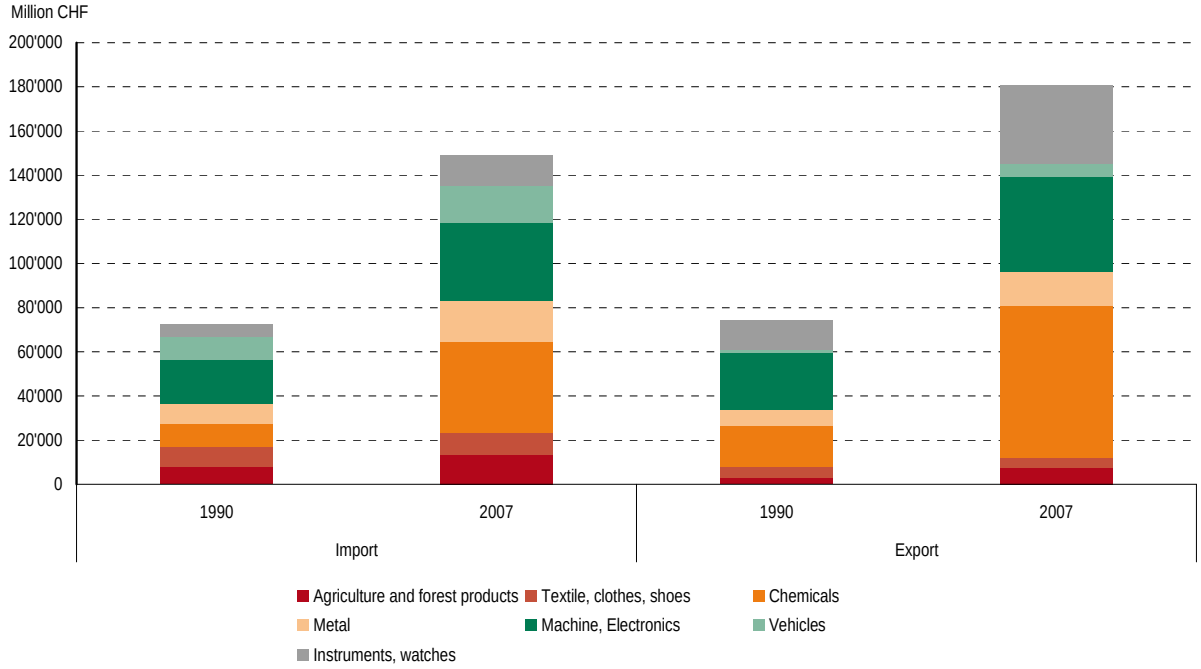
Fig. 30 > Foreign trade – important partners 2007



FSO (2009n) and (2009c)

Fig. 31 > Foreign trade – most important goods in million CHF

Machines and chemicals remain the most important export and import goods in comparison with the year 1990. Export of instruments and watches increased since 1990.



FSO (2009c)

2.7 Energy

Having no oil or gas resources of its own, Switzerland depends on imported energy for 80% of its primary energy supplies, whereas 20% was sourced domestically (more than 10% hydropower). 55.1% of total final energy consumption was oil, 23.5% electricity and 12.3% gas. The remaining 9.1% comprised wood, waste, coal and several renewable forms of energy.

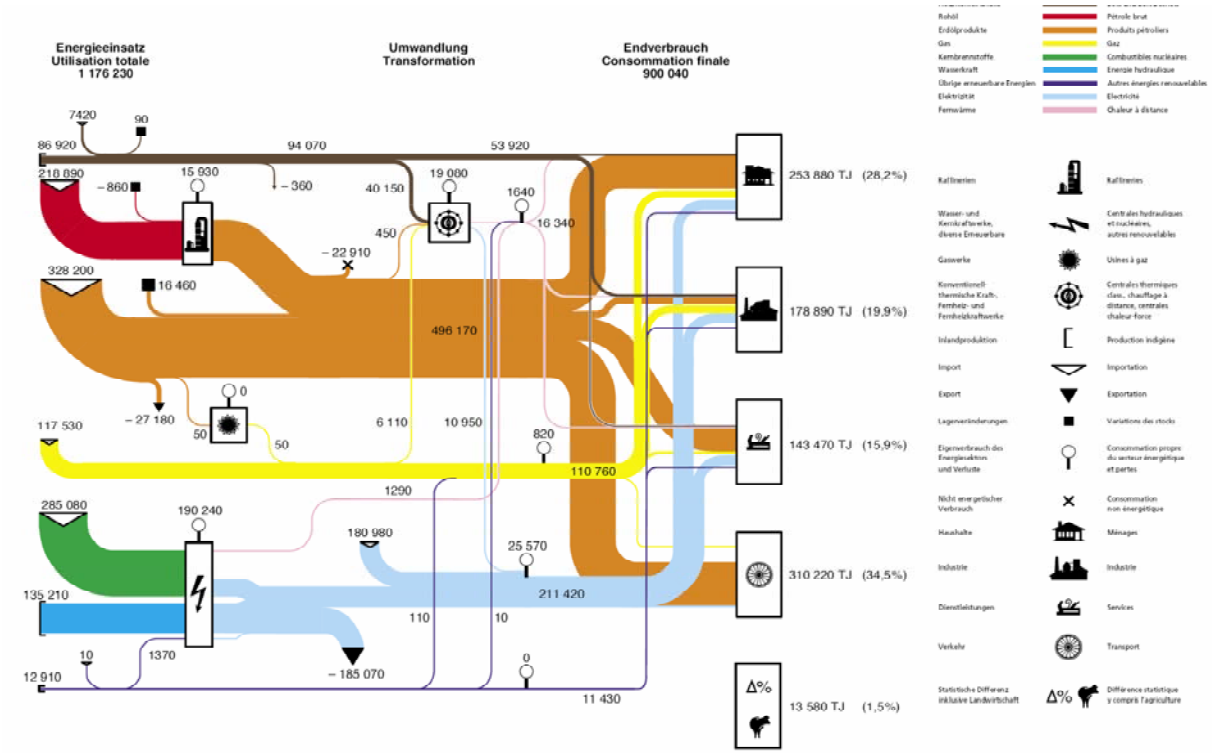
Energy supply and final energy consumption

In 2008, total energy supply (gross consumption) was 1'176'230 TJ. After a decrease of 2.6% in 2007, total final energy consumption increased by 4% and totalled at 900'040 TJ in 2008. Main drivers for this increase were colder weather conditions (more heating degree days, Fig. 19), positive economic development and further increase in population. Subsequently, the demand for heating oil increased by 5.1% and natural gas by 6.1%. Transport fuel demand increased as well, except the demand for petrol decreased by 2.2% (increasing trend to substitute petrol with diesel). For the same period, the demand for electricity increased by 2.3%. Energy flows for Switzerland in 2008, expressed in terajoules, are shown schematically in Fig. 32. Fig. 33 and Fig. 34 illustrate the relation of energy supply and final energy consumption. Fig. 34 shows final energy consumption by energy source and by type of consumer.

In 2008, 56.1% of electricity generation was from hydropower plants, 39% from the five domestic nuclear power plants and the remaining 4.9% from thermal power plants or other renewable sources, i.e. solar, wind and biogas. The contribution to electricity generation from solar and wind is still small (< 1 per mill). However, supported by the Energy 2000 programme and since 2001 by SwissEnergy, it increased markedly between 1990 and 2008: Solar energy from 1.0 to 34.2 GWh and wind power from 0.0 to 18.5 GWh.

Fig. 32 > Energy flow diagram for Switzerland in TJ for 2008

Total energy supply in 2008 accounted for 1'176'230 TJ. Because of transmission processes and losses the final energy consumption accounted for only 900'040 TJ.



SFOE (2009)

Fig. 33 > Gross energy consumption in 2008

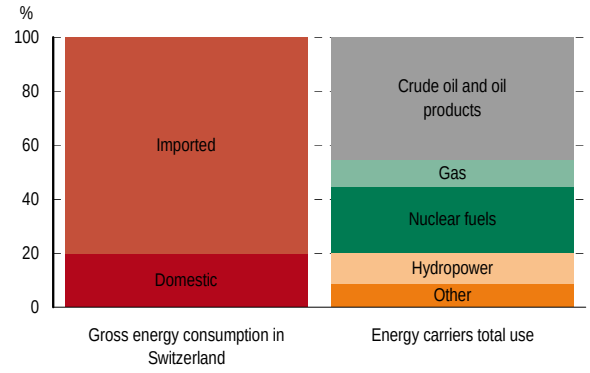
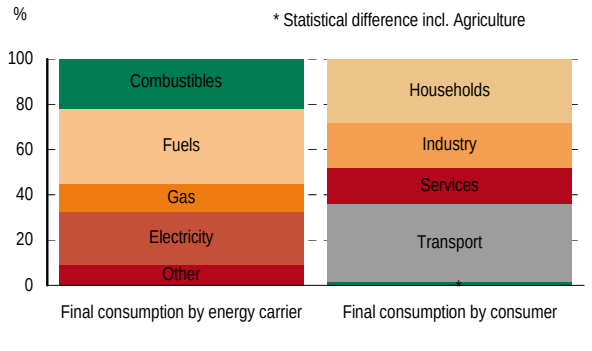


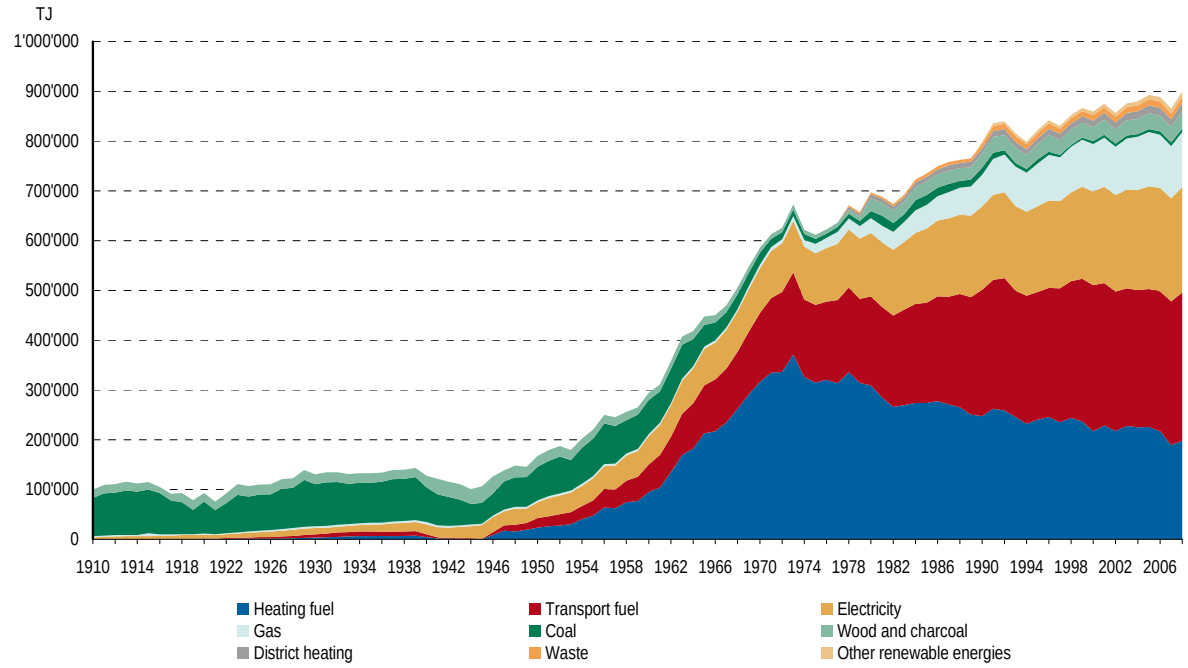
Fig. 34 > Final energy consumption in 2008



SFOE (2009)

Energy consumption since the first half of the last century increased significantly, the largest increases seen in heating fuel, transport fuel and electricity (Fig. 35). Between 1990 and 2008, total final energy consumption increased by 12%. Gas had the highest increase percentage of nearly 75%. Energy end use by the transport, industry and services, and household sectors relative to 1990 is shown in Fig. 36. The transport sector shows an increase of 18% over the period 1990-2008, but with fluctuations that correlate with the economic development, e.g. periods of stagnation from 1993-1996 and from 2001-2003, and periods of growth (gross value-added) 1997-2000 and 2004-2008.

Fig. 35 > Final energy consumption between 1910 and 2008 according to energy source



SFOE (2009)

The trend for energy consumption of households reflects the impact of climatic variations on demand for heating. There is a strong correlation between the energy demand of households and the number of heating degree days (Fig. 19). The extraordinary decrease from 2006 to 2007 reflects the higher average temperature in 2007, but also the high prices for heating oil (gas oil). In the period 1990-2007, the number of buildings and apartments increased, as well as the average floor space per person. Both phenomena resulted in an increase in the total area heated. Over the same period, however, higher standards were specified for insulation and for combustion equipment efficiency for both new and renovated buildings, compensating for the energy consumption from the additional area heated. The increase of energy end use of households in 2008 is mainly due to colder weather conditions. Although the energy consumption of the industry and services sector is also influenced by the meteorological conditions (especially the services sector), the trend 1990-2008 primary reflects the development of economic activity in this period. The future of the Swiss energy supply is outlined in the Swiss energy outlook (also known as energy perspectives) discussed in section 5.1.1. Further studies on the future of energy supply and demand (Denk-Schrift Energie) as well as the future of renewable energy (Road Map Renewable Energies) are outlined in section 5.2.3.

Energy productivity has remained constant in recent decades; in other words, the index of energy consumption has increased broadly in line with GDP. However, since 2005, real GDP and final energy consumption started to diverge (Fig. 37). The reasons for this development are, on the one hand, an increase in energy efficiency leading to a lower energy input per unit of GDP. On the other hand, since the early 90ies, the production of many energy intensive goods was sourced out to other countries. Although these goods are further consumed in the country, the energy required for their production is no more accounted for in the national total. The ratio of CO_2 emissions to real GDP is discussed in section 2.13.

Fig. 36 > Energy end use by sectors

Indices of energy end use by the transport, industry and services, and household sectors between 1990 and 2008. (1990=100)

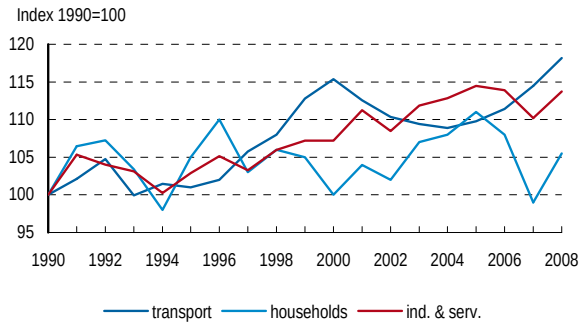
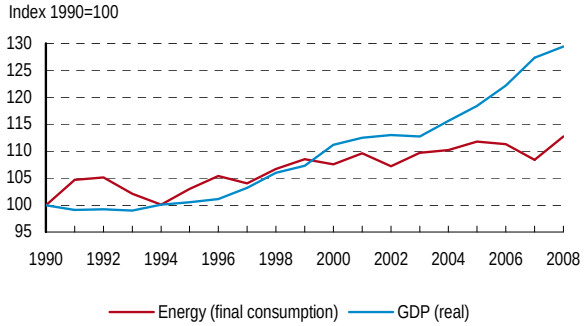


Fig. 37 > Energy end use and GDP

Energy end use and real GDP were increasing nearly synchronously until 2005, when they started to diverge. (1990=100)

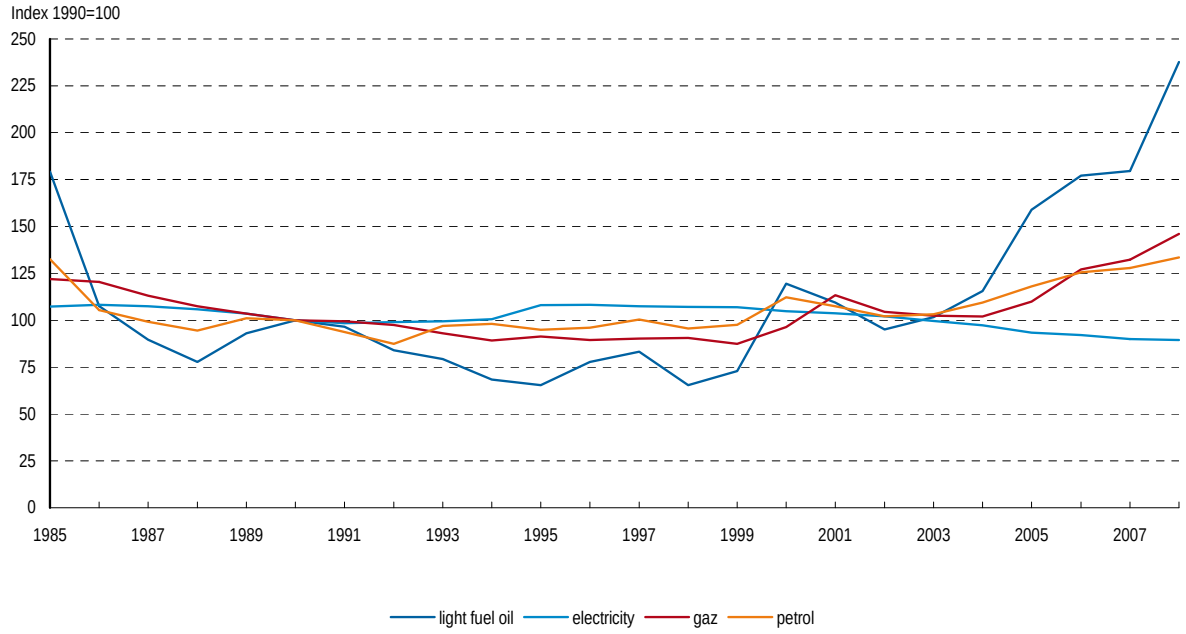


SFOE (2009)

Energy prices

After rather low energy prices in the early 70s, real prices of energy sources increased between 1978 and 1985. Prices for heating fuel then reached a historic low in 1998. However, from the end of the 1990s, real energy prices have risen again, with a stronger increase since 2004 and another very strong increase between 2007 and 2008 for heating fuel prices. Electricity is an exception, its real prices tended to decrease since the mid-1990s (Fig. 38).

Fig. 38 > Relative development of real energy prices (retail and household level)



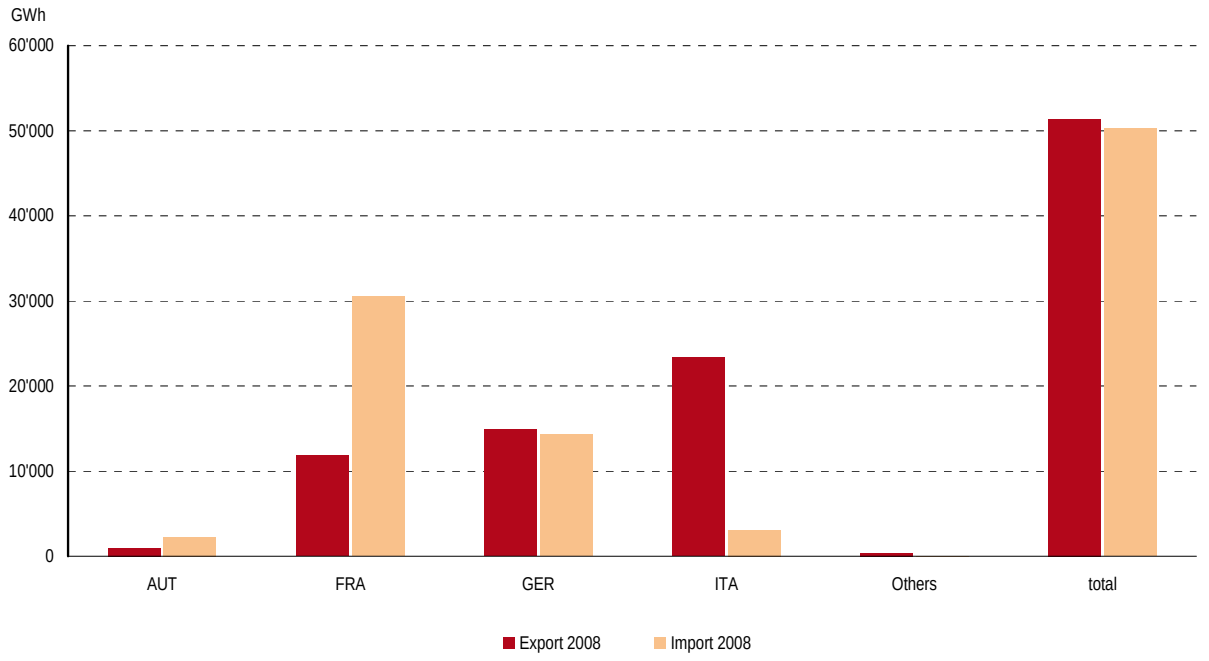
SFOE (2009)

Energy prices are composed of a basic price, energy taxes and value-added tax (VAT). According to a study of the International Energy Agency in 2008 (IEA 2008)[2], Switzerland has higher real energy prices[3] for households than the OECD average, but lower real energy prices for industry than the OECD average. With or without energy taxes, petrol prices in Switzerland are relatively low, unlike diesel prices, which are higher. The price for unleaded petrol comprises 48.3% taxes, whereas automotive diesel comprises 47%. Furthermore, among most European OECD countries, Switzerland has the lowest prices for light fuel oil comprising a tax rate of only 10.3%. Total taxes on electricity for households account for around 7% of the total price. Regarding prices for natural gas, taxes account for around 10% for households of the total price and 4% for industries.

Electricity trade

Electricity is traded across Switzerland's borders on a fairly large scale. Amongst the factors affecting the volume traded are hydrological and climatic conditions. Exchanges take place with several western and central European countries. Fig. 39 shows Switzerland's total physical electricity exchanges and its individual exchanges with neighbouring countries for 2008. In 2008, total Swiss electricity exports exceeded imports by only 1'135 GWh which corresponds to a slight increase since 2004.

Fig. 39 > Electricity trade



SFOE (2009a)

[2] Numbers refer to the 1st quarter of 2008.
[3] Including oil products, coal, natural gas and electricity.

2.8 Transport

2.8.1 Passenger transport

Modal split

The average daily distance travelled by individuals accounted for 38.2 km per person in 2005, which corresponds to an increase of around 30% compared to 1984. While daily distances travelled by car remained stable between 2000 and 2005, distances travelled by train increased by almost 20% to 6.2 km. Leisure traffic gained importance during the last decades and distances travelled for leisure purposes increased since 1984. The share of daily kilometres travelled for leisure purposes accounted for 40% in 1984 and for 44% in 2005 (flight travel not included). The share of daily distances for work accounted for 47% in 1984 and decreased to 36% in 2005.

This development is also in line with the total annual passenger kilometres. Between 1980 and 2007, total passenger kilometres increased by nearly 40% in private transport (road traffic) and by more than 60% in public transport (road and rail traffic). In 2006, almost 20% of total passenger kilometres were travelled by public transport means. Fig. 40 shows the demand for passenger transport by road and rail between 1970 and 2006. Fig. 41 shows the modal split development of passenger transport. Compared with other European countries, modal split of public passenger transport is rather high. The share of public transport in percentage of total passenger kilometres accounted for around 16% in EU 27 and 15% in EU 15 in 2006 (Eurostat 2009).

Swiss railways play an important role in the transport market, especially in passenger and transalpine freight transport. In 2006, rail network accounted for 5'065 km (FSO 2009c). To cover increasing mobility demand by rail, the railway project RAIL 2000 was implemented to enhance existent rail infrastructure. Although the rail length did no increase significantly during the last years, the rail capacity and reduction of travel time was improved due the implementation of the first stage of the project RAIL 2000 (SECO 2009).

Car ownership increased from 509'000 vehicles in 1960 to 3.96 million vehicles in 2007. Today, 80% of the households own at least one car. Specific fuel consumption of passenger cars sold in 2008 accounted for 7.14 litres per 100 km which corresponds to a decrease of 3.9% from 2007. Corresponding CO_2 emissions are on average 175 g/km in 2008. After a steady increase in weight of new cars until 2007, the value decreased by 1.93% for the first time since 1996 (Auto Suisse 2009).

Fig. 40 > Passenger transport

Passenger transport by road and rail between 1970 and 2006 in passenger kilometres.

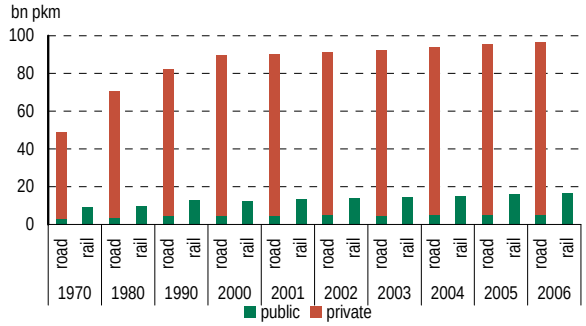
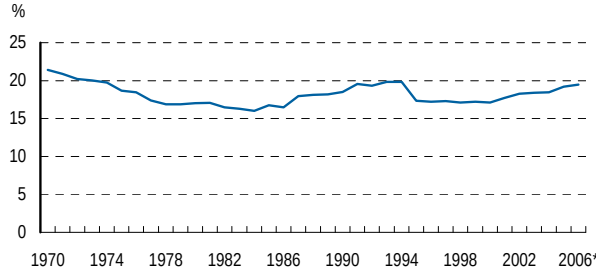


Fig. 41 > Share of public transport

Public transport percentage of total passenger kilometres (road and rail). *From 1994 change of method of collecting data.*



FSO (2008b) und (2009k)

Aviation

The reduction of negative climate impacts from aviation requires an internationally coordinated multi-step approach. Aircraft transport energy efficiency for scheduled and charter traffic originating from Switzerland (Fig. 42) has improved considerably since 1990. The strong efficiency increase between 1995 and 1997 can be explained by the introduction of new aircraft technology. The efficiency improvement after 2002 is a consequence of increased load factors, by using less but larger aircraft, weight saving measures and through operational optimisations. However, the efficiency improvements have been overcompensated by an even larger increase in passenger kilometres of the order of 85% compared to 1990, so that total aircraft CO_2 emissions are 22% higher than 1990 (Fig. 43). This has happened despite a sharp globally induced increase in the kerosene fuel price, starting in 2003. Aircraft movements have been nearly constant during the same time period. The aviation sector illustrates the paradox effect of increased absolute CO_2 emissions, despite increased transport efficiency per passenger and distance. The underlying cause for the increase is the tendency towards longer travel distances and/or more frequent travel.

In Switzerland, aviation fuels for domestic flights are taxed. Fuel consumption from domestic flights has fallen by around 50% since 1990 (Fig. 43). The largest contribution to the reduction can be attributed to the improved railway system.

Fig. 42 > Passenger kilometres per unit of fuel

Total of all km travelled by passengers for all flights departing from Switzerland to a destination abroad, divided by the total fuel used.

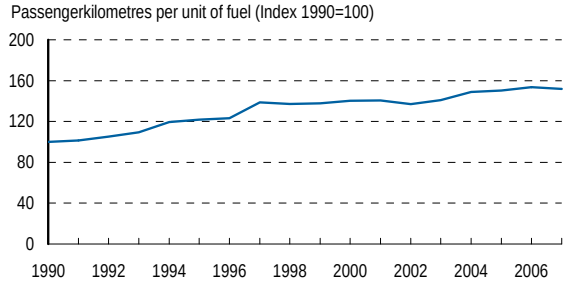
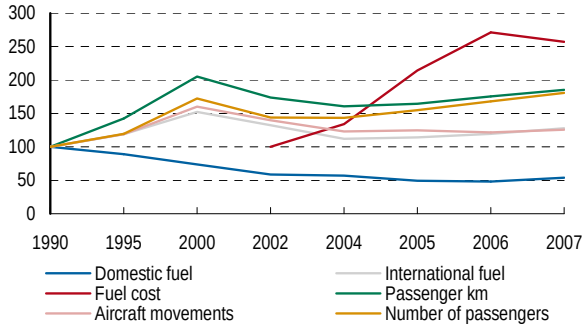


Fig. 43 > Aviation parameters since 1990

Results for each year are presented relative to the year 1990. (Index = 100)



Data compiled by FOCA based on FOEN (2009), SFOE (2009) and IATA (2009)

2.8.2 Freight transport

As in most European countries, freight transport has been increasing (Fig. 44) and rail has been losing market shares to road. However, the dwindling trend in rail transport percentage has been stalled at 40% since the early 1990s, mostly due to the restrictions imposed on road freight transport in Switzerland by federal legislation (Alpeninitiative) and bilateral agreements with the EU (Fig. 45). Swiss rail transport has traditionally had (and still has) a particularly strong position compared to that in neighbouring alpine countries. Comparing transalpine freight transport in Switzerland (CH) with France (FRA) and Austria (AUT) shows relatively low freight transport by road and high freight transport by rail in Switzerland in contrast to France and Austria (Fig. 46, Fig. 47). In 2006, Switzerland achieved a rail-to-road ratio of over 40% of total transported tonne-kilometres (tkm). As for domestic passenger transport, freight transport by air is negligible in comparison with road and rail transport.

Fig. 44 > Freight transport since 1980

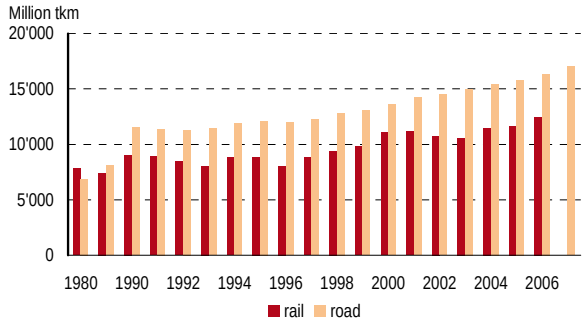
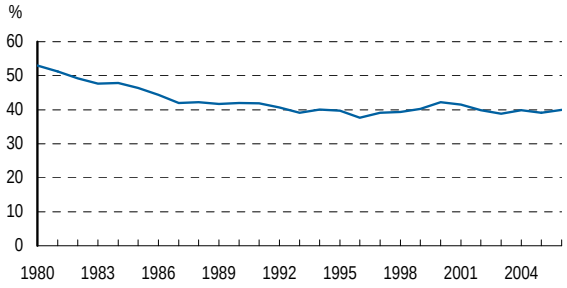


Fig. 45 > Modal split in freight transport



FSO (2008c) and (2009l)

Fig. 46 > Transalpine freight road traffic

Transalpine freight transport by road (including inland, import, export and transit traffic) for CH, AUT and FRA between 1983 and 2007.

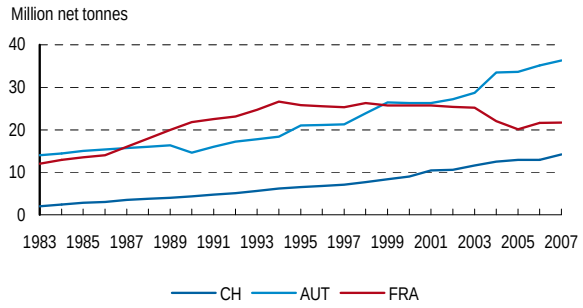
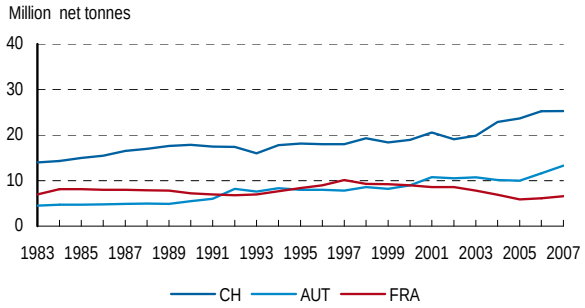


Fig. 47 > Transalpine freight rail traffic

Transalpine freight transport by road (including inland, import, export and transit traffic) for CH, AUT and FRA between 1983 and 2007.



FSO (2008d)

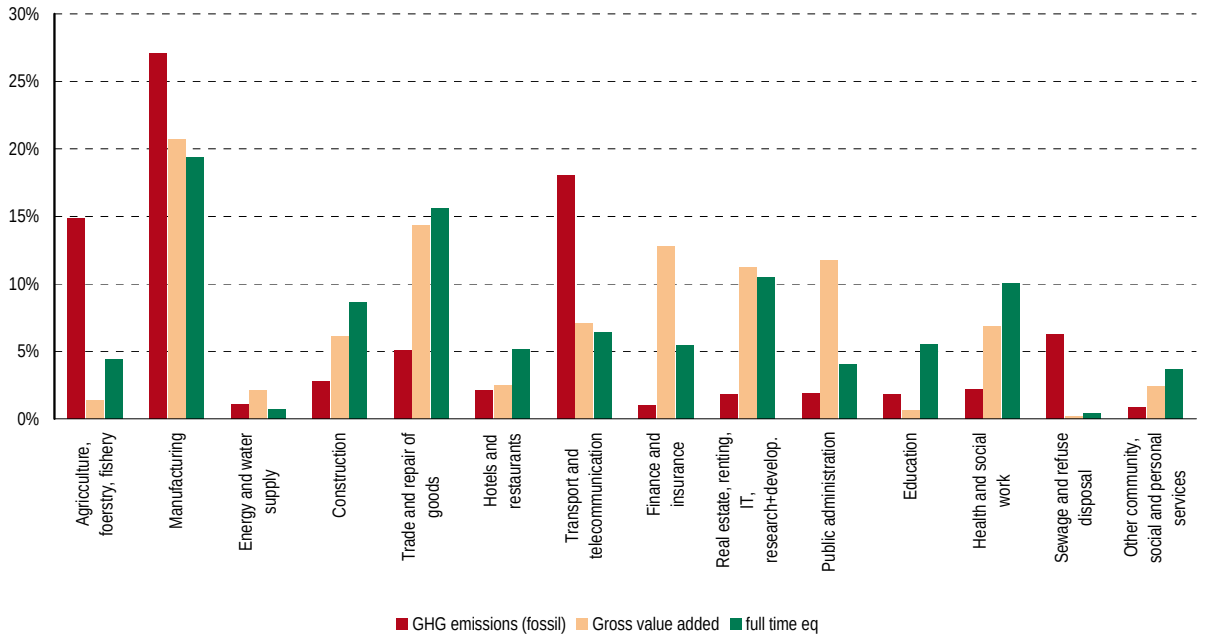
2.9 Industry

As outlined in section 2.6, the service industry is Switzerland's most important sector. The largest value of creation is added by the tertiary sector (over 70%), followed by the secondary sector (28%) and the primary sector (1%). The lion's share of value is created by the financial and insurance sector, trade sector and the industry and energy sector. However, 60% of GHG emissions are derived from the manufacturing industry, transport and agriculture as shown in Fig. 48. While emissions from stationary sources decreased in all three sectors, emissions from biomass combustion increased by 41% (Fig. 49). The emissions from transport remained more or less constant in all economic sectors, but increased substantially in private households

Structural change in Switzerland is continuing. Mainly branches from the secondary sector such as textile, leather manufacturing, paper and printing, as well as machine manufacturers have seen a decrease in employees due to relocation abroad. However, the secondary sector in Switzerland (excl. construction sector) has increased its production by 50% between 1990 and 2007 (FSO 2009c). Simultaneously, the greenhouse gas emissions have slightly decreased as a result of an increase in energy efficiency (see Fig. 49). The emissions of the service sector increased by 8.1% in the period 1990-2005, whereas its gross values increased by 20.5%. This shows a relative decoupling of economic growth from emissions. Actually, the emissions in the service sector decreased from 74 to 66 grams CO_2 eq per CHF gross value.

Fig. 48 > GHG emissions, gross value added and employment in 2005 for various economic activities

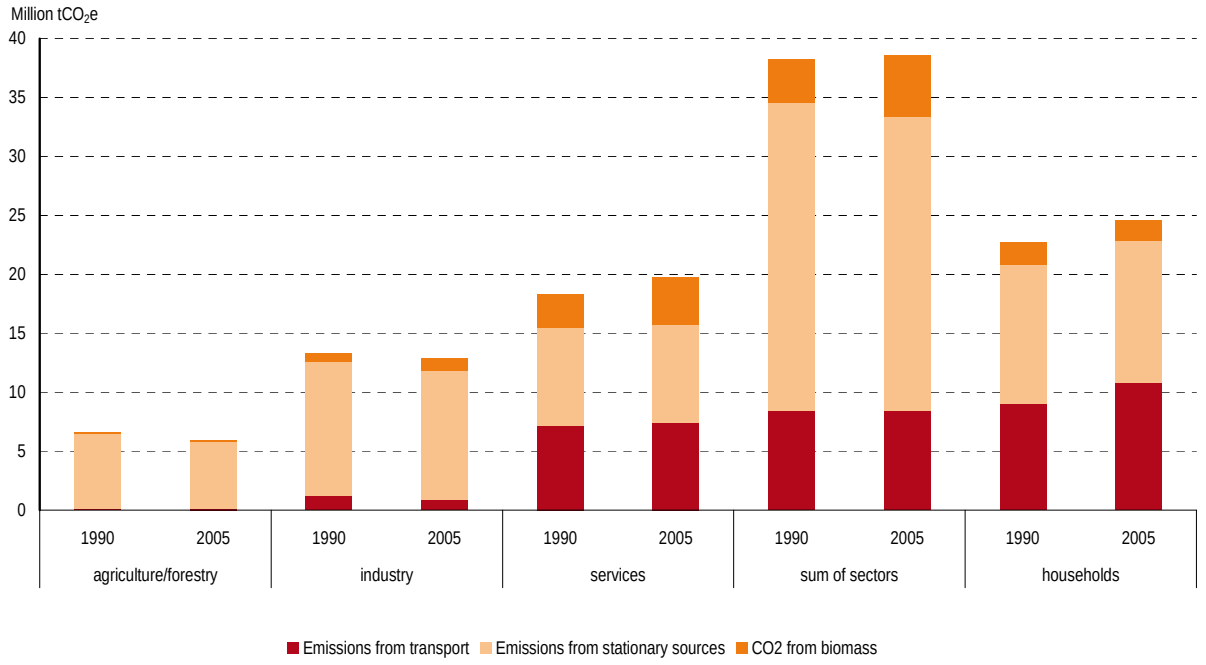
100% correspond to the Swiss national totals of greenhouse gas emissions (without LULUCF), gross value added and full time equivalents (employment).



FSO (2009p)

Fig. 49 > GHG emissions of economic sectors and private households in 1990 and 2005

Emissions in million tonnes of CO_2 equivalent.



FSO (2009p)

2.10 Agriculture

According to the Swiss Federal Statistical Office (FSO 2009f), the acreage amounted to 986'712 ha, or 24% of Switzerland's surface. Another 13% are alpine pastures (used for cultivation and animal husbandry). In 2007, the acreage related to 1400 m^2 per person. Settlement and infrastructure areas spread at the expense of alpine farmland and agriculture areas (Fig. 16). Since 1990 the loss of acreage is rather small (-0.6%). In 1900, 31% of the Swiss labour worked in the primary sector. Today the share is less than 5.3%.

Agriculture in Switzerland is responsible for roughly 10% of total GHG emissions, the most important source being methane from digestion and rumination of animals (mostly dairy cows). The application of nitrogenous fertilizer is a further source of GHG emissions (N_2O). However, GHG emissions from agriculture decreased slightly since 1990 mainly due to the decrease in cattle stock.

Since the 1950s, Swiss agriculture has undergone profound structural changes, with the number of farms falling by 1–2% annually on average. Between 1990 and 2007 around 1'600 farms closed down per year, which corresponds to more than 4 farms per day. On the other hand, the number of farms with areas larger than 20 ha has increased. Since the early 1990s, and increasingly since a new agricultural article was stipulated in the federal constitution in 1996, agricultural policy has become more commercially and environmentally sound, shifting towards more environmentally friendly farming methods. As a consequence, the required ecological standards are now met by almost all farms and the share of organic farms reaches about 10%. However, in 2007 the number of organic farms decreased for the second year in a row.

Tab. 6 > Livestock population

	1990	2000	2007	2008 (provisional)
Cattle	1'858'187	1'588'005	1'571'764	1'607'775
Whereof cows	790'904	714'292	708'340	728'118
Horses	37'712	50'347	57'720	59'319
Pigs	1'775'810	1'498'223	1'573'090	1'551'903
Sheep	354'582	420'740	443'584	447'043
Goat	60'764	62'499	79'081	81'689
Poultry	6'446165	6'789'720	8'101'840	8'522'003

FSO (2009m)

2.11 Forestry

According to the third National Forest Inventory (FOEN 2009b) one third of Switzerland's area is covered by forests. This is matched or even exceeded by some of our neighbouring countries: Austria (47%), Italy (34%), and Germany (32%). Forest cover is not evenly distributed across Switzerland: The Alps have the highest forest cover, with forest areas still expanding. Forest exploitation is concentrated in the central lowlands (40% of total wood harvest), which are more easily accessible and therefore less cost intensive to harvest. 29% of Swiss woodland is privately owned, whereas 71% is public property. The majority of the state owned woodland belongs to bourgeois communities (42%) and political communities (49%). Only 6% are owned by the Swiss Confederation.

Since the second National Forest Inventory surveyed between 1993 and 1995, the forested area has grown by 4.9%. The differences between the regions are striking: the greatest increase (around 9%) was recorded in the Alps as a consequence of natural regeneration of land previously used by agriculture, whereas the forested area in the central lowlands and the Jura remained unchanged.

According to the third National Forest Inventory (2004-2006), Switzerland's forests account for 420 million m^3. Of this, 30% are deciduous trees such as beech (18%) and 70% are coniferous trees such as spruce (47%) and fir (15%). Since the second National Forest Inventory (1993-1995), the stock increased by 3%. This increase is mainly due to an increase in forest area, because the average stock per ha barely changed (359m^3/ha). The average annual growth rate between 1995 and 2006 decreased by 3% compared to the previous period. Overall woodland growth throughout Switzerland amounts to about 9.5 million m^3 annually (8.5m^3/ha), varying significantly between the southern side of the Alps and the lowland. 70% of the wood harvested in Switzerland in 2007 was processed domestically. This is the lowest rate since 1999.

Since 1998, a few scattered forest areas have obtained certification for sustainable forest management under the FSC system (www.fsc.org) or the Q/PEFC system (*www.pefc.org*). Starting in 2000, group certifications enabled larger areas joining the scheme, so that the area of certified forest increased by 100'000 ha per year. In 2005, this trend began to slab. At the moment, 56% of the Swiss forest area and 67% of the harvested roundwood are certified under either or both of the two certifying systems. Switzerland chose to take forest management activities under article 3.4 of the Kyoto Protocol into account.

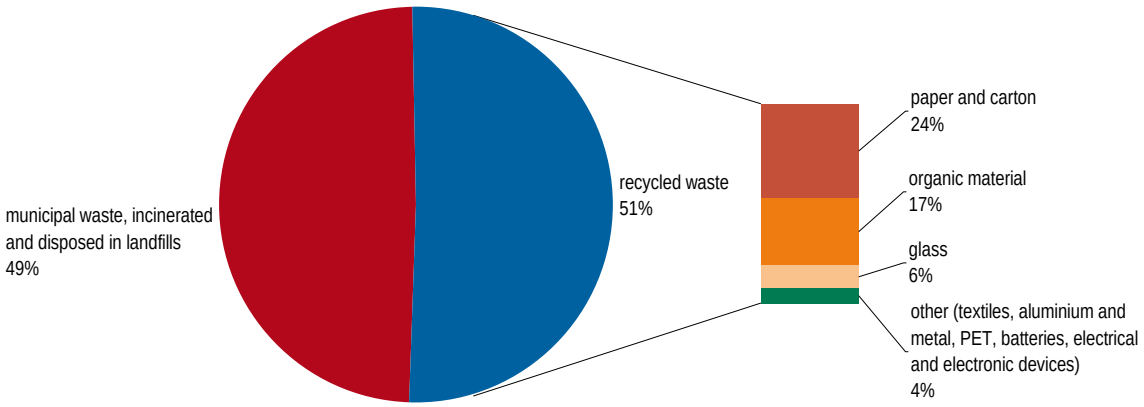
2.12 Waste

Total municipal waste generated in Switzerland amounted to 5.46 million tonnes in 2007. Thereof, 2.68 million tonnes (or 351 kg per person) were incinerated (0.05% deposited), and 2.78 million tonnes (or 367 kg per person) were recycled (Fig. 50). Switzerland imports waste to operate waste incineration plants at full capacity for power and heat generation. Recycling systems are highly developed in Switzerland. Solid waste collected for recycling more than doubled since 1990 (including compost, paper and cardboard, glass, tins, tinfoil, aluminium, PET, textiles, electrical and electronical devices), and makes up 50% of the municipal solid waste (Fig. 51). Separate collection of PET (relevant to CO_2 as comprising petrochemical material) has increased significantly in recent years, with 78% of the total PET being recycled in 2007. Recycling rates of glass, aluminium cans, and tins reach over 90% of the total consumed amounts.

Fig. 50 > Municipal waste disposed of and recycled between 1990 and 2007

FSO (2009h)

Fig. 51 > Share of recycled municipal waste in 2007



FSO (2009i)

2.13 Emission trends since 1900

In most sectors, the quality of data on GHG emissions is only satisfactory from about 1950 onwards, when emissions started to soar. Consequently, emission data from the period 1900 to 1950 are rough estimates, and are based on a number of assumptions. Fig. 52 shows historical CO_2 emissions from 1900 to 2007. Gross anthropogenic CO_2 emissions have increased markedly since 1950. This has mainly been due to a large increase in fossil fuel consumption. Since 1980, emissions have remained fairly stable, the trend for CO_2 emissions is mainly influenced by winter climatic conditions (strong correlation between emissions and heating degrees days (Fig. 19)). Fig. 53 shows historical CH_4 and N_2O emissions between 1900 and 2007. Total methane emissions increased steadily from 1900, peaked around 1980 and have since decreased. In 1990, the largest source of methane emissions was the agricultural sector (70%, mainly cattle), followed by the waste sector (17%, mainly landfills). Methane emissions have decreased by 19% between 1990 and 2007 due to decreasing number of livestock and improved feed quality, technical improvements to limit fugitive emissions, and a ban on land filling. Emissions of nitrous oxide were already substantial in 1900 (almost 2 million tonnes of CO_2eq) and increased steadily until the 1980s. Since then, N_2O emissions have decreased slightly. The main source is agriculture (79% in 1990, 78% in 2007).

Gross CO_2 emissions per capita and per unit of real GDP are shown in Fig. 54 and Fig. 55. CO_2 emissions per capita increased significantly after World War II due to increased economic growth. Both indicators have decreased since the 1970s. The reasons are an increase in energy efficiency and the outsourcing of the production of many energy intensive goods.

Fig. 52 > Evolution of CO_2 emissions

Emissions excl. LULUCF

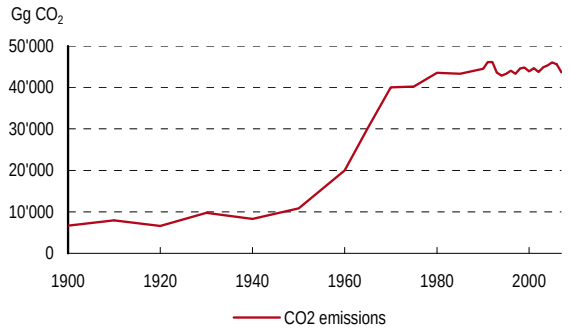
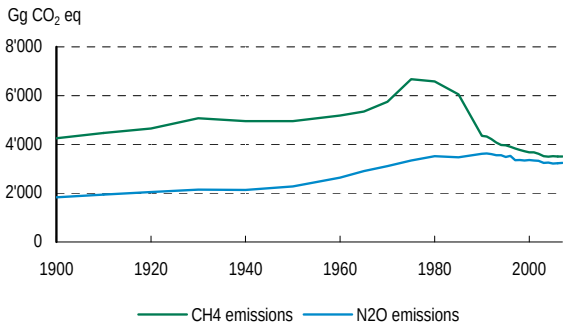


Fig. 53 > Evolution of CH_4 and N_2O emissions

Emissions excl. LULUCF



FOEN (2009)

Fig. 54 > CO_2 emissions per capita

Population values from SFOE (2008) are included from 1970 onwards. Before, historical data from FSO (1981) are used.

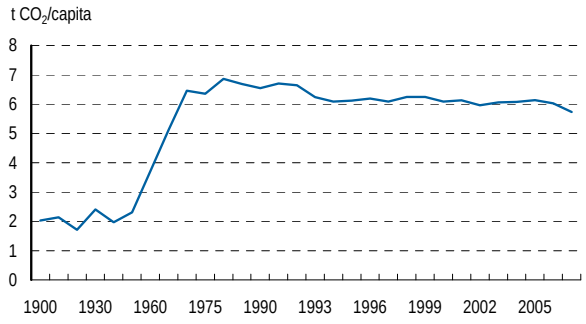
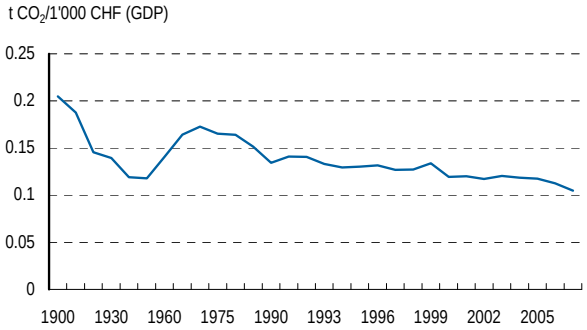


Fig. 55 > CO_2 emissions per GDP

GDP values from SFOE (2008) are included from 1970 onwards. Before, historical data from FSO (2009o) are used.



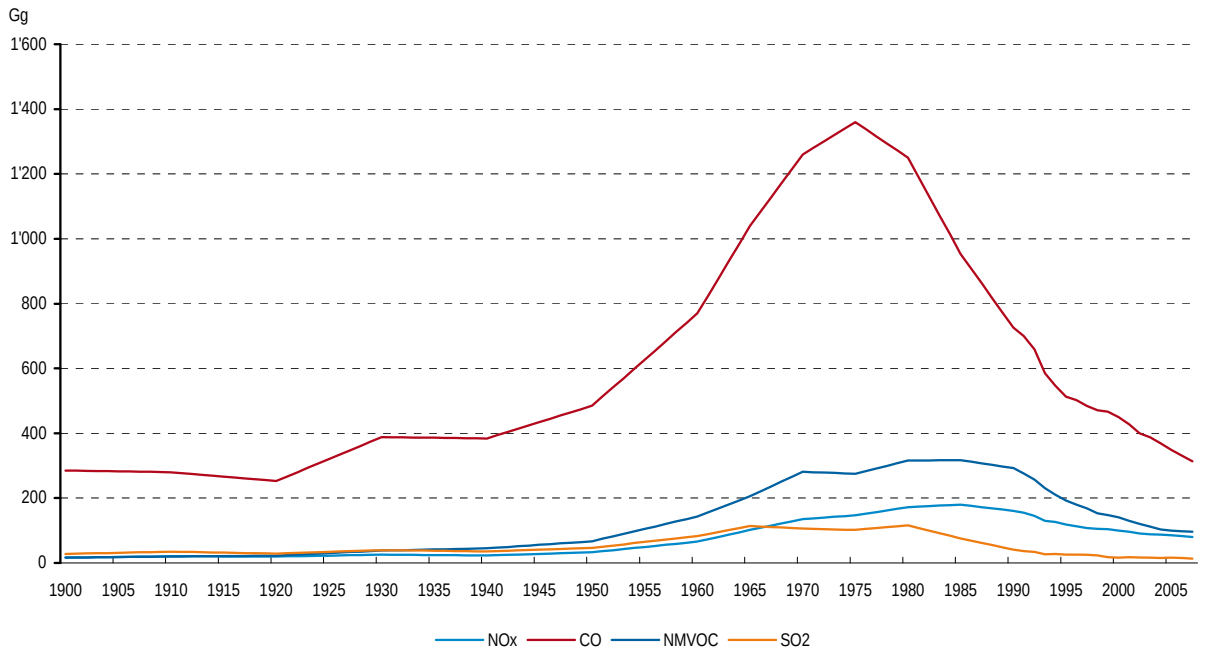
FOEN (2009), FSO (1981), SFOE (2008) and FSO (2009o)

Precursor gases (NO_X, NMVOCs, CO, SO_2)

Fig. 56 shows the development of the precursor gases NO_x, NMVOCs, CO, SO_2 between 1900 and 2007. Emissions of these four gases increased sharply up to the 1980s (respectively 1975 for CO) and significantly declined over the latest two decades. The reduction in CO emissions starting in 1975 is mainly due to new emission regulations in the traffic sector decreed in 1975. A strict air pollution control policy and the implementation of a large number of emission reduction measures led to a decrease of about 50% in emissions of air pollutants since 1990: Firstly, exhaust emissions from road vehicles were abated due to mandatory equipment of new passenger cars with catalyst converters and the introduction of new emission standards for road vehicles. Secondly, higher standards were specified for building insulation and for combustion equipment efficiency. Thirdly, solvents and sulphured fuels have been taxed, and voluntary agreements with industry sectors were concluded. The trend of SO_2 emissions is influenced by the legal restriction of the sulphur content in liquid fuels and the amount of coal consumption.

Fig. 56 > Emissions of the precursor gases CO, NMVOCs, NO_x and SO_2 between 1900 and 2007

Emissions excl. LULUCF. Data prior to 1990 have different system boundaries, data after 1990 from CRF.



FOEN (2009)

The reporting under the UNFCCC (e.g. national GHG inventory) does not include "grey emissions" (emissions derived from the production of goods and energy as well as from the disposal of products abroad). Switzerland mainly depends on imported energy (section 2.7) and on the tertiary sector (section 2.6). Traditionally, heavy industry is virtually absent in Switzerland due to a lack of local mineral resources, which implies that substantial grey emissions are associated with Swiss imports. Estimates of grey emissions suggest that CO_2 equivalents per capita would be around two-thirds higher in the past couple of years, if grey emissions would be included (Jungbluth et al. 2007). Estimates for historic "grey emissions" are not provided.

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Swiss Federal Office of Energy (SFOE): *www.bfe.admin.ch*
Swiss Federal Statistical Office (FSO): *www.bfs.admin.ch*

3 Information on GHG inventory, the national system and the national registry

3.1 Summary tables

Summary tables of the national greenhouse gas inventory 1990-2007 are provided in Annex 1 (p.227).

3.2 Trends in greenhouse gas emissions and removals (1990-2007)

3.2.1 Aggregated greenhouse gas emissions 2007

In 2007, Switzerland emitted 51'265 Gg CO_2 equivalent (excluding LULUCF), or 6.73 tonnes CO_2 equivalent per capita. With a share of 85% (Fig. 57), the largest contributor gas was CO_2, 43'636 Gg (5.73 tonnes per capita), and the most important source was the energy sector with 41'966 Gg CO_2 equivalent. Tab. 7 shows emissions by gas and sector in Switzerland for the year 2007. A breakdown of Switzerland's total emissions by gas (excluding LULUCF) is given in Fig. 57.

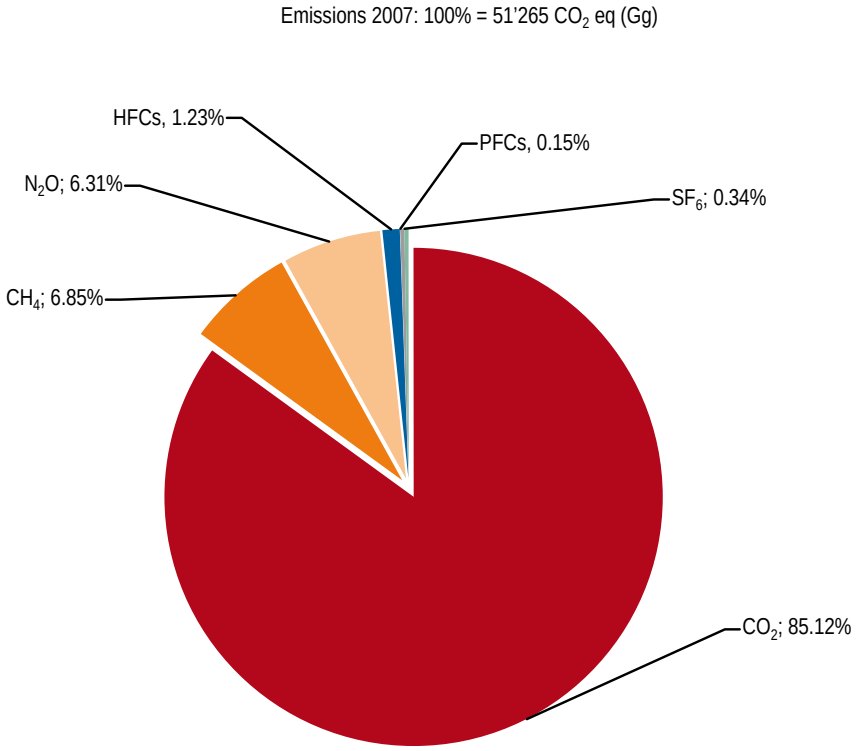
Fuel combustion within the energy sector was by far the largest source of emissions of CO_2 in 2007, accounting for 96% of total CO_2 emissions. Emissions of CH_4 and N_2O originated mainly from agriculture, and the synthetic gas emissions stemmed by definition from industrial processes.

Tab. 7 > Switzerland's GHG emissions in CO_2 equivalent (Gg) by gas and sector in 2007

Emissions 2007		CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total	Share
		CO_2 equivalent (Gg)							
1	All Energy	41'358	279	330				41'966	81.9%
2	Industrial Processes	2'086	7	83	630	77	175	3'058	6.0%
3	Solvent Use	177	0	54				231	0.5%
4	Agriculture	0	2'829	2'516				5'346	10.4%
6	Waste	15	396	252				663	1.3%
Total (excluding LULUCF)		43'636	3'511	3'235	630	77	175	51'265	100.0%
5	LULUCF	-655	2	6				-647	-1.3%
Total (including LULUCF)		42'982	3'513	3'241	630	77	175	50'617	98.7%
International Bunkers		*3'919*	*1*	*38*				*3'959*	

FOEN (2009)

Fig. 57 > Contribution of individual gases to Switzerland's GHG emissions (excluding LULUCF) in 2007



FOEN (2009)

3.2.2 Emission trends by gas

An overview of the emissions by gas and their contribution towards total greenhouse gas emissions is summarized in Tab. 8 for selected years. Emission trends by gas for the period 1990–2007 are given in Tab. 9.

Tab. 8 > GHG emissions (excluding LULUCF) by gas for selected years

Greenhouse gas emissions	1990		1995		2000		2005		2006		2007	
(excluding LULUCF)	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
CO_2	44'504	84.4%	43'322	84.9%	43'900	85.0%	46'038	85.8 %	45'575	85.7%	43'636	85.1%
CH_4	4'348	8.2%	3'960	7.8%	3'669	7.1%	3'516	6.6%	3'505	6.6%	3'511	6.8%
N_2O	3'613	6.9%	3'483	6.8%	3'360	6.5%	3'220	6.0%	3'228	6.1%	3'235	6.3%
HFCs	0	0.0%	169	0.3%	422	0.8%	629	1.2%	609	1.1%	630	1.2%
PFCs	100	0.2%	15	0.0%	93	0.2%	57	0.1%	74	0.1%	77	0.2%
SF_6	144	0.3%	95	0.2%	203	0.4%	205	0.4%	181	0.3%	175	0.3%
Total (excluding LULUCF)	52'709	100%	51'043	100%	51'648	100%	53'665	100%	53'173	100%	51'265	100%

FOEN (2009)

Tab. 9 > GHG emissions in CO_2 equivalent (Gg) by gas between 1990-2007

The column on the far right (digits in italics) indicates the change in emissions in 2007 relative to 1990.

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	42'144	44'466	45'004	40'357	37'308	38'016	39'472	40'809	42'873	43'423
CO_2 emissions excluding net CO_2 from LULUCF	44'504	46'142	46'161	43'578	42'826	43'322	44'002	43'324	44'560	44'802
CH_4 emissions including CH_4 from LULUCF	4'356	4'325	4'212	4'072	3'980	3'963	3'906	3'837	3'772	3'720
CH_4 emissions excluding CH_4 from LULUCF	4'348	4'324	4'212	4'072	3'978	3'960	3'904	3'826	3'770	3'719
N_2O emissions including N_2O from LULUCF	3'624	3'640	3'614	3'567	3'563	3'491	3'538	3'366	3'367	3'349
N_2O emissions excluding N_2O from LULUCF	3'613	3'632	3'606	3'560	3'555	3'483	3'530	3'354	3'360	3'343
HFCs	0	0	6	13	29	169	209	270	315	362
PFCs	100	85	69	30	18	15	17	24	28	40
SF_6	144	146	148	126	112	95	92	130	159	146
Total (including LULUCF)	50'369	52'662	53'053	48'165	45'010	45'749	47'234	48'436	50'514	51'039
Total (excluding LULUCF)	52'709	54'330	54'202	51'379	50'517	51'043	51'754	50'928	52'192	52'412

Greenhouse gas emissions	2000	2001	2002	2003	2004	2005	2006	2007	Change base year to 2007 (%)
	CO_2 equivalent (Gg)								
CO_2 emissions including net CO_2 from LULUCF	44'645	44'894	44'147	43'293	45'642	46'897	46'646	42'982	*2.0%*
CO_2 emissions excluding net CO_2 from LULUCF	43'900	44'682	43'771	44'877	45'347	46'038	45'575	43'636	*-1.9%*
CH_4 emissions including CH_4 from LULUCF	3'669	3'681	3'621	3'518	3'498	3'516	3'506	3'513	*-19.4%*
CH_4 emissions excluding CH_4 from LULUCF	3'669	3'680	3'618	3'514	3'498	3'516	3'505	3'511	*-19.2%*
N_2O emissions including N_2O from LULUCF	3'366	3'343	3'328	3'254	3'254	3'225	3'233	3'241	*-10.6%*
N_2O emissions excluding N_2O from LULUCF	3'360	3'337	3'321	3'246	3'248	3'220	3'228	3'235	*-10.5%*
HFCs	422	496	521	574	640	629	609	630	
PFCs	93	53	51	88	75	57	74	77	*-23.1%*
SF_6	203	235	211	195	182	205	181	175	*22.1%*
Total (including LULUCF)	52'399	52'701	51'878	50'922	53'291	54'530	54'250	50'617	*0.5%*
Total (excluding LULUCF)	51'648	52'483	51'493	52'494	52'990	53'665	53'173	51'265	*-2.7%*

FOEN (2009)

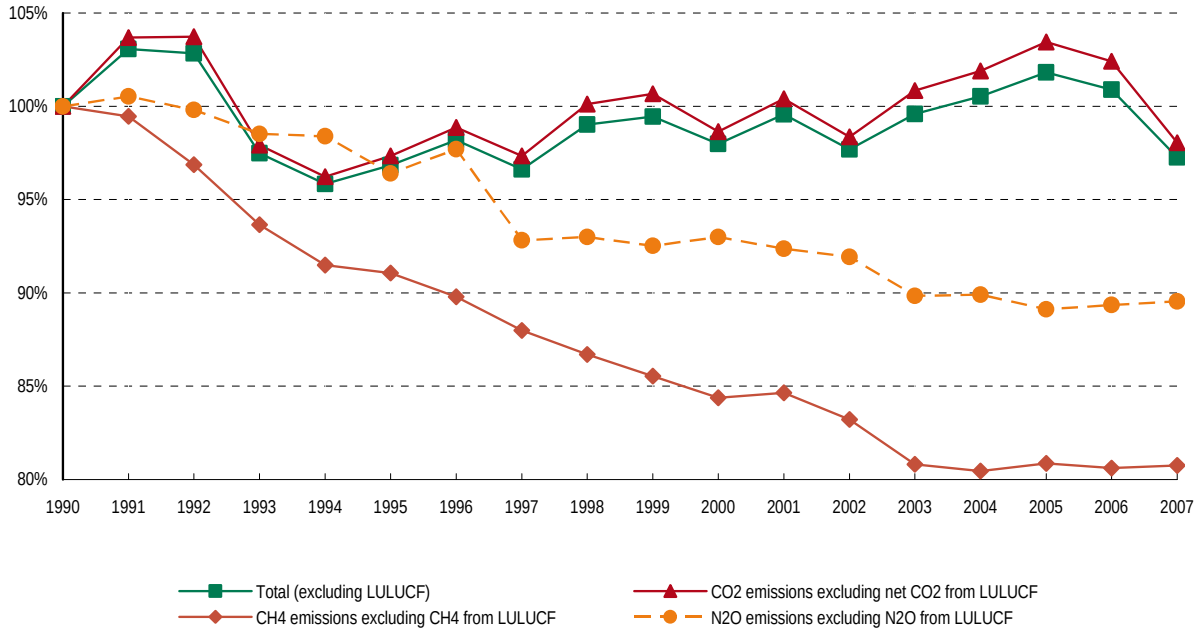
The emission trends for individual gases are as follows (Tab. 8, Tab. 9, Fig. 58 and Fig. 59).

- Total emissions (excluding LULUCF) show a minimum of 95.8% in 1994 and a maximum of 103.1% in 1991 (with 100% = value of base year 1990). The 2007 total emissions were -2.7% lower than emissions in the base year 1990. CO_2 contributed the largest share of emissions, accounting for 85.1% of the total in 2007.
- Total emissions (including LULUCF) in 2007 were 0.5% higher than emissions in the base year 1990. Heavy storms in 1990 and, in particular, at the end of 1999 ("Lothar") led to significant reductions in net removals within the LULUCF sector (visible over several years due to 3-year-averaging of the storm effects). Due to the accounting of

annual climatic parameters, the net CO_2 emissions from LULUCF show considerable variability from year to year (Fig. 63).

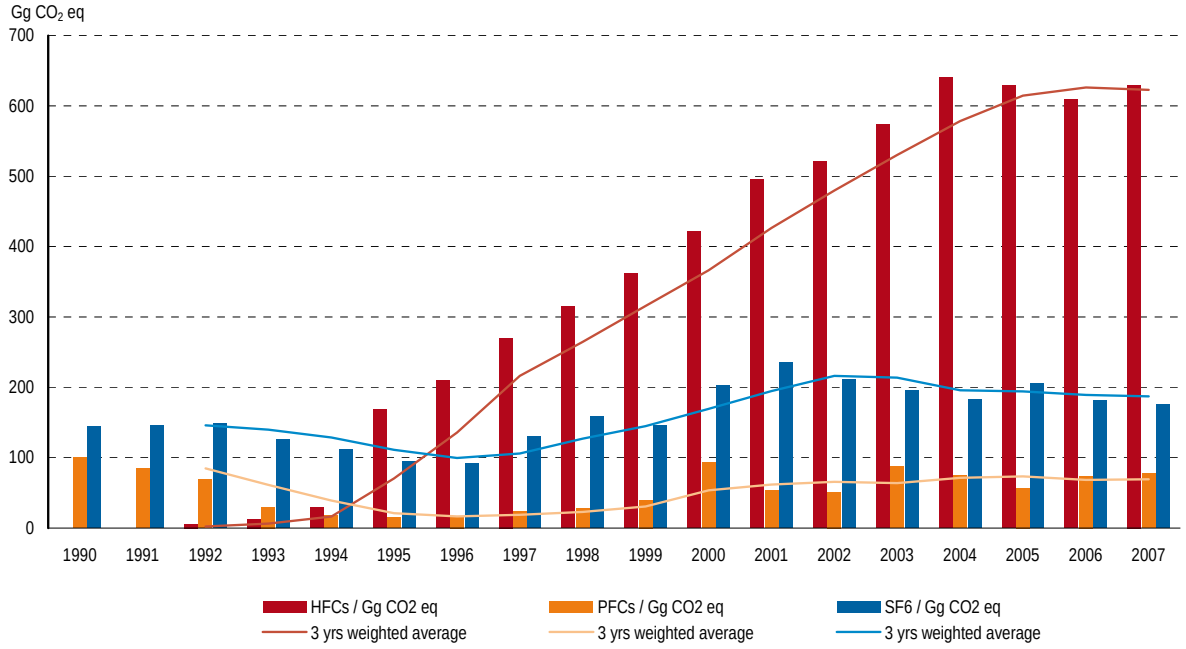
- As CO_2 persistently forms the major part of total GHG emissions (1990: 84.4% and 2007: 85.1%, respectively) its relative trend between 1990 and 2007 runs largely parallel to total GHG emissions excluding LULUCF (Fig. 58).
- Between 1990 and 2007, CH_4 (excluding LULUCF) decreased by -19.2%, which was mainly attributable to a reduction of productive livestock and the resulting reduction of emissions from enteric fermentation and the significant reduction of fugitive emissions. Moreover, from 2000 onwards, a change in waste legislation banning the disposal of municipal solid waste in landfills contributed to this trend. The CH_4 share of total GHG emissions decreased from 8.2% in 1990 to 6.8% in 2007.
- In parallel to the reduction of CH_4 due to decreases in livestock populations, N_2O emissions from manure management and agricultural soils (excluding LULUCF) declined by 10.5% between 1990 and 2007. The N_2O share of total GHG emissions decreased from 6.9% in 1990 to 6.3% in 2007.
- HFC emissions increased significantly due to their application as substitutes for CFCs, while PFC emissions declined by 23.1%. SF_6 emissions have shown relatively large fluctuations between 92 and 235 Gg CO_2eq since 1990. In 2007, SF_6 emissions were 22.1% higher than 1990. The share of all synthetic gases combined rose from 0.5% in 1990 to 1.7% in 2007.

Fig. 58 > Relative trend of GHG emissions by gas (excluding LULUCF), 1990–2007. The increase of synthetic gases, which amounts to 362% in 2007 relative to 1990, is shown in Fig. 59



FOEN (2009)

Fig. 59 > HFC, PFC and SF_6 emissions in Switzerland between 1990-2007



FOEN (2009)

3.2.3 Emission trends by sources and sinks

Tab. 10 shows the emission trends for all major source and sink categories. As the largest share of emissions originated from the energy sector, the table also includes the contributions of the energy sub-sectors. The percentage shares of source categories are shown for selected years in Tab. 11. Fig. 60 to Fig. 63 are graphical representations of the data in Tab. 10.

Tab. 10 > GHG emissions in CO_2 equivalent (Gg) by sources and sinks, 1990–2007. The column on the far right (digits in italics) indicates the change in emissions in 2007 relative to 1990

Source and Sink Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)									
1. Energy	42'086	44'081	44'235	41'880	40'974	41'651	42'530	42'030	43'270	43'486
1A1 Energy Industries	2'545	2'827	2'911	2'564	2'589	2'619	2'829	2'793	3'116	2'966
1A2 Manufacturing Industries and Construction	6'013	5'886	5'719	5'512	5'591	5'438	5'272	5'431	5'584	5'620
1A3 Transport	14'772	15'255	15'576	14'508	14'703	14'376	14'421	14'988	15'193	15'788
1A4 Other Sectors	17'786	19'149	19'085	18'367	17'161	18'296	19'087	17'906	18'460	18'182
1A5 Other (Offroad)	450	466	482	498	514	531	542	553	564	575
1B Fugitive emissions from oil and natural gas	520	497	462	432	416	392	379	361	353	355
2. Industrial Processes	3'258	2'912	2'745	2'438	2'617	2'554	2'410	2'268	2'380	2'470
3. Solvent and Other Product Use	468	448	429	406	390	371	348	324	299	294
4. Agriculture	5'903	5'907	5'833	5'755	5'706	5'638	5'655	5'499	5'468	5'410
6. Waste	994	982	961	901	830	824	811	807	776	753
Total (excluding LULUCF)	52'709	54'330	54'202	51'379	50'517	51'039	51'754	50'928	52'192	52'412
5. Land Use, Land-Use Change and Forestry	-2'340	-1'668	-1'149	-3'214	-5'508	-5'294	-4'521	-2'492	-1'678	-1'373
Total (including LULUCF)	50'369	52'662	53'053	48'165	45'010	45'745	47'234	48'436	50'514	51'039

Source and Sink Categories	2000	2001	2002	2003	2004	2005	2006	2007	*2007/1990*
	CO_2 equivalent (Gg)								%
1. Energy	42'433	43'197	42'309	43'430	43'788	44'390	43'953	41'966	*-0.3%*
1A1 Energy Industries	2'886	3'019	3'083	3'066	3'381	3'527	3'766	3'461	*36.0%*
1A2 Manufacturing Industries and Construction	5'797	5'820	5'737	5'714	5'756	5'861	5'916	5'857	*-2.6%*
1A3 Transport	16'021	15'713	15'592	15'759	15'864	15'940	16'026	16'347	*10.7%*
1A4 Other Sectors	16'810	17'715	16'994	18'016	17'908	18'182	17'363	15'428	*-13.3%*
1A5 Other (Offroad)	586	588	590	593	595	597	597	597	*32.5%*
1B Fugitive emissions from oil and natural gas	334	342	313	282	285	282	285	276	*-46.9%*
2. Industrial Processes	2'789	2'897	2'840	2'876	3'034	3'081	3'041	3'058	*-6.1%*
3. Solvent and Other Product Use	282	265	253	244	230	230	229	231	*-50.7%*
4. Agriculture	5'411	5'416	5'391	5'285	5'259	5'282	5'287	5'346	*-9.4%*
6. Waste	733	708	700	659	679	682	663	663	*-33.3%*
Total (excluding LULUCF)	51'648	52'483	51'493	52'494	52'990	53'665	53'173	51'265	*-2.7%*
5. Land Use, Land-Use Change and Forestry	751	218	385	-1'572	300	865	1'076	-647	*-72.3%*
Total (including LULUCF)	52'399	52'701	51'878	50'922	53'291	54'530	54'250	50'617	*0.5%*

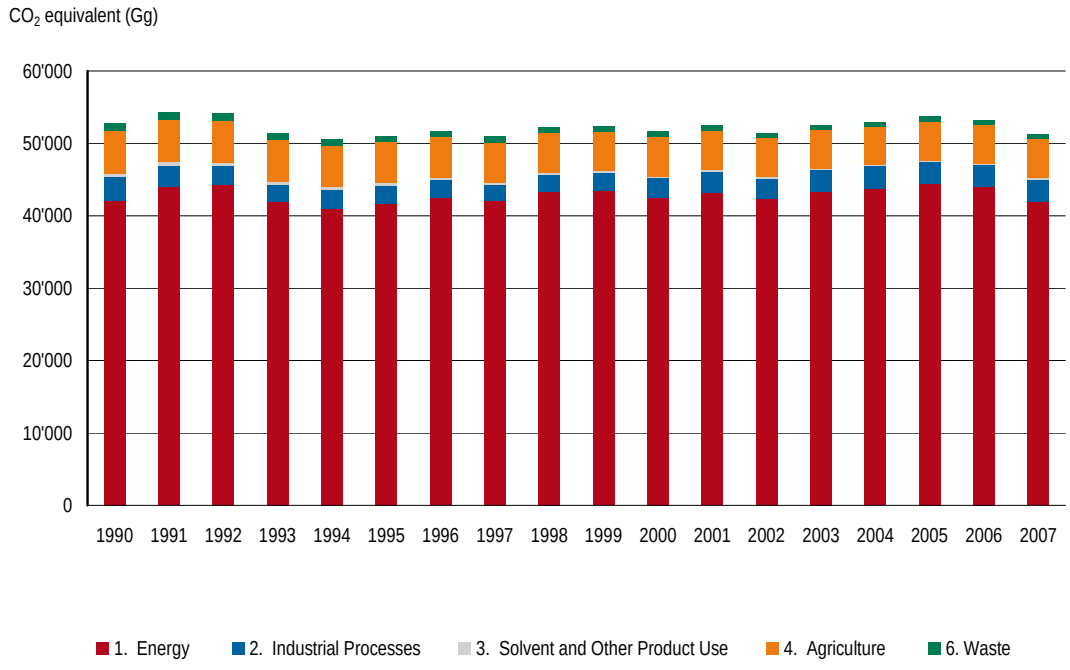
FOEN (2009)

Tab. 11 > GHG emissions (excluding LULUCF) and the percentage of individual source categories

Source and Sink Categories	1990		1995		2000		2005		2006		2007	
	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
1. Energy	42'086	79.8%	41'651	81.6%	42'433	82.2%	44'390	82.7%	43'953	82.7%	41'966	81.9%
1A1 Energy Industries	*2'545*	*4.8%*	*2'619*	*5.1%*	*2'886*	*5.6%*	*3'527*	*6.6%*	*3'766*	*7.1%*	*3'461*	*6.8%*
1A2 Manufacturing Industries and Construction	*6'013*	*11.4%*	*5'438*	*10.7%*	*5'797*	*11.2%*	*5'861*	*10.9%*	*5'916*	*11.1%*	*5'857*	*11.4%*
1A3 Transport	*14'772*	*28.0%*	*14'376*	*28.2%*	*16'021*	*31.0%*	*15'940*	*29.7%*	*16'026*	*30.1%*	*16'347*	*31.9%*
1A4 Other Sectors	*17'786*	*33.7%*	*18'296*	*35.8%*	*16'810*	*32.5%*	*18'182*	*33.9%*	*17'363*	*32.7%*	*15'428*	*30.1%*
1A5 Other (Offroad)	*450*	*0.9%*	*531*	*1.0%*	*586*	*1.1%*	*597*	*1.1%*	*597*	*1.1%*	*597*	*1.2%*
1B Fugitive emissions from oil and natural gas	*520*	*1.0%*	*392*	*0.8%*	*334*	*0.6%*	*282*	*0.5%*	*285*	*0.5%*	*276*	*0.5%*
2. Industrial Processes	3'258	6.2%	2'554	5.0%	2'789	5.4%	3'081	5.7%	3'041	5.7%	3'058	6.0%
3. Solvent and Other Product Use	468	0.9%	371	0.7%	282	0.5%	230	0.4%	229	0.4%	231	0.5%
4. Agriculture	5'903	11.2%	5'638	11.0%	5'411	10.5%	5'282	9.8%	5'287	9.9%	5'346	10.4%
6. Waste	994	1.9%	824	1.6%	733	1.4%	682	1.3%	663	1.2%	663	1.3%
Total (excluding LULUCF)	52'709	100%	51'039	100%	51'648	100%	53'665	100%	53'173	100%	51'265	100%

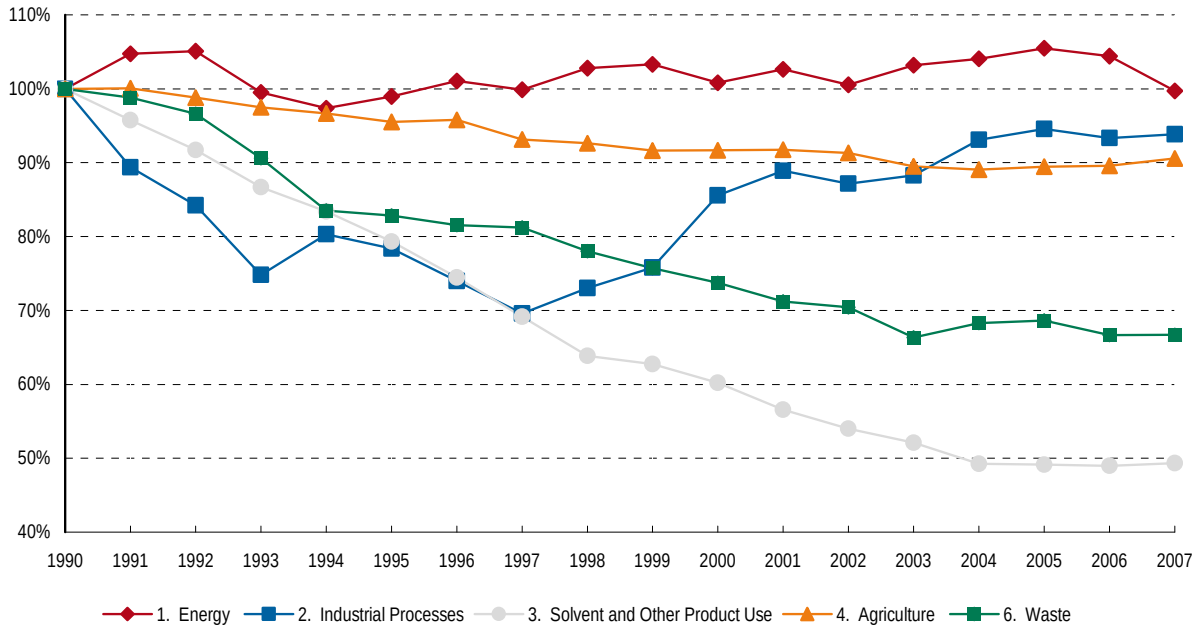
FOEN (2009)

Fig. 60 > GHG emissions (excluding LULUCF) by sectors between 1990–2007



FOEN (2009)

Fig. 61 > Relative emission trends by main source categories (base year 1990 = 100%)



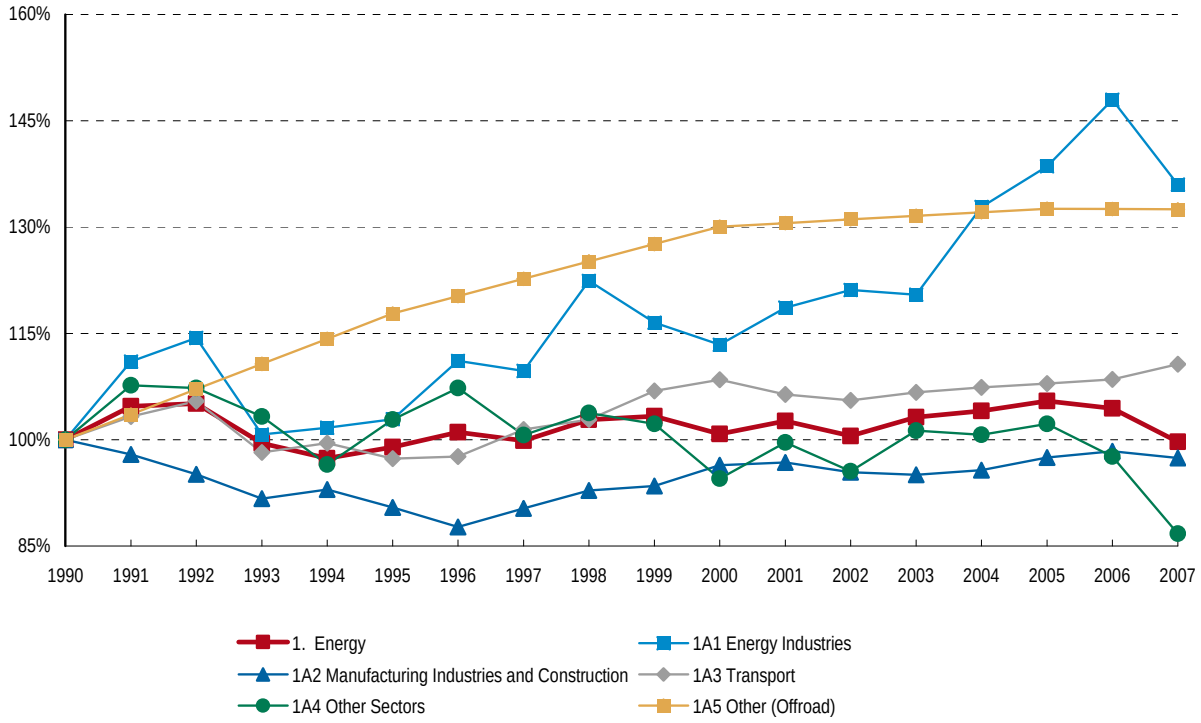
FOEN (2009)

1 Energy

In order to understand the variations in this sector the trends within the sub-categories – representing the major sources of Switzerland's GHG emissions – have to be considered separately (Fig. 62). It is noteworthy that, due to Switzerland's electricity production structure (about 95.2% generated by hydroelectric and nuclear power plants in 2007; see SFOE 2008: Table 24), the sector 1A1 Energy Industries plays only a minor role – representing waste incineration plants rather than classical thermal power stations.

- Despite differing trends for the sub-sectors, the overall emissions resulted in a relatively constant level for the energy sector (red line in Fig. 62).
- The trend for sub-sector 1A1 Energy Industry is mainly caused by annual fluctuation in waste incineration and in combustion activities in the petroleum refinery industry. In the period 1990-2007 less than 9 % of sector 1 Energy emissions stem from 1A1.
- The trend for sub-sector 1A3 Transport (39% of sector 1 Energy in 2007) shows a slight increase over the period 1990–2007, but with fluctuations indicating a fairly strong correlation between this sector and economic development.
- The trend for sub-sector 1A4 Other sectors reflects the impact of climatic variations on heating demand. A strong correlation with the number of "heating degree days" – an index of cold weather conditions – is apparent (Fig. 19). An extraordinary decrease from 2006 to 2007 reflects the high prices for heating oil in 2007, with a concurrent pronounced reduction of heating oil stocks. Furthermore, the number of heating degree days was lower in 2007 compared to 2006 (7% lower than the average of the period 1990-2007). From 1990 to 2007, the number of buildings and apartments increased as well as the average floor space per person and workplace, resulting in an increase in the total area heated. Over the same period, however, higher standards were specified for insulation and for combustion equipment efficiency for both new and renovated buildings, compensating for the emissions from the additional area heated.
- For sub-sector 1A5 Other (representing offroad vehicles including military offroad) GHG emissions increased steadily during the 1990s, due to increasing fuel consumption of construction vehicles and machinery. Levels are stable since 2000 at ~130% compared to 1990.

Fig. 62 > Relative emission trends for the sub-categories in the energy sector compared to the sector as a whole. Fugitive emissions (category 1B, not shown) have dropped to 53% over the same period.



FOEN (2009)

2 Industrial processes

In line with economic development, overall emissions in the industry sector showed a decreasing trend in the 90s and a rebound between 1998 and 2005 (Fig. 61). Their share of the total greenhouse gas emissions in 2007 was of the order of 6% (Tab. 11).

3 Solvent and other product use

NMVOC emissions, the main source of indirect CO_2 emissions of the sector, have diminished between 1990 and 2004 due to their limitation brought by the Ordinance on Air Pollution Control (Swiss Confederation 1985) and the introduction of the VOC tax in 2000 (Swiss Confederation 1997) (Fig. 61). Emissions from this sector make up less than 0.5% of total Swiss greenhouse gas emissions in 2007 (Tab. 11).

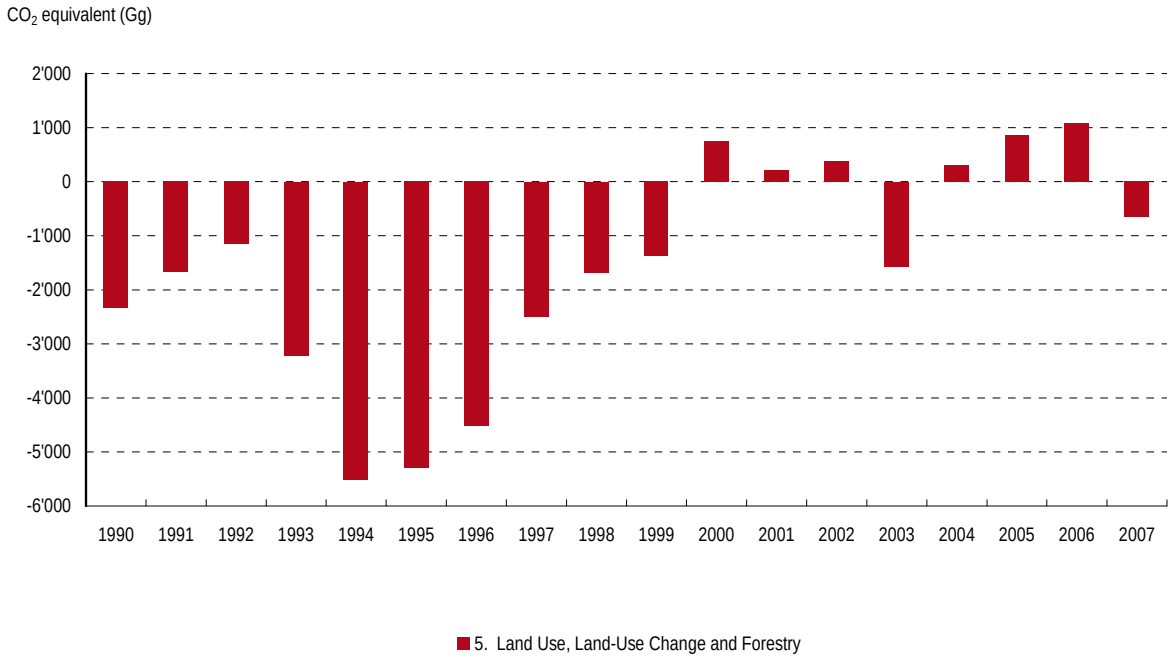
4 Agriculture

Declining populations of cattle and swine and reduced fertilizer use have led to a decrease in CO_2 equivalent emissions until 2004. Since then CH_4 emissions have slightly increased again due to higher livestock numbers (mainly cattle) (Fig. 61). The agriculture sector contributed 10.4% to the total greenhouse gas emissions in 2007 (Tab. 11).

5 Land Use, Land-Use Change and Forestry

Fig. 63 shows net emissions and removals from the LULUCF sector in Switzerland, which is dominated by biomass dynamics in forests. Prior to the year 2000 removals were higher than emissions. The forest carbon sink seems to diminish since the mid-nineties, with emissions balancing removals since 2000. Due to the accounting of annual climatic parameters even 3-year-moving averages as shown in Fig. 63 display a strong year to year variation over the whole period. In 2007, the LULUCF sector was a net CO_2 sink of the order of 1% of total greenhouse gas emissions.

Fig. 63 > Net CO_2 equivalent balance of sector Land Use, Land-Use Change and Forestry (LULUCF). Positive values refer to emissions, negative values to removals. The contributions of CH_4 and N_2O emissions are very small compared to the net CO_2 emissions and removals (8 Gg CO_2 eq. on average).



FOEN (2009)

6 Waste

Total emissions from the source category Waste decreased steadily throughout the period 1990-2003 (Fig. 61). Since 2000, emissions have been reduced further by a change in legislation: disposal of combustible municipal solid wastes on landfills has been banned, leading to a decrease in methane emissions from landfill sites and an increasing amount of municipal solid waste being incinerated in waste incineration plants, with emissions reported under source 1A1 Energy Industries rather than sector 6 Waste. Altogether, "waste-related" emissions including emissions from waste management activities reported in source categories 1A, 4D and 6 have increased since 1990 by 19% (this data is not shown in Fig. 61).

3.2.4 Emission trends for indirect greenhouse gases and SO_2

Emission trends for indirect greenhouse gases show a very pronounced decline (Tab. 12 and Fig. 64). From 1990 to 2007, a strict air pollution control policy and the implementation of a large number of emission reduction measures led to a decrease of 50% to 70% in emissions of air pollutants. The main reduction measures were abatement of exhaust emissions from road vehicles and stationary combustion equipment, taxation of solvents and sulphured fuels, and voluntary agreements with industry sectors (SAEFL 2004; Swiss Confederation 1985, 1997).

The energy sector was by far the largest source of indirect greenhouse gas emissions (Tab. 13), with the only exception being NMVOC, where in 2007 sector 3 Solvent and Other Product Use accounted for 24.3% of the total. The total shown in Tab. 13 includes NMVOC emissions from LULUCF, which amounted to 95.5 Gg in 2007. Fig. 65 shows the relative contributions of the various sectors for each individual gas in 2007 (data from Tab. 13, but excluding NMVOC from LULUCF). The energy sector can clearly be identified as the main source of NO_x, CO and SO_2, whereas sector Solvent and Other Product Use dominates NMVOC emissions.

Tab. 12 > Indirect GHG and SO_2 emissions (Gg), 1990–2007 (excl. NMVOC from LULUCF)

Indirect Greenhouse	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Gases and SO_2	Gg									
NO_x	159	153	144	129	125	117	111	106	104	102
CO	725	700	659	585	547	513	502	484	471	466
NMVOC	293	276	257	231	210	192	180	168	153	148
SO_2	41	37	34	27	28	26	25	25	23	18

Indirect Greenhouse	2000	2001	2002	2003	2004	2005	2006	2007
Gases and SO_2	Gg							
NO_x	98	94	89	87	86	84	82	79
CO	449	427	400	387	369	349	331	313
NMVOC	141	130	121	112	104	100	98	96
SO_2	16.3	18.0	16.6	15.6	15.4	16.4	15.4	13.6

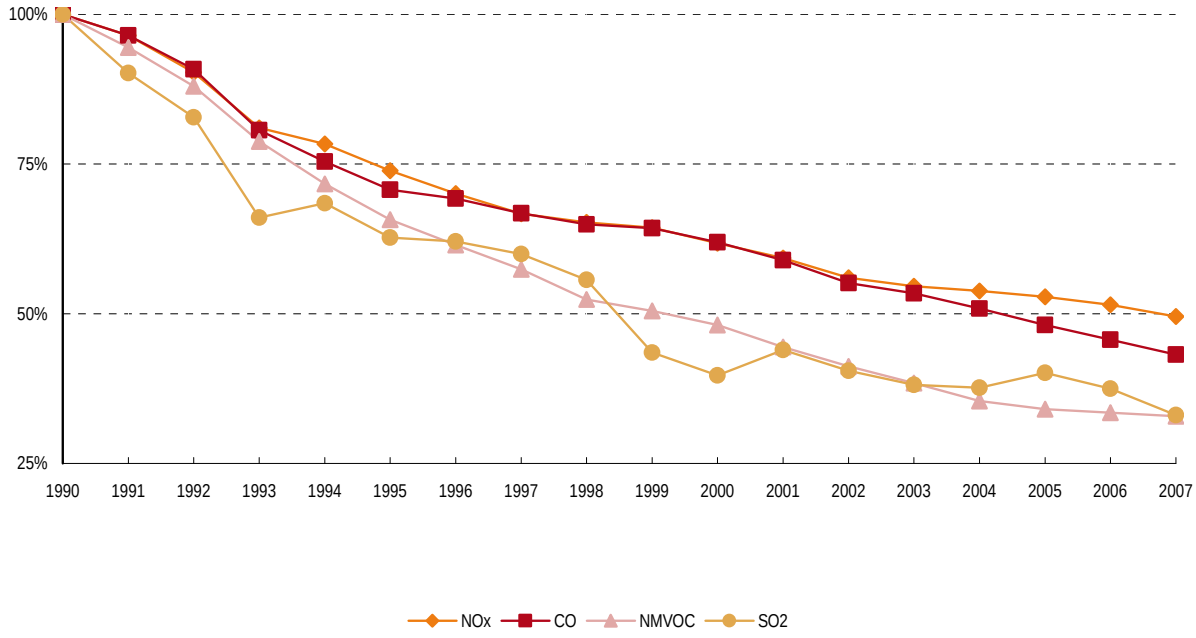
FOEN (2009)

Tab. 13 > Indirect GHG and SO_2 emissions (Gg) by source, 2007. The total NMVOC emissions include NMVOC from LULUCF.

Sources	NO_x	CO	NMVOC	SO_2
	Emissions 2007 (Gg)			
1 Energy	74.7	297.2	32.0	11.4
2 Industrial Processes	0.4	6.8	11.0	2.0
3 Solvent and Other Product Use	0.0	0.0	46.6	0.0
4 Agriculture	4.6	7.3	4.6	0.0
5 LULUCF	IE, NE	IE, NE	95.5	NE
6 Waste	0.4	1.9	2.1	0.1
Total	80.1	313.2	191.8	13.6

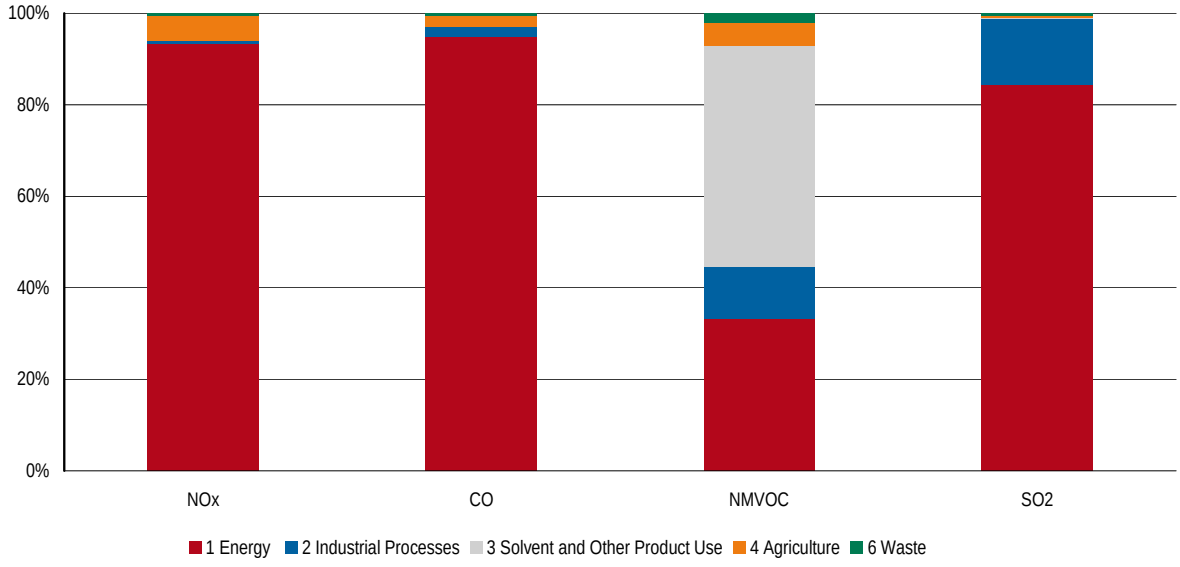
FOEN (2009)
IE = Included elsewhere; NE = Not Estimated

Fig. 64 > Relative emission trends for indirect GHG and SO_2 emissions (excluding NMVOC from LULUCF) between 1990–2007 (base year 1990 = 100%)



FOEN (2009)

Fig. 65 > Relative contributions of individual sectors to indirect GHG and SO_2 emissions in 2007 (excluding NMVOC from LULUCF)



FOEN (2009)

3.3 Data for activities under Art. 3, para. 3 and 4 of the Kyoto Protocol (KP-LULUCF)

Switzerland decided to account for forest management under the elective voluntary activities of Art. 3, para. 4 of the Kyoto Protocol (FOEN 2006h, section F). In accordance with decision 16/CMP.1 (FCCC/KP/CMP/2005/8/Add.3), credits from forest management are capped in the first commitment period. For Switzerland, the cap amounts to 1.83 Mt CO_2 (0.5 Mt C) per year, or 9.15 Mt CO_2 for the whole commitment period. An overview of GHG sources and sink activities for the time series 2000 to 2007 is given in Tab. 14 and Fig. 66.

Tab. 14 > Overview of net CO_2 equivalent emissions and removals for activities under article 3, paragraphs 3 and 4 of the Kyoto Protocol, 2000-2007.

GHG Source and Sink Activities	Net CO_2 equivalent emissions and removals (Gg) Positive values refer to emissions, negative values refer to removals.							
	2000	2001	2002	2003	2004	2005	2006	2007
A. Article 3.3 activities	18.78	29.63	46.96	8.99	-6.69	-17.10	26.80	8.66
A.1. Afforestation and reforestation	-50.22	-52.68	-55.15	-57.61	-60.07	-63.29	-65.69	-67.73
A.1.1. Units of land not harvested since the beginning of the commitment period	-50.22	-52.68	-55.15	-57.61	-60.07	-63.29	-65.69	-67.73
A.1.2. Units of land harvested since the beginning of the commitment period	0	0	0	0	0	0	0	0
A.2. Deforestation	69.00	82.31	102.11	66.60	53.38	46.19	92.49	76.39
B. Article 3.4 activities	-372.83	-905.49	-738.39	-2'695.34	-822.76	-338.06	-87.31	-1'741.70
B.1. Forest management incl. biom. burning	-372.83	-905.49	-738.39	-2'695.34	-822.76	-338.06	-87.31	-1'741.70
- growth of living biomass	-12'950.12	-13'946.89	-13'492.10	-12'610.33	-11'748.55	-10'901.07	-12'234.35	-13'409.85
- cut and mortality	13'830.08	14'295.67	14'144.82	11'445.76	11'065.46	11'538.57	11'999.80	12'499.35
- dead wood pool	-1'253.20	-1'254.68	-1'395.73	-1'537.11	-139.90	-976.09	146.09	-833.84
- sum forest manag. without biom. burning	-373.24	-905.91	-743.01	-2'701.68	-822.99	-338.59	-88.45	-1'744.34
B.2. Cropland management (if elected)	NA	NA	NA	NA	NA	NA	NA	NA
B.3. Grazing land management (if elected)	NA	NA	NA	NA	NA	NA	NA	NA
B.4. Revegetation (if elected)	NA	NA	NA	NA	NA	NA	NA	NA
SUM Art. 3.3 and 3.4	-354.05	-875.86	-691.43	-2'686.35	-829.45	-355.16	-60.51	-1'733.04

NA = Not Applicable

Fig. 66 > Net CO_2 equivalent emissions and removals for activities under article 3, paragraph 3 (afforestation, deforestation) and paragraph 4 (forest management) of the Kyoto Protocol, 2000-2007. Positive values refer to emissions, negative values refer to removals.

FOEN (2009)

3.4 Status of the national inventory system

3.4.1 National entity with overall responsibility

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National GHG Inventory System, Dr. Paul Filliger (project leader)
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3.4.2 Institutional, legal and procedural arrangements

The Swiss National Inventory System (NIS) is developed and managed under the auspices of the Federal Department of the Environment, Transport, Energy and Communications (DETEC). It is hosted by an office of DETEC, the Federal Office for the Environment (FOEN). As stipulated in the Ordinance on the Internal Organization of DETEC of 13.12.2005, the FOEN has the lead within the federal administration regarding climate policy and its implementation.

As part of a comprehensive project (Swiss Climate Reporting Project), the FOEN directorate mandated its Climate, Economics, and Environmental Monitoring Division to design and establish the NIS in order to ensure full compliance with the reporting requirements of the UNFCCC and the Kyoto Protocol by 2006. Having regard to the provisions of Art. 5, paragraph 1 of the Kyoto Protocol, the project encompassed the following elements:

- arrangements with partner institutions, relating to roles and responsibilities
- participation in the inventory development process
- data use, communication and publication
- inventory development plan
- setting-up of a QA/QC system
- official consideration and approval
- upgrading and updating of the national air pollution database (EMIS)
- data documentation and storage

The project came to an end with the establishment of an operational NIS (Fig. 67), the submission of Switzerland's initial report under article 7, paragraph 4 of the Kyoto Protocol (FOEN 2006h) and its formal approval by the Federal Council in November 2006.

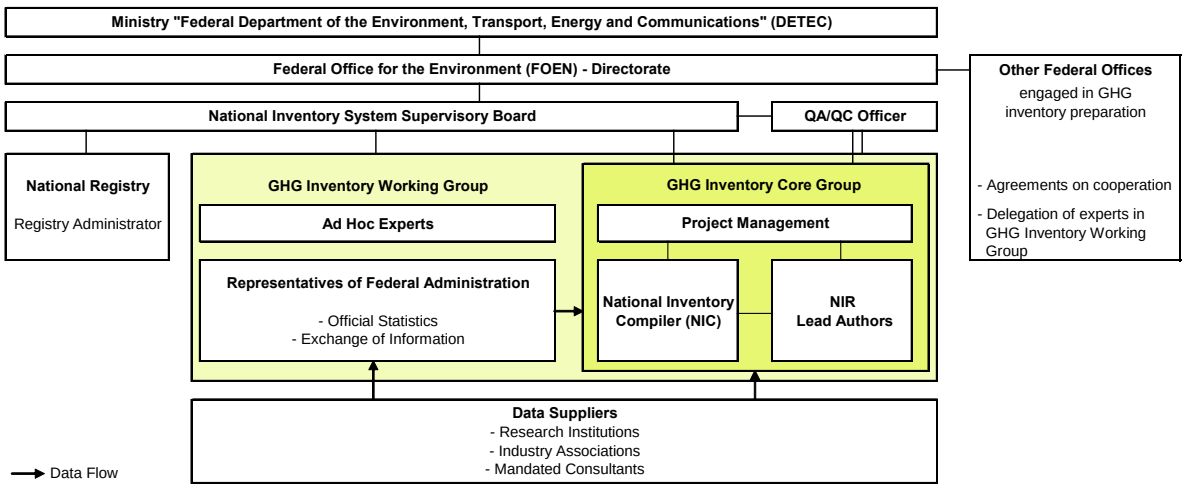
3.4.3 Roles and responsibilities

The **NIS supervisory board** was established by decision of the FOEN directorate in summer 2006. The board oversees activities related to the GHG inventory and to the national registry. It is independent of the inventory preparation process and, by its composition, combines technical expertise and political authority. According to its mandate, the main tasks of the NIS supervisory board are:

- official consideration of the annual inventory submission and recommendation of the inventory for official approval by the FOEN directorate
- assessment and approval of the recalculation of inventory data
- handling of any issues arising from the UNFCCC review process that cannot be resolved at the level of the inventory project management
- facilitation of any non-technical negotiation, consideration or approval processes involving other institutions within the federal administration

The QA/QC officer is responsible for enforcement of the defined quality standards. He / she also advises the NIS supervisory board on matters relating to the conformity of the inventory with reporting requirements. His / her tasks and competences are described in detail in the description of the quality management system (FOEN 2009a).

Fig. 67 > Institutional setting of the National Inventory System



FOEN (2006h, 2009)

The **GHG inventory working group** encompasses all scientific and technical personnel involved in the inventory preparation process or representing institutions that play a significant role as suppliers of data. The group as a whole meets at least once per year to take stock of the state of the inventory, discuss priorities in the inventory development process, and to address specific issues of general interest that arise, e.g. from domestic or international reviews.

The **GHG inventory core group** comprises the inventory experts employed by the FOEN or mandated on a regular basis, who are entrusted with major responsibilities for inventory planning, preparation and/or management. All inventory data are assembled and prepared for input into the CRF reporter by the GHG inventory core group, which is responsible for ensuring the conformity of the inventory with the Updated UNFCCC Reporting Guidelines on Annual Inventories (UNFCCC 2006b) and the 2008 Kyoto Protocol Reference Manual (UNFCCC 2008). The core group consists of:

- the inventory project management (with overall responsibility for the integrity of the inventory, communication of data, and information exchange with the UNFCCC secretariat);
- the national inventory compiler (responsible for the EMIS inventory data base and for the CRF tables);
- the NIR lead authors (responsible for the inventory report and carrying out centralized data assessments such as uncertainty analysis and key category analysis);
- selected sectoral experts.

The QA/QC officer, albeit no formal member, attends the meetings of the core group.

The GHG inventory core group coordinates and integrates the activities of data suppliers within and outside the FOEN as well as those of mandated experts. Further data suppliers contributing to the inventory are research institutions and industry associations (see Table 1-1 in FOEN 2009 for a detailed list of data suppliers). The latter are obliged by Art. 46 of the Federal Act on the Protection of the Environment (Swiss Confederation 1983) to provide the authorities with the information needed to enforce the law and, if necessary, to carry out inquiries or to cooperate by providing information for inquiries. Further details of the function of the core group and the roles and responsibilities of its members are given in the description of the quality management system (FOEN 2009a, section 2.2.)

The formal arrangements (agreements, contracts, and documentations of roles and responsibilities) that have been established to consolidate and formalize cooperation between the relevant partners contributing to, or involved in, the GHG inventory preparation process are described in section H.1.1 of Switzerland's initial report under article 7, paragraph 4 of the Kyoto Protocol (FOEN 2006h). The general agreement on cooperation between the Federal Statistical Office (FSO) and the FOEN has been updated in 2008, now explicitly describing the mutual responsibilities in the framework of UNFCCC reporting.

Information regarding the Swiss GHG inventory is available online at *www.climatereporting.ch*.

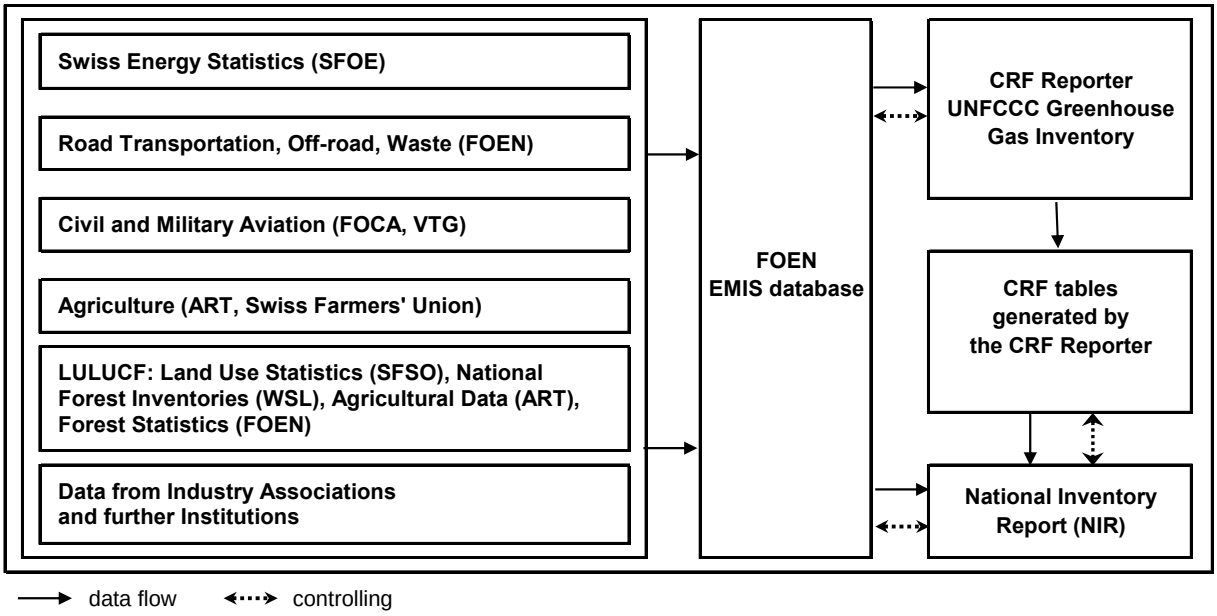
3.4.4 Process of inventory preparation

The data needed to prepare the UNFCCC greenhouse gas inventory in the CRF is collected by various data suppliers and collated by the Air Pollution Control and Non-Ionizing Radiation division at the FOEN. Since the individual data suppliers bear the main responsibility for the quality of data provided, they are also responsible for the collection of activity data and for the selection of emission factors and methods. However, the relevant guidelines, including the revised IPCC guidelines (IPCC 1997a, 1997b, 1997c), and the IPCC good practice guidance (IPCC 2000, IPCC 2003), are necessarily taken into account. Some data suppliers have further started to adopt the good practice guidance presented in the 2006 IPCC guidelines (IPCC 2006). Diverse QA/QC activities (see section 3.4.7 and, more detailed, FOEN 2009a) provide safeguards to maintain and continuously improve the quality of inventory data.

The Air Pollution Control and Non-Ionizing Radiation Division maintains the EMIS database, which contains all the basic data needed to prepare the GHG inventory in the CRF. At the same time, background information on data sources, activity data, emission factors and methods used for emission estimation is documented in the data base and/or the NIR.

Fig. 68 illustrates the data collection and processing steps leading to the CRF tables required for reporting under the UNFCCC and under the Kyoto Protocol. From EMIS, an interface transfers the data to the CRF reporter (Version 3.2.3) that generates the CRF tables that are submitted using the UNFCCC submission portal released in February 2009. Representative data from the CRF tables are shown in the NIR. The NIR authors and the reviewers control the correctness of the data transferred from CRF tables into the NIR. Figures and tables shown in the NIR are exported from EMIS. The NIR authors check the correspondence between the exports and the CRF tables. A detailed illustration of the sectoral steps of inventory processing is given in the monitoring protocols of NIS core processes and sub-processes assembled in FOEN (2009a).

Fig. 68 > Data collection for EMIS database, CRF reporter and National Inventory Report (NIR)



FOEN (2009)

Methodologies: General description

Emissions are calculated on the basis of the standard methods and procedures published in the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 1997a, 1997b, 1997c), in IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC 2000), and in IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC 2003), Under the UNFCCC, these guidelines and good practice guidance have been adopted for mandatory use in reporting on GHG inventories. The 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006), adopted in April 2006 by the IPCC, but not yet under the UNFCCC, have been consulted in a few cases.

National and reference approach for sector 1 Energy

The national approach for sector 1 Energy is based on import and fuel consumption statistics (fuel sales in the transport sector) in Switzerland. The other sectors rely on national statistics and data surveys. For the various sectors, tier 1, tier 2 and tier 3 methodologies according to IPCC guidelines (IPCC 1997b) and good practice guidance (IPCC 2000) are used. GHG emissions by sources and removals by sinks due to land use, land-use change and forestry (LULUCF sector) are calculated according to IPCC 2003. Tab. 1-2 in FOEN (2009) indicates the approaches adopted in compiling the Swiss GHG inventory.

The reference approach is used as a check for (i) overall energy consumption and (ii) the resulting CO_2 emissions reported in source category 1 Energy. In Switzerland, it is applied on the basis of customs statistics for imported oil and oil products, and data published in the annual report of the Swiss Petroleum Association. The results of the reference approach are compared with the results of the national approach for sector 1 Energy in order to test the quality and completeness of the inventory.

National Air Pollution Database EMIS
One part of the emissions has been calculated by multiplying emission factors and activity rates in the "FOEN EMIS database". Another part of the emissions has been calculated by the data suppliers (transport, synthetic gases, agriculture). In the latter cases, the resulting emission data have been directly inserted into FOEN EMIS database.

A large body of emission data is adopted from Switzerland's national air pollution database EMIS, which is operated by FOEN (FOEN 2006c). EMIS was established at SAEFL (former name of FOEN) in the late 1980s. Its initial purpose was to record and monitor emissions of air pollutants. It has since been extended to cover greenhouse gases, too. Its structure corresponds to the EMEP/CORINAIR system for classifying emission-generating activities. EMEP/CORINAIR uses the nomenclature for reporting ("NFR code", UNECE 2003). The revised 1996 IPCC guidelines provide a correspondence key between IPCC and EMEP/CORINAIR source categories (IPCC 1997a: Annex 2). EMIS thus contains cross-references to IPCC/UNFCCC coding formats.

EMIS calculates emissions for various pollutants using emission factors and activity data according to the EMEP/CORINAIR methodology. Pollutants in EMIS include sulphur dioxide (SO_2), nitrogen oxides (NO_x), nitrous oxide (N_2O), ammonia (NH_3), non-methane volatile organic compounds (NMVOC), carbon monoxide (CO), hydrochloric acid (HCl), particulate matter, heavy metals (lead, zinc, cadmium, mercury), polychlorinated dibenzodioxins and -furanes (PCDD/PCDF), hydrogen fluoride (HF), hydrofluorocarbons (HFC), perfluorinated carbon compounds (PFC), sulphur hexafluoride (SF_6), methane (CH_4), carbon dioxide CO_2 (fossil/geological origin) and CO_2 (biogenic). The input data originate from a variety of sources, such as production data and emission factors from industry, industry associations and research institutions, as well as population, employment, waste and agriculture statistics. EMIS is documented in an internal FOEN manual for the database (FOEN 2006c).

The original EMIS database underwent a full redesign in 2005/2006. It was extended to incorporate more data sources, updated, and migrated to a new software platform. At the same time, activity data and emission factors were being checked and updated. Emission data from EMIS that are relevant for the GHG inventory are exported to the CRF Reporter.

Input data for the EMIS database comprise the SFOE Swiss overall energy statistics, FOEN statistics and models for emissions from road transportation, statistics and models of off-road activities, import statistics for synthetic gases, waste and agricultural statistics, the National Forest Inventory and the national forest statistics (see Fig. 68).

3.4.5 Key source identification

The key category analyses are performed according to the good practice guidance (IPCC 2000: section 7). A tier 1 level and trend assessment is applied with the proposed threshold of 95%. A tier 2 key category analyses has also been carried out for the submission in 2009 (updated biennially) with the proposed threshold of 90% of the sum of all level assessments weighted with their uncertainty.

According to good practice guidance (IPCC 2003), the result of tier 2 key category analysis should be used when results between tier 1 and tier 2 differ. However, it would also be possible to keep tier 1 key categories as key categories based on qualitative criteria. It is planned that this topic will be examined for future submissions. The GHG inventory core group has agreed to keep tier 1 key categories in the 2009 submis-

sion as key categories, even if they are not key in tier 2. This procedure would also be compatible with the 2006 IPCC guidelines (IPCC 2006), which recommend exactly such a procedure of combining results from tier 1 and tier 2 categories if results from the two approaches differ. When combining tier 1 and tier 2 key category analysis results, we consider a category to be key because of trend, if the category is key due to trend according to tier 1 or tier 2, and a category is considered to be key because of level, if the category is key due to level according to tier 1 or tier 2. All key category identification data are archived on the GHG inventory web platform (see section 3.4.7).

KCA without LULUCF categories

Tier 1

For 2007, among a total of 134 categories, 36 have been identified as key categories with an aggregated contribution of 97.9% to total national emissions. 25 categories are key due to the level assessment, 30 due to the trend assessment. For comparison, there are 24 level key categories in the base year 1990, all of which are also key categories in 2007 (see FOEN, 2009 for further details regarding key categories).

Of the 36 key categories, 21 are in sector 1 Energy, accounting for 80.7% of total CO_2 equivalent emissions in 2007. The other key categories are from sectors 2 Industrial Processes (5.4%), 3 Solvent and Other Product Use (0.3%), 4 Agriculture (10.4%), and 6 Waste (1.1%). There are two major key sources:

- 1A3b Energy, Fuel Combustion, Road Transportation, gasoline, CO_2, level contribution 20.7%,
- 1A4b Energy, Fuel Combustion, Other Sectors, Residential, liquid fuels, CO_2, level contribution 15.5%.

Tier 2

For 2007, among a total of 134 categories, 32 have been identified as key categories with an aggregated contribution of 93.4% to total national emissions and 95.25% of the sum of all level assessments weighted with their uncertainty in 2007. 24 categories are key due to the level assessment, 26 due to the trend assessment. For comparison, there are 23 level tier 2 key categories in the base year 1990, all of which are also key categories in 2007. Tab. 15 shows the contributions of the individual key categories (tier 2).

Of the 32 key categories, 17 are in sector 1 Energy, accounting for 45.7% of the sum of all level assessments weighted with their uncertainty in 2007 (15.70%). Sector 4 Agriculture accounts for 38.9% of that sum. Tier 2 key category analysis shows that these two sectors have the highest impact on inventory uncertainty. The other key categories are from sectors 2 Industrial Processes (3.7%), 3 Solvent and Other Product Use (1.6%), and 6 Waste (5.2%). There are three major key sources:

- 1A1 Energy, Fuel Combustion, Energy Industries, Other Fuels, CO_2, contribution of 8.9% to the sum of all level assessments weighted with their uncertainty.
- 4D1 Agricultural Soils, Direct Soil Emissions, N_2O, contribution of 11.7% to the sum of all level assessments weighted with their uncertainty.
- 4D3 Agricultural Soils, Indirect Emissions, N_2O, contribution of 13.7% to the sum of all level assessments weighted with their uncertainty.

Tab. 15 > Tier 2 key categories 2007 (without LULUCF categories) sorted by category code

IPCC Source Categories (and fuels if applicable)			Direct GHG	1990	2007	Level Assessm. with Uncert.	Contribution in Trend
				Gg CO_2eq	Gg CO_2eq		
1A1	Energy Industries	Other Fuels	CO2	1'519.7	2'162.0	1.40%	9.1%
1A1	Energy Industries	Other Fuels	N2O	48.4	112.4	0.18%	2.1%
1A1	Energy Industries	Solid Fuels	CO2	46.9	161.2	0.08%	1.2%
1A2	Manufacturing Industries and Construction	Gaseous Fuels	CO2	1'066.7	2'161.7	0.57%	6.1%
1A2	Manufacturing Industries and Construction	Liquid Fuels	CO2	3'339.6	2'572.3	0.25%	1.4%
1A2	Manufacturing Industries and Construction	Other Fuels	CO2	156.9	295.2	0.41%	4.0%
1A2	Manufacturing Industries and Construction	Solid Fuels	CO2	1'387.8	774.5	0.48%	7.4%
1A3b	Transport; Road Transportation	Diesel	CO2	2'647.4	5'188.3	0.42%	4.4%
1A3b	Transport; Road Transportation	Diesel	N2O	8.4	31.9	0.09%	1.4%
1A3b	Transport; Road Transportation	Gasoline	CH4	91.3	17.9	0.02%	1.7%
1A3b	Transport; Road Transportation	Gasoline	CO2	11'335.3	10'615.0	0.86%	0.7%
1A3b	Transport; Road Transportation	Gasoline	N2O	87.8	81.6	0.24%	0.2%
1A4a	Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	939.0	1'350.1	0.35%	2.4%
1A4a	Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	4'444.1	3'310.5	0.32%	2.0%
1A4b	Other Sectors; Residential	Gaseous Fuels	CO2	1'406.6	2'141.7	0.56%	4.2%
1A4b	Other Sectors; Residential	Liquid Fuels	CO2	10'215.6	7'922.9	0.77%	4.0%
1B2	Oil and Natural Gas		CH4	380.5	173.3	0.17%	4.0%
2A1	Mineral Products; Cement Production-CO2		CO2	2'524.8	1'844.1	0.23%	1.6%
2B	Chemical Industry		N2O	173.8	83.2	0.07%	1.4%
2C_o	Metal Production without Aluminium Production		CO2	112.5	179.1	0.14%	1.1%
2F1	Consumption of Halocarbons and SF6; Refrig. & AC Eq.		HFC	0.0	568.7	0.15%	3.2%
3	Solvent and Other Product Use		CO2	357.8	177.1	0.17%	3.4%
3	Solvent and Other Product Use		N2O	110.1	53.7	0.08%	1.7%
4A	Enteric Fermentation		CH4	2'474.8	2'318.6	0.83%	0.7%
4B	Manure Management		CH4	557.4	500.8	0.53%	0.9%
4B	Manure Management		N2O	448.2	408.4	0.50%	0.7%
4D_o	Agricultural Soils without 4D1-N2O & 4D3-N2O		N2O	200.2	180.1	0.26%	0.4%
4D1	Agricultural Soils; Direct Soil Emissions		N2O	1'389.9	1'231.5	1.84%	3.7%
4D3	Agricultural Soils; Indirect Emissions		N2O	818.9	692.4	2.15%	6.7%
5A1	*Forest Land remaining Forest Land*		*CO2*	*3'362.0*	*1'722.8*	*1.28%*	*18.8%*
5A2	*Land converted to Forest Land*		*CO2*	*126.4*	*28.8*	*0.02%*	*1.3%*
5B1	*Cropland remaining Cropland*		*CO2*	*570.9*	*559.0*	*0.40%*	*0.3%*
5E2	*Land converted to Settlements*		*CO2*	*398.9*	*301.6*	*0.30%*	*1.3%*
6A	Solid Waste Disposal on Land		CH4	693.0	279.3	0.33%	9.5%
6B	Wastewater Handling		N2O	179.4	201.0	0.39%	1.1%
6D	Other		CH4	30.3	99.9	0.10%	1.4%

FOEN (2009)

Comparison of KCA without and with LULUCF categories

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 including LULUCF.

Tier 1
In the tier 1 KCA for the year 2007 including LULUCF categories there are four additional categories:

- 5A1 Forest Land remaining Forest Land (level and trend key category)
- 5A2 Land converted to Forest Land (trend key category)
- 5B1 Cropland remaining Cropland (level key category)
- 5E2 Land converted to Settlements (level and trend key category)

Source category 5A1 Forest Land remaining Forest Land is a large category, contributing 3.2% to the level assessment. Source categories 5A2, 5B1 and 5E2 contribute less to the level assessment with 0.05%, 1.0% and 0.6%, respectively. For the combined KCA without and with LULUCF categories these categories are added to the other 36 key categories from the KCA without LULUCF. In the KCA for the year 1990, three of these four LULUCF categories are also key categories. Source category 5A2 is not a key category for the year 1990.

Tier 2
In the tier 2 KCA for 2007 including LULUCF categories, the same four additional categories out of the LULUCF sector are key as in tier 1. Also, for the year 1990, source category 5A2 is not a key category.

Source category 5A1 Forest Land remaining Forest Land is a large category, contributing 7.5% to the sum of all level assessments weighted with their uncertainty. Source categories 5A2, 5B1 and 5E2 contribute less, with 0.1%, 2.4% and 1.8%, respectively. For the combined KCA without and with LULUCF categories these categories are added to the other 32 key categories from the KCA without LULUCF as shown in Tab. 15.

3.4.6 Recalculation of data

Recalculations were performed in the past on an ad hoc basis, driven by the continuous improvement process of the inventory. Meanwhile, the inventory has reached a consolidated state. In the future, recalculations will follow strict rules as defined in the monitoring protocols of the NIS core processes (FOEN 2009a). All data suppliers and members of the inventory core group will have to apply for recalculations to the inventory project management. The project management itself may consider the recalculation of data on the basis of review results. It will assess the rationale for any recalculation and propose its performance to the NIS supervisory board if deemed justified and in line with the criteria set out in IPCC good practice guidance. Implementation of recalculations will also depend on their implications for consistency of time series with base year (1990) data.

3.4.7 QA/QC activities

The quality management system
The GHG inventory is managed according to a quality management system (QMS) that was established in 2004. The QMS is designed to comply with the quality objectives of good practice guidance of IPCC (2000), i.e. to ensure and continuously improve transparency, consistency, comparability, completeness, accuracy, and confidence in national GHG emission and removal estimates. Based on these quality criteria, the objective of Switzerland's inventory system is to annually produce a high quality inventory that ensures full compliance with the reporting requirements of the UNFCCC and the Kyoto Protocol.

The NIS quality management system is designed according to a plan-do-check-act cycle. It complies with the ISO 9001:2000 standard and has been certified by the Swiss Association for Quality and Management Systems in December 2007 (SQS 2008). The major QMS elements are summarized below. A detailed description and the current state of implementation are updated annually in the supplement to the National Inventory Report (FOEN 2009a).

Inventory agency responsible for coordinating QA/QC activities
The FOEN has the lead within the federal administration regarding climate policy and its implementation. With the establishment of Switzerland's initial report under Art. 7, para. 4 of the Kyoto Protocol (FOEN 2006h) and its formal approval by the Federal Council, the Swiss NIS became operative. By providing for structures and in defining tasks and responsibilities of institutions, organisations and consultants involved, the NIS itself is a key tool in improving the quality and the process management of inventory preparation. Within the NIS, a dedicated QA/QC officer at FOEN is responsible for enforcement of the defined quality objectives.

Quality manual
The quality manual constitutes the core of the quality management system. It is designed as an interlinked compilation of all documents relevant to quality issues and runs on the FOEN internal document management system (IDM). Fig. 69 illustrates the annual cycle of inventory planning, preparation, and management with a focus on the timelines for the performance of QA/QC activities as specified in the quality manual.

The quality manual contains basics on the QMS, requirements, core processes, and results of the GHG inventory project, current QA/QC activities and planned improvements (according to the inventory development plan, IDP), supporting processes as well as links to supporting documents (see Annex B in FOEN 2009a). Specific monitoring protocols for core und sub processes have been added to ensure agreed standards and transparency. These flow charts specify the methodologies used, institutional responsibilities, the data collection processes, reference material and guidelines, and provide access to archived material.

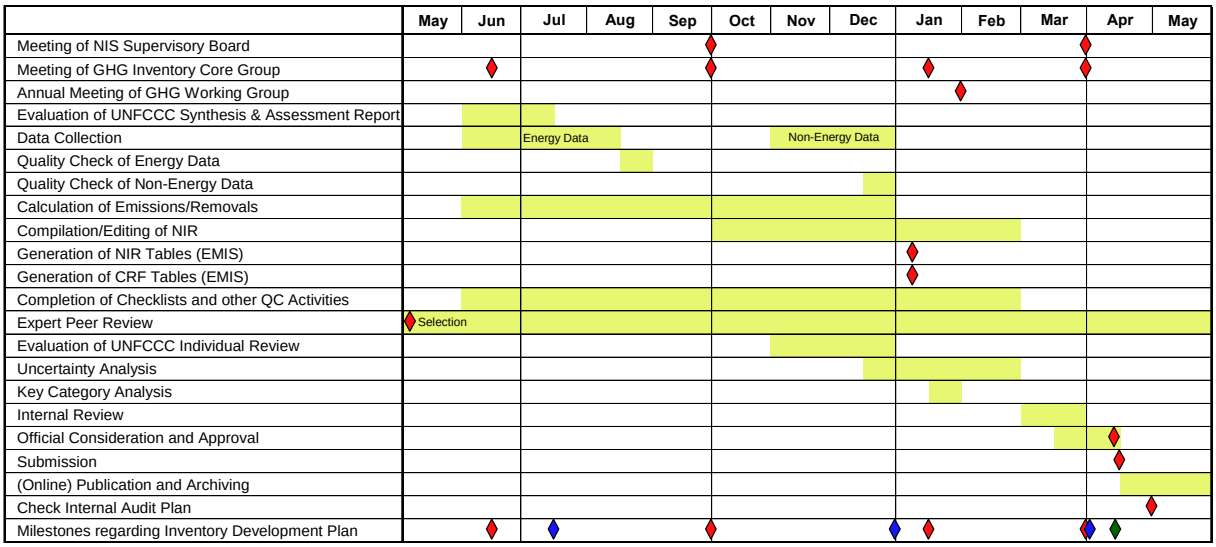
QC procedures
All contributors to the inventory complete checklists that have been designed following the requirements of table 8.1 of the good practice guidance (tier 1; IPCC 2000) and that have been subsequently modified to meet the specific needs of the experts. During the period of data collection, the data suppliers fill in the checklists. Once completed, the checklists are returned to FOEN. Simultaneously to GHG inventory preparation, the suppliers of emission data, the national inventory compiler, the NIR lead authors and the project management complete the respective checklists as well. The QA/QC officer reviews the checklists and contacts the suppliers if concerns about data integrity and/or the quality control procedures arise.

In addition to general QC, the inventory project management ensures the performance of tier 2 QC procedures both by providing for a FOEN (co-)funding of selected research projects and by initiating internal studies, where appropriate. Significant outcomes are recorded in the inventory development plan (IDP; FOEN 2009a, section 3).

QA review procedures
QA procedures include an internal review of NIR, GHG inventory CRF tables, Kyoto Protocol LULUCF CRF tables, and the QA/QC supplement prior to each submission to the UNFCCC and the Kyoto Protocol. It is performed by members of the GHG inventory core group as well as by the staff of the consultants involved in inventory compilation. Periodically, external experts are mandated to review selected key categories after submission (expert peer review, domestic review). Additionally, the outcomes of the UNFCCC inventory review reports are evaluated by the project management together with the QA/QC officer, put up for discussion in the GHG inventory core group, and subsequently used to update the IDP.

Fig. 69 > Annual cycle of inventory planning, preparation, and management

Red diamonds refer to meetings of the NIS supervisory board and the inventory core group, blue diamonds to the evaluation of external or internal reviews, the green one to the official consideration by the supervisory board.



FOEN (2009)

FOEN operates a homepage (*www.climatereporting.ch*) where the Swiss GHG inventories (NIR, CRF tables, QA/QC supplement, UNFCCC review reports), the Swiss national communications and other reports submitted to the UNFCCC and the Kyoto Protocol are available for download. On this web site, most papers, internal reports, domestic reviews, Excel calculation sheets, and other difficult-to-access materials ('grey literature') quoted in the Swiss GHG inventory are provided online. The website thus provides access to the information required for public review.

Reporting, documentation, and archiving procedures

Inventory data as well as background information on activity data and emission factors are archived by the national inventory compiler in the EMIS data base. EMIS allows to file background information (e.g. interim worksheets; references; rationale for choice of methods) for any subset of inventory-related data (EMIS 2009/ (NFR-Code); FOEN 2006c).

Information on the QMS, all QA/QC activities performed, decisions reached by the experts (minutes), results of key category analyses and uncertainty analyses as well as inventory development (IDP) is documented and archived in the FOEN IDM system. Since autumn 2007, the most important contributors to the GHG inventory are authorised to work online on IDM-based inventory master files by means of a SSL connection to a web platform (see Figure 3 in FOEN 2009a). All inventory information, as far as needed to reconstruct and interpret inventory data and to describe the inventory system and its functions, is accessible at a single location at the FOEN in Ittigen near Bern. Data backup is managed by the Federal Office of Information Technology, Systems and Telecommunication (FOITT) using a storage area network. FOITT runs backup facilities at two distinct locations on a nocturnal as well as on a weekly basis.

Treatment of confidential data

Nearly all of the data necessary to compile the Swiss GHG inventory are publicly available. There are, however, a few exceptions:

- Emission data that refer to a single enterprise are in general confidential.
- The reporting of disaggregated emissions of synthetic gases is confidential (not confidential as aggregated data).

- In the civil aviation sub-sector one data source (FOCA 1991), containing aircraft data of individual airlines, has been marked confidential by the Federal Office of Civil Aviation (FOCA).
- Unpublished AREA land use statistics raw data have been temporarily classified confidential by the Swiss Federal Statistical Office (FSO).

The FOEN collects the data needed for calculating emissions of HFCs, PFCs and SF_6 from private companies or industry associations. In the National Inventory Report, the activity data underlying emission estimates of HFCs, PFCs and SF_6 are only partly presented at the most disaggregated level for reasons of confidentiality. However, complete emissions are reported in aggregated tables.

Confidential data will be made available by the FOEN in line with the procedures agreed under the UNFCCC for the technical review of GHG inventories (UNFCCC 2003).

3.4.8 Procedures for official consideration and approval of the inventory

The process for the official consideration of the GHG inventory is defined in the mandate of the NIS supervisory board (see section 3.4.3 and Fig. 69). It is furthermore illustrated in the monitoring protocols of NIS core processes and sub-processes assembled in the QA/QC manual (FOEN 2009a). At the NIS supervisory board meeting that takes place after the completion of the inventory (generally in mid-March) the inventory project management submits the National Inventory Report and the CRF tables to the members of the board for consideration. Following that procedure the chair of the NIS supervisory board presents the inventory for official approval to the FOEN directorate.

3.5 National registry

3.5.1 Name and contact information of the registry administrator

Federal Office for the Environment (FOEN)
Swiss National Registry
Climate, Economics, Environmental Observation Division
CH-3003 Bern, Switzerland
Phone: +41 (0)31 322 05 66 Fax: +41 (0)31 323 03 67
Email: national-registry@bafu.admin.ch
Registry: *https://www.national-registry.ch*
Web: *www.environment-switzerland.ch/emissions-trading*

Contact	**Alternate**
Mr. Yvan Keckeis	Mr. Reto Schafer
Phone: +41 (0)31 324 71 84	+41 (0)31 322 47 10
Email: yvan.keckeis@bafu.admin.ch	reto.schafer@bafu.admin.ch

3.5.2 Cooperation with other parties

Switzerland uses 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. As of today the same software is used by the Czech Republic, France, Liechtenstein, Monaco, Poland, Portugal, Slovakia and Russia.

In addition, Switzerland cooperates with Liechtenstein and Monaco and hosts the registry of these parties on Swiss servers. All three national registries are however maintained as independent systems with independent registry administrators.

3.5.3 Description of the data base structure and capacity of the national registry

Switzerland has implemented the Seringas™ system using a Microsoft SQL server relational data base management system with a dedicated data model. The total capacity of the registry is only limited by the maximum size of the Microsoft SQL server.

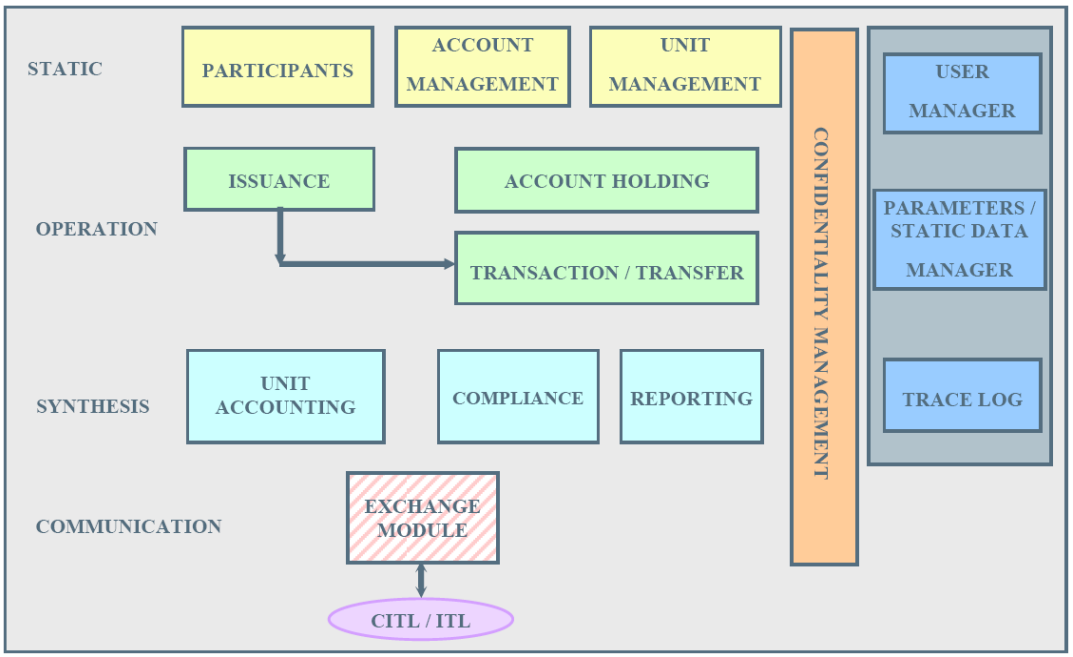
The data model for the national registry was developed by CDC (Fig. 70). As a specific characteristic of the data base structure, the registries of Liechtenstein and Monaco are run in parallel on Swiss servers. The information and communication technology (ICT) architecture is illustrated in Fig. 71.

3.5.4 Conformity to the technical standards for data exchange

The Swiss national registry conforms to the technical standards for data exchange as specified in the UNFCCC data exchange standards (DES) for registry systems under the Kyoto Protocol, technical design specification, version 1.1.1, of 21.08.2008.

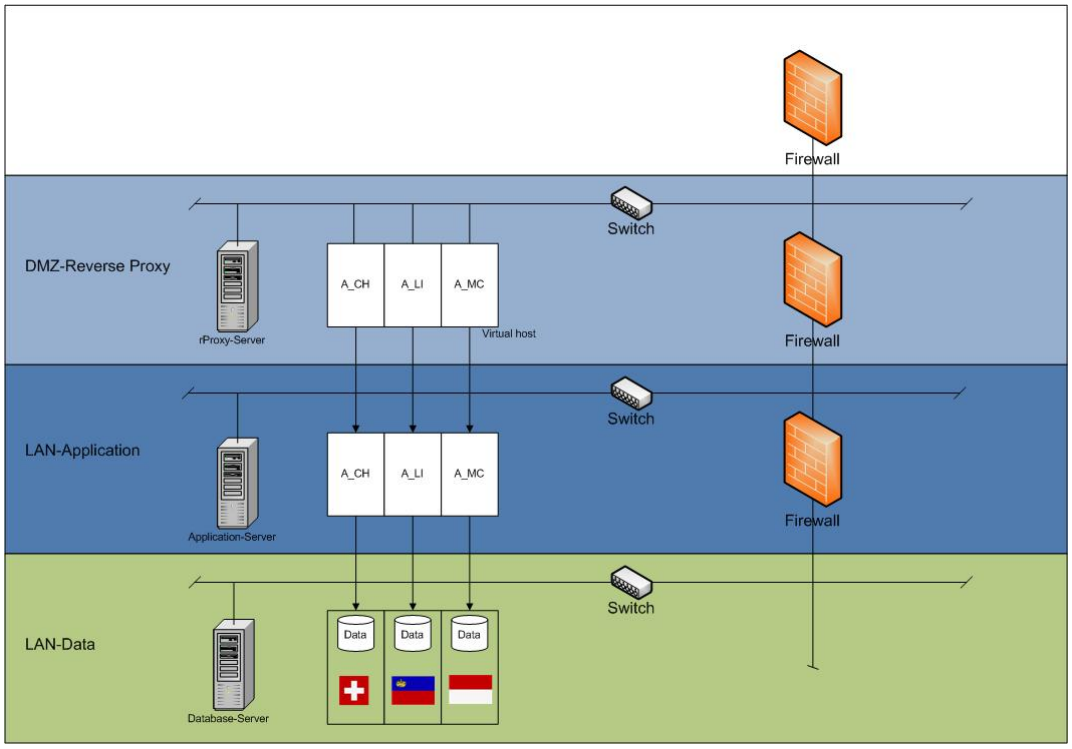
As stated in the independent assessment report IAR, the Swiss national registry has fulfilled the obligations regarding conformity with the DES and is therefore fully compliant with the registry requirements defined in decisions 13/CMP.1 and 5/CMP.1. The Swiss national registry is connected to the ITL and fully operational since 4.12.2007. The daily reconciliations confirm the integrity of the database.

Fig. 70 > Data model for the national registry



Caisse des Dépôts et Consignations, CDC

Fig. 71 > Information and Communication Technology (ICT) architecture



FOEN (2006h)

3.5.5 Procedures employed to minimize and manage discrepancies and to correct problems

In case of discrepancies, the conformity of the Swiss national registry to DES ensures the correct treatment and reception of information by the ITL. In case of discrepancies, the common operational procedures of the UNFCCC are followed.

Internal incident and change management procedures were defined in cooperation with Liechtenstein, Monaco, our support team, and the Federal Office of Information Technology, Systems and Telecommunication FOITT where the servers are hosted.

3.5.6 Security measures

The solution is based on a two-tier architecture. The front-end and the database tier are separated from each other by means of a firewall. The front-end tier is protected from the Internet by means of a firewall and a reverse proxy. Access to the front-end is restricted to port 443 (https). The users of the system are authenticated by means of username and password. In order to keep the system software up to date, the servers are subject to a continuous patch process. All servers are physically installed in a data centre and therefore the appropriate physical controls are in place.

System operations are in compliance with the IT security instructions of the federal administration ("Directives du Conseil de l'informatique concernant la sécurité informatique dans l'administration fédérale", *www.isb.admin.ch*).

3.5.7 Information publicly accessible by means of the user interface

Publicly accessible information is provided on the Swiss national registry website at *https://www.national-registry.ch*. The national allocation plan is accessible under "National Allocation Plan". All other information can be downloaded by selecting the menu item "Public reports". Information made available to the public is conforming to the criteria defined in annex E to decision 13/CMP.1:

- § 45 13/CMP.1:Reports "List of participants holding an account in the national registry" and "List of accounts opened in the national registry"
- § 46 13/CMP.1:No report available as no ERUs were issued by Switzerland
- § 47 13/CMP.1:Report "Annual summary of quantity per type of operation made in the national registry"
- § 48 13/CMP.1: Report "List of participants holding an account in the national registry"

3.5.8 Internet address of the interface to the national registry

The user interface is located on the Swiss national registry website (*www.national-registry.ch*).

3.5.9 Measures taken to safeguard, maintain and recover data in the event of a disaster

The planned backup strategy is illustrated in Tab. 16. The system itself is not redundant. In case of loss of a system, it has to be rebuilt from the backup files.

Tab. 16 > Back up strategy

	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 log files	Hourly	1 week	Local system disk on the data base server. This device is separate from the device holding the DB.
Transaction log files	Transaction log files will be subject to the system data backup			

3.5.10 Test procedures

Basic tests are performed by the developer, CDC Seringas, on the international transaction log (ITL) DEVELOPER environment. The Annex H test during the registry initialization process successfully tested the software of the Swiss national registry against the ITL. New versions, updates or bug fixes of the Swiss national registry software are tested in the integration environment before implementation in the production environment. Major changes are tested during the testing cycle on the REGISTRY environment of the ITL. If test end criteria are reached the new version or update is installed in the production environment.

Tab. 17 > Total quantities of Kyoto Protocol units by account type at beginning of 2008

Standard Electronic Format (SEF) Table 1

	Unit type					
Account type	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Party holding accounts	5'000'000	NO	NO	NO	NO	NO
Entity holding accounts	NO	NO	NO	302'480	NO	NO
Sum of Party and Entity holding accounts	5'000'000	NO	NO	302'480	NO	NO
Article 3.3/3.4 net source cancellation accounts	NO	NO	NO	NO		
Non-compliance cancellation accounts	NO	NO	NO	NO		
Other cancellation accounts	NO	NO	NO	NO	NO	NO
Retirement account	NO	NO	NO	NO	NO	NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
lCER replacement account for expiry	NO	NO	NO	NO		
lCER replacement account for reversal in storage	NO	NO	NO	NO		NO
lCER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
Total	5'000'000	NO	NO	302'480	NO	NO

FOEN (2009)

3.5.11 Status of national registry at the beginning of 2008

The Swiss Registry got fully operational with the international transaction log (ITL) on 4.12.2007. As part of the go-live process, 5 million assigned amount units (AAUs) had been issued. Tab. 17 shows the total quantities of Kyoto Protocol units in the Swiss Registry by account type at beginning of 2008. The decision of Switzerland to issue only 5 million AAUs during the go-live process triggered a notification type 7 "Commitment Period Reserve" from the ITL. In response to this notification, the Swiss registry issued the entire assigned amount units of 242'838'402 on 14.2.2008.

A summary of the information on starting values and annual transactions in the Swiss registry is given in Tab. 18. Tab. 19 shows the total quantities of Kyoto Protocol units in the Swiss registry by account type at end of 2008. All three tables (Tab. 17, Tab. 18 and Tab. 19) are part of the SEF, the standard electronic format for reporting Kyoto Protocol units, as per decision 14/CMP.1 and decision 15/CMP.1 section I.E.

Tab. 18 > Summary information on additions and subtractions

Standard Electronic Format (SEF) Table 5(a)

						Additions		Subtractions
						Unit type		Unit type
Starting values	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs
Issuance pursuant to Article 3.7 and 3.8	242'838'40[5]							
Non-compliance cancellation							NO	NO
Carry-over	NO	NO		NO				
Sub-total	242'838'402	NO		NO			NO	NO
Annual transactions								
Year 2007	NO	NO	NO	302'480	NO	NO	NO	NO
Year 2008	42'859'242	NO	NO	114'864'819	NO	NO	22'000'000	NO
Sub-total	42'859'242	NO	NO	115'167'299	NO	NO	22'000'000	NO
Total	285'697'644	NO	NO	115'167'299	NO	NO	22'000'000	NO
FOEN (2009)								

Tab. 19 > Total quantities of Kyoto Protocol units by account type at end of 2008

Standard Electronic Format (SEF) Table 4

	Unit type					
Account type	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Party holding accounts	239'914'821	NO	NO	NO	NO	NO
Entity holding accounts	23'782'823	NO	NO	18'033'992	NO	NO
Sum of Party and Entity holding accounts	263'697'644	NO	NO	18'033'992	NO	NO
Article 3.3/3.4 net source cancellation accounts	NO	NO	NO	NO		
Non-compliance cancellation accounts	NO	NO	NO	NO		
Other cancellation accounts	NO	NO	NO	117'639	NO	NO
Retirement account	NO	NO	NO	NO	NO	NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
lCER replacement account for expiry	NO	NO	NO	NO		
lCER replacement account for reversal in storage	NO	NO	NO	NO		NO
lCER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
Total	263'697'644	NO	NO	18'151'631	NO	NO
FOEN (2009)						

[5] * Including 5 million AAUs issued during go-live process in 2007.

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4 Policies and measures

4.1 General policy context

The overarching context for environment and climate policy is the federal constitution where, prominently in the opening paragraphs (Swiss Confederation 1999, Art. 2), sustainable development is listed as one of the main objectives. In pursuit of this commitment, Switzerland has established an Interdepartmental Sustainable Development Committee (ISDC), which defined the priorities for action and oversees implementation and monitoring of progress. The intention is to make sustainability assessments an integral part of decision making and policy evaluation.

In 2008, ISDC further developed the national strategy and action plan for sustainable development (Swiss Federal Council 2008). The action plan "Sustainable development" for the current parliamentary term lists 11 key areas[7], with a total of 30 measures allocated to them. In addition to existing legislation in the 11 key areas, the action plan suggests complementary measures, e.g. advancing the national climate policies, development of adaptation strategies and integral risk management, promotion of energy efficiency, use of renewable energy sources, and support for sustainable and safe transport, amongst others.

In the field of climate policy, many topics affect the area of responsibility of various federal departments and offices. The Federal Council has therefore appointed the Swiss Interdepartmental Committee for Climate Policy (SICCP) to facilitate a coherent Swiss climate policy compliant with the UN framework convention on climate change. As a top-level authority, it develops the overall strategy, coordinates activities of the federal administration and mandates its offices to do the technical groundwork required for passing of a resolution by the federal government. The inauguration of the SICCP with its six fields of activity was in April 2008 (Fig. 72). All working groups are fully operational and deliver crucial input to the decision-makers in the federal administration. The SICCP draws input from specialists and experts, from independent advisory bodies, such as the Swiss advisory body on climate change (OcCC), the national platform for natural hazards (PLANAT), the Swiss academies of arts and sciences, and NGOs.

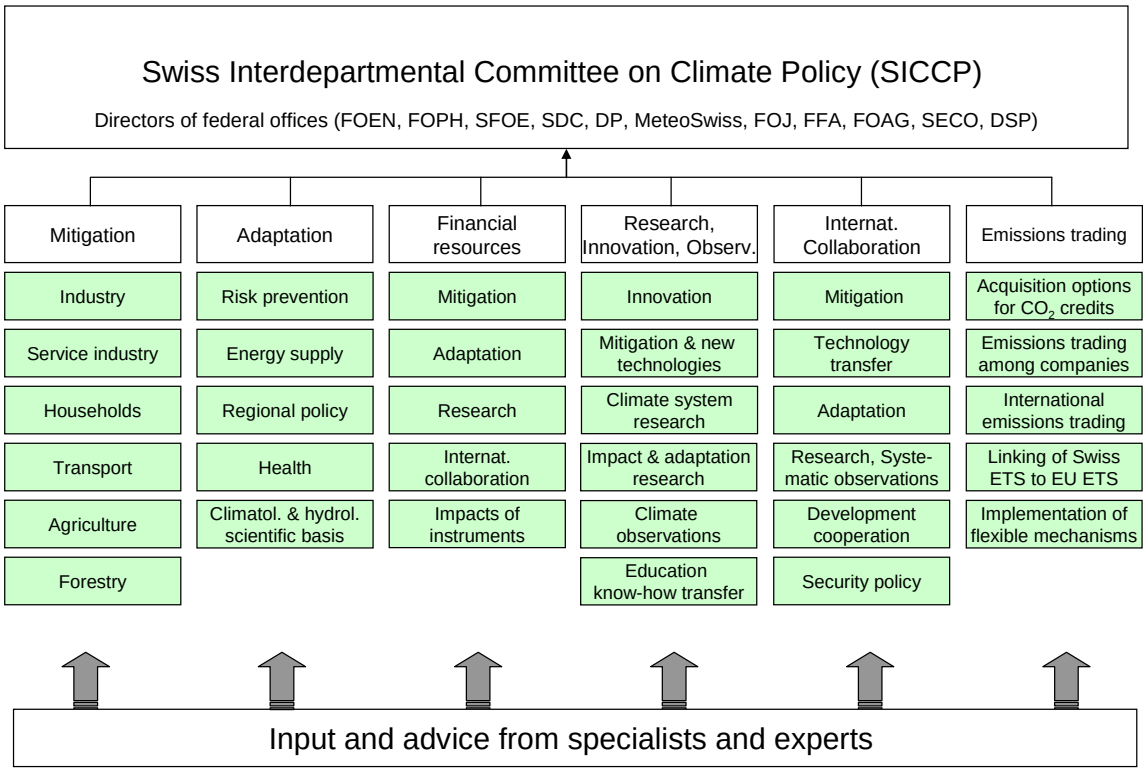
As Switzerland has ratified the Kyoto Protocol, the national greenhouse gas emission target is set to 8% below emissions in 1990 over the period from 2008-2012. In national legislation, Switzerland has translated this reduction commitment into national targets for energy related CO_2 emissions. Within the CO_2 Act, which is a central element of Swiss climate policy, CO_2 emissions from the energy sector are required to decrease by 10% over the period 2008-2012 compared to 1990. This overall objective is split between fossil fuel combustion for heating and process energy, with a reduction target of 15%, and fossil fuel combustion for transport, with a reduction target of 8%. The CO_2 Act allows the use of flexible mechanisms to comply with these reduction targets, as under the Kyoto Protocol.

Implementation of measures to reach the national emission targets are divided between different authorities. In Switzerland, the principle of subsidiarity is deeply ingrained (Swiss Confederation 1999, Art. 3, 5a) and therefore the allocation of tasks to the federal authorities is limited in favour of cantonal or municipal authorities. While the strategic decisions and the overall framework lie within the remit of the federal authorities, the concrete legislation and its implementation remains within the competences of the Cantons (Swiss Confederation 1999, Art. 74). This is reflected in the complex and diverse cantonal and federal legislative frameworks that are relevant to the overall Swiss climate policy. Consequently, also the funding of measures is divided between federal, cantonal and private entities, depending on the individual measures. In some instances, for example, federal funds are allocated to cantonal implementing agencies, provided cantonal funds matching the amount of the federal contribution are also allocated.

[7] Climate change and natural hazards; energy; spatial development and transport; industry and commerce, production, and consumption; natural resources; social cohesion, demography and migration; public health; global development and environmental protection; financial policy; education, research, innovation; culture.

Fig. 72 > Organizational structure of the Swiss Interdepartmental Committee for Climate Policy

The SICCP is chaired by the directors of the relevant federal offices. Its activities are divided into six operational units, each of which pursues its tasks independently from the others. Experts and specialists are invited to sit in the working groups depending on the tasks on the current agenda.



SICCP, Federal Office for the Environment FOEN

The Swiss political system, with its strong public participation process (see section 2.1), thus leads to a wealth of implementing agencies and a complex funding structure. Policies and measures funded (at least partly) by federal funds are subject to evaluation by the Swiss Federal Audit Office; specific incentive programmes are normally evaluated independently during and at the end of the term.

In view of the current economic situation, various short-term measures against a severe downturn have been put in place. Several of them are related to Swiss climate policy. At the federal level, a first stability package was passed in November 2008, within which CHF 66 million are dedicated to flood protection, existing funds of CHF 14 million in the budget for 2009 for improving energy efficiency of buildings are increased by CHF 86 million, and an extra 45 million for energy efficiency measures are given to the Federal Office for Housing. A second package was agreed in February 2009, containing CHF 50 million for specific renewable energy projects (replacement of electric heating systems, district heating and small-scale photovoltaic installations), CHF 10 million for heat pumps, and CHF 50 million for research and development, particularly in the fields of clean technologies and intelligent materials. The third package adopted in June 2009 focused on consumption and the labour market and dedicated CHF 15 million to occupational training of energy experts especially for the buildings and construction sector. All measures aimed at reducing greenhouse gas emissions are scrutinized for their effects on the Swiss economy, their costs and impact on tax revenues. Incentives for investments, start-up funds and provision of tax privileges etc. are normally limited to a couple of year's duration, and thus prone to short-term developments and trends.

4.2 Domestic and regional programmes pursuant to the implementation of the Kyoto Protocol

The principles and instruments of Swiss environmental policy are stipulated in the Federal Act on the Protection of the Environment, adopted in 1985 and revised in 1995 and 2003. This modern legislative framework has been supplemented by the Act on the Reduction of CO_2 Emissions, which was adopted in 1999. These two laws provide the principle basis for the Swiss national policy on climate change.

Both pieces of legislation have a direct bearing on compliance with commitments under the Kyoto Protocol. The CO_2 Act covers about 80% of Switzerland's GHG emissions. The Environmental Protection Act provides for measures to mitigate emissions from waste disposal (CH_4), synthetic gases (HFC, PFC, SF_6) and GHG precursors. Fiscal incentives are recognized as an essential instrument for promoting the efficient use of resources. Energy and climate policy are guided by the vision of the "2000-watt society", which roughly corresponds to per capita emissions of one tonne of CO_2 per year (see section 4.3.4). In the framework of the SICCP, representatives of several ministries under the chairmanship of the Federal Office for the Environment (FOEN) ensure that international developments are followed up at the national level.

Institutional arrangements with regards to flexible mechanisms
The national focal point for the **flexible mechanisms** (designated national authority under the CDM and designated focal point under JI) was established and announced to the UNFCCC in 2004 and 2007 respectively. Activities relating to the implementation of the flexible mechanisms as well as enquiries concerning the mechanisms and the examination and approval of project proposals, are coordinated by the interdepartmental working group of the SICCP assigned for emissions trading. Besides FOEN, the members of this group are drawn from the Swiss Federal Office of Energy (SFOE), the State Secretariat for Economic Affairs (SECO), the Swiss Agency for Development and Co-operation (SDC) and the Federal Department of Foreign Affairs (FDFA). The homepage of the national secretariat for the flexible mechanisms can be found here: *http://www.bafu.admin.ch/emissionshandel/06135/index.html?lang=en*

The use of the flexible mechanisms is governed by rules defined at the international level (UNFCCC, CDM Executive Board, JI Supervisory Committee). The Swiss government does not intend to purchase certificates from CDM/JI projects. The major user of the flexible mechanisms is likely to be the Climate Cent Foundation. Additionally, some activities by entities included in the Swiss emissions trading scheme are expected. In principle, all Swiss natural or legal persons are allowed to participate in the mechanisms. An ordinance concerning the requirements for CDM/JI projects, and the amount of certificates from abroad which can be used for compliance (supplementarity), was adopted by the Federal Council in June 2005.

As of July 2009, the designated national authority has issued 709 letters to CDM projects: 175 letters of approval to Swiss or Swiss-based entities and 534 letters of authorization for participation in already registered projects mainly to foreign entities. The issuance of authorizations to foreign entities is mainly due to the early connection of the Swiss registry to the international transaction log (ITL) of the UNFCCC. In order to be able to transfer CERs from the CDM registry into a national registry, an authorization from the receiving registry is needed. Therefore, many foreign entities willing to deliver early credits opened an account in the Swiss registry and applied for authorizations. For JI-projects, 4 letters of approval have been issued.

4.3 Sectoral and cross-sectoral policies and measures

This section describes policies and measures in the different policy sectors. Some of the policies are developed across sector boundaries. In section 4.3.1, an overview over most recent developments is given, followed by a brief description of the general framework of environmental legislation (4.3.2). The section on climate policy (4.3.3) focuses on the CO_2 Act and the measures directly related to it (CO_2 levy, climate cent, agreements with trade and industry). The following section (4.3.4 Energy) deals with policies and measures related to energy efficiency and renewable energy, while the subsequent section (4.3.5 Transport)

includes aspects of spatial development, transport infrastructure, sustainable modes of transport and emission standards. The remaining sections are concerned with the respective sectors: Industry (4.3.6), agriculture (4.3.7), forestry (4.3.8) and waste (4.3.9).

4.3.1 Most important developments since 2005

The policies and measures presented in the fourth national communication have been upheld and developed over the past years. Some of the planned policies have been implemented in the mean time and make part of the Swiss policy portfolio for compliance with the Kyoto Protocol.

- Introduction of "climate cent" on fuels for transport (0.015CHF/litre) levied by mineral oil importers to fund the Climate Cent Foundation on 1.10.2005
- Second term of SwissEnergy programme 2006-2010 (follow-up to Energy 2000)
- Federal decree on compulsory compensation of all CO_2 emissions from projected combined cycle gas power stations (currently limited until 31.12.2010)
- Introduction of levy on heating fuels on 1.1.2008 at 12CHF/t CO_2, increased to 36CHF/t CO_2 as of 1.1.2010
- Action plan "Energy efficiency" and "Renewable energy" launched by the Federal Council in February 2008
- Addendum to the contract with the Climate Change Foundation to deliver additional CO_2 credits within and outside Switzerland
- Swiss Interdepartmental Committee for Climate Policy SICCP (since April 2008)
- Promotion of natural gas and biofuels via reduced mineral oil tax rates since 1.7.2008 (with the proviso that the biofuel has a favourable ecological balance)
- Parts of CO_2 tax revenues to fund building programme (passed by parliament in June 2009)

4.3.2 Environmental policy

Swiss environmental policy is addressing a wide spectrum of environmental issues within Switzerland, ranging from pollution of air, water and soil, to protecting stratospheric ozone or to reducing and managing waste. Some of these policy areas are linked directly or indirectly to Swiss greenhouse gas emissions.

The Environmental Protection Act is based on three main principles:

- Principle of precaution
- Control of ecological damage at source
- "Polluter pays" principle

The main instruments to implement those principles are the definition of legally binding emission limits, introduction of levies on potentially damaging substances or practices, as well as the obligation of environmental compatibility assessments for particular facilities and installations. The Environmental Protection Act also stipulates that the Confederation and the cantons monitor the state of the environment and its evolution. The latest national report on the state of the environment has been published in June 2009 (FOEN/FSO 2009), documenting mixed results of the national efforts.

Apart from the Environmental Protection Act, there are various other legislative arrangements that are related to environmental issues. The two most relevant laws in the context of climate change mitigation are the CO_2 Act and the Energy Act. But also the Forests Act, the Spatial Planning Act, the Agriculture Act, the Road Traffic Act, and Heavy Vehicle Charge Act have components that contribute to sectoral policies. A detailed description of policies and measures is given in the following sections.

In view of the international dimension of environmental problems, Switzerland seeks to further international efforts to tackle problems on a global level. Environmental issues are an integral part of Swiss foreign policy, and Switzerland is contributing at a political as well as at a technological level to resolving environmental problems in multilateral consortia.

4.3.3 Climate policy

The centrepiece of Swiss climate policy is the **CO_2 Act** that came into force in May 2000. It limits CO_2 emissions from fossil fuel use for heating and transport to 10% below 1990 levels over the period from 2008-2012. The overall target is further divided into a reduction target of 15% on heating and process fuels and 8% on transport fuels. The primary instruments to reach the targets are

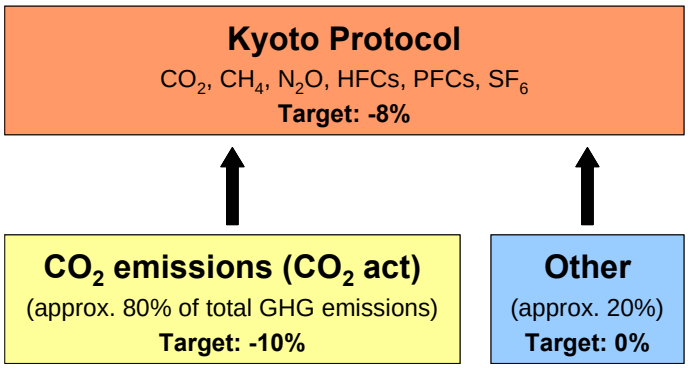
- voluntary actions in various areas
- subsidiary CO_2 levy for heating and process fuels as well as transport fuels
- measures in other policy areas that are relevant to climate change mitigation
- emissions trading (cap and trade) and complementary use of flexible mechanisms

A CO_2 levy is to be introduced if the effect of voluntary measures is insufficient to reach the targets based on projections of emissions. The proceeds from the CO_2 levy are refunded to the Swiss population and businesses. In 2005, the Federal Council proposed a CO_2 levy on heating and process fuels to parliament and accepted the oil importers' initiative to levy a "climate cent" on transport fuels to fund offset projects rather than introducing a CO_2 levy also on transport fuels.

The CO_2 Act complies with the Swiss commitment in the Kyoto Protocol. While the CO_2 Act only covers approximately 80% of the total greenhouse gas emissions as regulated under the Kyoto Protocol, the reduction target of 10% in the CO_2 Act is sufficient to reach the Kyoto target, provided that the other greenhouse gas emissions remain unchanged compared to 1990 (Fig. 73).

Fig. 73 > Comparison of emission reduction targets set out under the Kyoto Protocol and CO_2 Act

The CO_2 Act exclusively limits the emissions of CO_2 from fossil fuel use for transport and heating. The reduction target (-10% compared to 1990) is higher than the target defined by the Kyoto Protocol (-8% compared to 1990) in order to compensate for stable emission levels from other greenhouse gas sources.



The Climate Cent

The revenue from the private sector initiative "climate cent", the price surcharge levied on all petrol and diesel imports at a rate of 1.5 cents per litre since October 2005, is fed into the Climate Cent Foundation. The purpose of the Climate Cent Foundation, the implementing entity for the levy on transport fuels, is to invest those revenues into projects aimed at reducing CO_2 emissions in Switzerland and abroad. Annually, approximately 100 million Swiss francs are available for such mitigation projects. With these funds, the Climate Cent Foundation has to meet the reduction target of twelve million tonnes of CO_2 over the period 2008 to 2012, as agreed with the Federal Department of the Environment, Transport, Energy and Communications (DETEC). Of the total annual reductions of 2.4 million tonnes, at least 0.4 million tonnes need to be offset within Switzerland, either in the transport, the building, or the industrial sector. The remainder of the annual reduction commitment can be met by use of project-based mechanisms as set out in the Kyoto Protocol. The Climate Cent Foundation can either fund mitigation projects abroad and count the resulting emission certificates towards its commitment or buy certificates from third parties to match its annual target. All international credits need to be issued from projects approved by the UN executive board in order to count towards the reduction target.

The CO_2 levy on heating and process fuels

By increasing the price of heating fuels, the CO_2 levy will set an incentive for a more efficient use of fossil fuels, promote investment in energy-efficient technologies and the use of low-carbon or carbon-free energy sources. The schedule for introducing the CO_2 levy and the tax rates were adopted by parliament in March 2007. Depending on the development of the CO_2 emissions from heating fuels in comparison with yearly interim targets, the CO_2 levy is to be increased gradually. It was introduced as of January 2008 at an initial rate of CHF 12 per tonne of CO_2 and left at that level for 2009. However, it will be increased to CHF 36 per tonne CO_2 as per January 2010, because CO_2 emissions from heating fuels in 2008 were above the threshold triggering the increase.

Companies, especially those industries with substantial CO_2 emissions from use of heating fuels, may apply for exemption from the CO_2 levy, provided the company commits to emission reductions. The company has to elaborate an emission reduction target, based on the technological potential and economic viability of various measures within the company. The Energy Agency for the Economy (EnAW) is mandated by the Swiss confederation to identify CO_2 emission reduction and energy efficiency potentials in trade, industry and service companies. In collaboration between the company and the EnAW, an action plan is developed and a reduction target is defined. These are audited by FOEN and SFOE to become legally binding commitments that grant exemption from the CO_2 levy. In case of non-compliance, the company has to pay the CO_2 levy plus any interest retroactively for the entire period since it was granted exemption. Guidelines and ordinances regulate the CO_2 levy and the procedures for exemption.

A company has three options to comply with the agreed emission reduction:

- increasing energy efficiency within the company (as set out by the measures in the action plan)
- buying emission allowances from other companies that are exempt from the CO_2 levy and that have achieved larger reductions than agreed in their reduction target
- buying emission credits from international mitigation projects (e.g. CERs) up to 8% of the company's emissions

While the proceeds from the CO_2 levy were initially to be fully and equally refunded to the Swiss population and to the business community in proportion of wages paid, a parliamentary decision of June 2009 earmarked a third (up to CHF 200 million per year) of the revenues from the CO_2 levy to CO_2 relevant measures in the building sector (refurbishment of buildings, upgrade of heating systems, and use of renewable energies) from 2010 (see also section 4.3.4 below).

Partial revisions of the CO_2 Act

Three partial revisions of the current CO_2 Act, which should be implemented before the end of the commitment period of the Kyoto Protocol, are currently under way:

Building refurbishment programme

In order to increase the energy efficiency of buildings and to promote the use of renewable energies in the building sector, CHF 200 million of the revenues from the CO_2 levy on heating fuels have been earmarked for this purpose. The new building programme will supersede the building programme that was run in the framework of SwissEnergy and will benefit from a much larger financial input from the revenues of the CO_2 levy. It has been adopted by parliament in June 2009 and will become operational on 1.1.2010. Its duration is limited to ten years, however, a mid-term evaluation must demonstrate its effectiveness to release the second five-year period. The funds for the building refurbishment programme are split between two sub-programmes: Two thirds are dedicated to refurbishing existing buildings, and up to one third is used to subsidize renewable heating systems, use of waste heat, and services engineering. The entire programme is estimated to result in a cumulative reduction of 2.2 Mt CO_2 by 2020.

Regulations for combined cycle power plants

According to a federal decree that came into force in January 2008, planned combined cycle power plants only obtain planning permission if their CO_2 emissions are fully compensated. The compensation should be achieved domestically to at least 70%, with supplementary use of emission certificates. If an electricity shortage is imminent, the share of domestic compensation can be reduced to 50%. The federal decree is limited until the end of 2010, however, current parliamentary discussion is ongoing to arrange for follow-up legislation until the end of the commitment period.

Regulations for CO_2 emission levels for the new passenger car fleet

At the moment, no binding limits for CO_2 emission levels of new passenger cars exist. The effect of a voluntary agreement between the Swiss automobile importers and DETEC was insufficient. Therefore, triggered by a parliamentary motion, regulations limiting the CO_2 emission levels for the new car fleet have been drafted. In accordance with the EU regulations decreed in December 2008, average emission levels of the new car fleet should be gradually reduced. The current proposal that went into public consultation aimed at 130g CO_2/km by 2015. It is also considered as counter-proposal to the popular initiative "for humane vehicles", that request a ban on vehicles that are particularly dangerous (i.e. off-road type) or cause disproportionately high emissions of CO_2 or particulate matter.

Total revision of the CO_2 Act

Within the CO_2 Act of May 2000, the Federal Council is obliged to propose further reduction targets for the time after 2012. The legislative process to start shaping the future of the Swiss climate policy was initiated by a popular initiative „for a sound climate", which requests domestic emission reductions of at least 30% below 1990 by 2020, mainly by promoting energy efficiency measures and renewable energy. Following public consultation, the Federal Council has put forward a draft CO_2 legislation for parliamentary discussion in August 2009 as a counter-proposal to the popular initiative. The total revision of the CO_2 Act is subject to parliamentary discussion and planned to come into force in January 2013, superseding the current CO_2 Act which is limited to the commitment period of the Kyoto Protocol.

The proposed total revision of the CO_2 Act includes the amendments made within the three partial revisions of the CO_2 Act. The main contents of the proposal for the total revision of the CO_2 Act are listed below:

- reduction of emissions by 20% below 1990 in 2020 (possibly 30%, depending on other nations' commitments)
- continuation of CO_2 levy on heating fuels

- intensified efforts to promote energy efficiency and renewable energies in the building sector by earmarking up to CHF 200 million of the revenues from the CO_2 levy on heating fuels
- introduction of CO_2 emission limits for new cars, compatible with EU regulations; obligation to offset parts of the CO_2 emissions from the transport sector by domestic or international projects; option to introduce a CO_2 levy on transport fuels if other measures in the transport sector prove insufficient
- full compensation of emissions from gas fired combined cycle power plants
- enlargement of national emissions trading scheme with a view to link it to the EU scheme
- national coordination of adaptation measures in Switzerland

Obviously, parliamentary discussion may modify the proposed policy outline. Whether the popular initiative "for a sound climate" or the policy proposal from parliament will pass the referendum remains open.

Tab. 20 > Summary of climate policies and measures

Name of policy or measure	Objective and/or activity affected	GHG affected	Type of instrument	Status	Implementing entity or entities	Estimate of mitigation impact, by gas (for a particular year, not cumulative, in 1'000 Gg CO_2 eq)					
						1995	2000	2005	2010	2015	2020
CO_2 Act	-10% CO_2 by 2010	CO_2	legislation	implemented, in force since 1.5.2000	FOEN	[a]	[a]	[a]	[a]	[a]	[a]
Negotiated agreements with trade & industry	Emission reductions to obtain exemption from CO_2 levy	CO_2	negotiated	implemented, in force since 1.1.2008	Developed with EnAW; Audited by FOEN/SFOE	n.a.	n.a.	n.a.	0.38-0.50	0.45-0.60	0.45-0.60
Emission trading (cap and trade)	Flexibility to comply with negotiated agreements	CO_2	market based	implemented, in force since 1.1.2008	FOEN	n.a.	n.a.	n.a.	n.e.	n.e.	n.e.
CO_2 levy	12CHF/tCO_2 on fossil combustibles	CO_2	fiscal	implemented, levied since 1.1.2008	FOEN	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
CO_2 levy	36CHF/tCO_2 on fossil combustibles for 2010-2012[b]	CO_2	fiscal	adopted, levied 2010-2012, planned for 2013-2020	FOEN	n.a.	n.a.	n.a.	0.7	0.9	1.1
National building refurbishment programme	refurbishment of existing buildings	CO_2	financial (subsidized via CO_2-levy)	adopted for 2010-2012, planned for 2013-2020	FOEN/SFOE	n.a.	n.a.	n.a.	0.1	0.4	0.7
Climate cent	0.015CHF/litre diesel or petrol	CO_2	financial	implemented	Climate cent foundation	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.
Climate cent	Additional mitigation projects within Switzerland	CO_2	negotiated	implemented	Climate cent foundation	n.a.	n.a.	n.a.	0.2	0.1	0.1
Flexible mechanisms according to Kyoto Protocol	Emission reduction certificates to comply with negotiated agreements	CO_2	negotiated	implemented	Climate cent foundation, EnAW	n.a.	n.a.	n.a.	2.0	[c]	[c]

a: The CO_2 Act is the legal framework for various measures. Its overall mitigation target is -10%, however, where possible, the mitigation impact is listed under the individual measures.
b: The rate of 36 CHF/t CO_2 is fixed for 2010-2012. For 2013-2020 it is assumed that either the oil price will increase or the CO_2 levy will be increased.
c: Operation of climate cent is limited to 2012.
i.e.: included elsewhere.
n.a.: not applicable
n.e.: not estimated

4.3.4 Energy policy

Legal framework
Energy policy was only anchored in the Swiss federal constitution in 1990, when an energy article was added. It stipulates that the federal government and the cantons are obliged to use their competences to ensure an adequate, broad-based, secure, economical and ecological energy supply, and the economical and efficient use of energy. This comprehensive list of requirements places high demands on energy policy at the federal and cantonal levels, and simultaneously demonstrates how difficult it is to find suitable solutions that meet the given criteria.

The energy article in the federal constitution is elaborated further in the Energy Act, the Nuclear Energy Act and the Electricity Supply Act, which form the legal basis for a sustainable and modern energy policy. In addition to legal instruments, the energy policies of the federal government and the cantons are also based on energy perspectives (see "Energy outlook", section 5.1.1) as well as on strategies, implementation programmes and the evaluation of energy-related measures at the municipal, cantonal and federal level.

Although Switzerland has pursued a consistent energy policy since 1990 with its Energy2000 and SwissEnergy programmes, it is still a long way from achieving the goal of securing a sustainable energy supply. To achieve the declared objectives requires a sustained effort with a comprehensive policy mix, which involves voluntary agreements with trade and industry, financial incentives, and regulations regarding energy efficiency of appliances, motor vehicles and buildings.

Review of the Swiss energy policy by the International Energy Agency
In 2007, the International Energy Agency IEA (IEA 2007) carried out an in-depth review of the Swiss energy policy and recommended Switzerland to:

- pay due attention to the requirements of building new energy infrastructure, such as shortening regulatory processes, securing supply contracts and rationalising GHG requirements, in addition to energy efficiency measures;
- advance the electricity market and cross-border trade in accordance with market-based principles within the framework and spirit of an internal electricity market in Europe;
- prepare a comprehensive strategy on energy relations with the European Union and continue work to make policies compatible with the EU and neighbouring countries;
- continue efforts to harmonise cantonal energy and environmental policies to the greatest extent possible;
- ensure the continuation of the SwissEnergy programme after 2010 and clarify its interaction with the forthcoming instruments such as the grid levy and the CO_2 tax; adopt regulation whenever voluntary approaches do not deliver sufficient results;
- rationalise taxes across the energy sector, taking due account of externalities.

Policies and measures in the energy sector
The policies and measures in the energy sector are addressing three priority areas: the building sector, the transport sector and the regulatory framework concerning renewable energy (in particular electricity). Policies and measures are allocated to various interlinked programmes and frameworks, both at federal and cantonal level. The major programmes, their measures and their effects are described in more detail below.

The SwissEnergy programme: Efforts to curb growing energy consumption and to promote renewable energy have been sustained and increased since 1990, when the national programme "Energy2000" was launched in the wake of the introduction of the energy article in the federal constitution. In 2001, the Federal Council launched the successor programme "SwissEnergy", in line with the Energy Act and the CO_2 Act that came into force in 1999 and 2000 respectively. Running from 2001 to 2010 and managed by the SFOE, it represents the main policy instrument aimed at increasing energy efficiency and use of renewable energy in order to reduce CO_2 emissions and the dependence on fossil fuels. It works mainly on the basis of

information campaigns aimed at the general public and specific target groups (e.g. home-owners), and voluntary agreements with trade and industry.

The programme consists of a wide array of projects, most of them voluntary. The projects are normally run in close cooperation between the SFOE, cantons, municipalities, industry and environmental and consumer associations. Initially, the SwissEnergy programme had four general priority areas. Three focused on end-use efficiency and one on renewables. The programme was reviewed in 2005, and its priorities were shifted more strongly towards energy efficiency. By 2010, SwissEnergy aims at

- reducing fossil fuel consumption by 10% compared to 2000
- limiting the increase in electricity consumption to 5% compared to 2000
- promoting the use of hydropower, in particular from small hydropower plants
- increasing the percentage of electricity from renewable sources by 1%
- increasing the percentage of heat from renewable sources by 3%

Programme results are subject to detailed monitoring and evaluation. In 2006, the programme funds provided by the SFOE amounted to CHF 42 million, supplemented by even larger amounts of co-funding from associations and cantons. According to the impact analysis of SwissEnergy (Infras 2009), SwissEnergy contributes substantially towards the goals of Switzerland's climate and energy policies. Without SwissEnergy, CO_2 emissions would be approximately 1.7 million tonnes higher than the present-day level Thanks to SwissEnergy, energy efficiency has been significantly improved and the proportion of renewable energy has been greatly increased. This programme has become a major driving force behind innovation in Switzerland's economy.

Regulations in the electricity market: The federal Electricity Supply Act provides the regulatory framework for a reliable and sustainable electricity supply. It calls for an opening of the market in two stages: in the first five years, end-consumers with an annual consumption of more than 100 MWh have free access to the market. After five years, all end-consumers can freely choose their electricity supplier, though it should be noted that the full liberalisation of the market is subject to an optional referendum. The high-tension transmission network (220/380 kV) has to be operated by a national network operator with Swiss majority ownership. For this purpose, electricity companies have already established Swissgrid, a public limited company entrusted with the operation of the Swiss high-voltage grid. Ownership of the high-voltage transmission networks has to be transferred to this network operator within five years after the act entered into force on 1.1.2008.

With the revision of the federal Energy Act (in force since 1.1.2008) the federal Electricity Supply Act also contains a set of regulations governing the promotion of renewable energy (in particular hydropower) and the introduction of measures to promote efficient electricity use. The most important measure concerns the cost-effective remuneration of feeding in renewable energy (feed in tariff). Since January 2009, electricity produced from new power plants and installations that use renewable energy (hydropower plants up to 10 MW) will be paid at a rate specified on the basis of a reference facility rather than electricity market prices. An annual sum of around CHF 320 million is earmarked, currently drawn from a fee of 0.45 cents per kWh and charged by the transmission system operator. The cost ceiling had been reached within months after the launch of the programme, and many projects have been waitlisted. The projects have to become operative within a few years of approval, otherwise they loose the support. A debate on increasing the cost ceiling is ongoing. (*http://www.bfe.admin.ch/energie/00588/00589/00644/index.html?lang=en&msg-id=25142*).

Energy policy in the cantons and municipalities: The Swiss constitution allows for large cantonal independence in most areas of legislation. Therefore, federal authorities need to collaborate closely with cantonal partners in order to implement the national policies. In the context of the Swiss energy policy, the SwissEnergy programme builds on the co-operation between the national and cantonal authorities. This is most evident in the fact that cantons that wish to benefit from SwissEnergy funds need to contribute equally out of their budgets.

In the building sector, cantonal energy legislation is currently being harmonised, with a common basis for cantonal regulations and guidelines (MuKEn): By 2007, 23 cantons had adopted the basic MuKEn module, which regulates building standards, into their energy legislation. In April 2008, the conference of the cantonal energy directors adopted the new building codes (SIA 380/1 2007) in the MuKEn. These regulations limit the energy use required per square meter and year to 4.8 litres of heating oil equivalents for new buildings, and approximately 9 litres of heating oil equivalents for fully refurbished buildings. With this new regulation, the building codes are approaching the values of the Minergie® label (1997). This new regulation is currently in the process of being adopted. In most cantons, it will enter into force by 1.1.2010.

The cantons are also seeking joint measures for a sustainable energy supply, energy planning and energy-efficient mobility. However, most cantons lack the necessary legal basis to implement measures in the areas of electricity (SIA standard 380/4, use of energy-efficient appliances, energy label, etc.), transport (motor vehicle tax based on fuel consumption), and internalisation of external costs (energy price surcharges for cantonal projects).

The third main pillar of cantonal energy policy (alongside legal and voluntary measures) seeks to enhance energy efficiency, the use of waste heat and renewable energies. However, exploiting the potentials associated with the modernisation of buildings and the use of renewable energy require additional incentives. In total, the cantons dedicate around 58.1 million Swiss francs (including 13.3 million Swiss francs in global federal subsidies and funds brought forward from last year) to direct and indirect promotional measures. The legal and financial (budget) prerequisites for a cantonal promotion programme currently exist in 22 cantons.

Action plans for energy efficiency and renewable energies: In February 2007, the Federal Council decided to focus its energy policy on four main areas: energy efficiency, renewable energy, management of large-scale power plants (existing and new), and foreign policy in the energy sector (*http://www.bfe.admin.ch/energie/00588/00589/00644/index.html?lang=de&msg-id=10925*). In order to implement this strategy, the Federal Department of the Environment, Transport, Energy and Communications (DETEC) prepared action plans to enhance energy efficiency and the use of renewable energies, which the Federal Council approved on 20.2.2008 (*http://www.bfe.admin.ch/themen/00526/02577/index.html?lang=en*).

These action plans set out to reduce the consumption of fossil fuels by 20% by 2020 in line with the declared objectives of Swiss climate policy, to increase the share of renewable energy by 50% to approx. 24% of total energy consumption by 2020, and to limit the increase in electricity consumption to a maximum of 5% between 2010 and 2020. From 2020 onwards, the objective is to stabilise electricity consumption.

The action plans comprise a carefully balanced package of measures that complement and supplement one another. The package combines incentives (e.g. a bonus/penalty scheme for vehicle tax on new cars), direct promotional measures (e.g. a national programme to promote the renovation of buildings), and regulations and minimum standards (e.g. introduction of a ban on conventional light bulbs in 2012). The action plans include measures for which either the federal government, parliament or the cantons are responsible. Measures for which the federal government itself is not directly responsible are implemented in close collaboration with the relevant partners. For example, the federal government supports efforts by cantons to introduce consumption-based cantonal motor vehicle taxes, and is working closely with the cantons to develop the existing energy label into an effective eco-label, which is to provide the cantons with the basis for a uniform solution.

The action plan for increasing *energy efficiency* encompasses 15 measures in the areas of buildings, mobility, appliances, training and further education, research and technology transfer (SFOE 2008d). A major contribution to increase energy efficiency and the use of renewable energies in buildings is the earmarking of up to CHF 200 million from the CO_2 levy (see p.97).

The action plan for promoting *renewable energy* encompasses 7 measures in the areas of heat production for buildings from renewable energy, a strategy for producing energy from biomass, measures to promote hydropower, research, technology transfer and training and further education (SFOE 2008e).

Short-term measures in view of the economic downturn: The current economic situation gave rise to a series of short-term measures, aimed at supporting the Swiss economy. Among the various actions, several are directly or indirectly CO_2 relevant. All measures are designed to generate quick wins in 2009 or 2010 and third-party investments beneficial for local industry and trades.
http://www.seco.admin.ch/aktuell/00277/01164/01980/index.html?lang=de&msg-id=27480)

Substantial funds are dedicated to improving energy efficiency and the use of renewable energy in the housing sector by increasing the financial resources of existing programmes:

- CHF 30 million investment aid for district heating systems based on waste heat or renewable sources. These funds are expected to subsidise 20% of investment costs of DH systems, triggering some CHF 150 million of third-party investment. The measure runs in parallel with current legislative efforts to introduce a feed-in tariff for DH from renewable sources, as outlined in the Renewable Energy Action Plan of February 2008.
- CHF 10 million for a programme to replace electric heating systems by heat pumps, wood or solar heating systems. Beneficiaries will be single- or dual-family dwellings (holiday homes are excluded), which will receive up to 20% (CHF 8,000 on average) of systems replacement costs. These monies are expected to trigger some CHF 50 million of private investment. The measure should help kick-start a programme foreseen in the Federal Council's February 2008 Renewable Energy Action Plan aimed at phasing out some 230,000 electric heating systems, which were installed in the 1970s and 80s and which account for 3 TWh (or 5%) of electricity demand. Current replacement rates are very slow (0.6% p.a.).
- CHF 20 million for solar PV systems. These funds will be allocated to waitlisted PV projects, which did not qualify for feed-in tariffs in the 2008 application round. Legislation caps feed-in tariffs for PV at 5% of total feed-in tariffs, to prevent costly technologies from draining a disproportionate share of funds and jeopardizing overall renewable targets. Because of this cap, some 3000 mostly small (5-6 kW) PV project applications had to be waitlisted. Some 500 to 600 projects will now receive CHF 3500/kW, equivalent to about 30% of investment costs. Recipients will forgo feed-in tariffs for a period equivalent to the disbursed investment aid.
- When approving the 2009 budget for the regular "SwissEnergy" programme, parliament increased subsidies for buildings refurbishment from CHF 14 million to CHF 100 million. Of those 100 million, CHF 18 million will be allocated to a consulting programme, including energy check-ups and the issuance of energy certificates for buildings; CHF 2 million will be seed money for launching a ten-year national building refurbishment programme to be launched in 2010 (see p.97), in line with the Energy Efficiency Action Plan, and CHF 80 million will be disbursed for cantonal programmes in 2009, since buildings fall within the legal remit of cantons. In order to qualify for these funds, cantons must provide matching funds.
- CHF 45 million for energy refurbishment of non-profit housing developments. *http://www.news-service.admin.ch/NSBSubscriber/message/de/25010*
- CHF 15 million for training and further education in the energy sector.

Tab. 21 > Summary of policies and measures in the energy sector

Name of policy or measure	Objective and/or activity affected	GHG affected	Type of instrument	Status	Implementing entity or entities	Estimate of mitigation impact, by gas (for a particular year, not cumulative, in 1'000 Gg CO_2 eq)					
						1995	2000	2005	2010	2015	2020
Voluntary agreements with trade & industry	emission reductions to comply with CO_2 and Energy Act	CO_2	voluntary	implemented	SFOE	n.a.	n.a.	0.10-0.14	superseded by negotiated agreements with trade and industry, see Tab. 20		
Programme Swiss Energy; actions plans for renewable energies and energy efficiency	sector specific targets	CO_2	various	implemented	SFOE	n.a.	n.a.	0.39-0.48	0.55-0.82	0.45-0.75	0.45-0.75
National building refurbishment programme	renewables, waste heat, services engineering	CO_2	financial (subsidized via CO_2 levy)	adopted for 2010-2012, planned for 2013-2020	SFOE, FOEN, Cantons	n.a.	n.a.	n.a.	0.14	0.8	1.5
Cantonal building programme	supplementary to national programme	CO_2	financial	implemented	Cantons / SFOE	n.a.	0	0.06-0.11	0.17-0.29	0.17-0.29	0.17-0.29
Building codes with the Cantons	energy consumption of buildings	CO_2	legislation	ongoing process of implementation by the Cantons	Cantons in coordination with SFOE	0.24-0.32	0.5-0.66	0.74-1.05	0.62-1.11	0.77-1.43	1.33-2.17
Feed in tariff for renewable electricity	5.4 TWh until 2030	none	financial	implemented	SFOE	0	0	0	0	0	0

4.3.5 Transport policy

General policy context

Switzerland has developed an integrated strategy for transport policy, seeking better coordination between transport modes and taking into account environmental concerns. This strategy has been strengthened in recent years with a broader integration of transport policy into spatial development and the general sustainability context. The main thrust of the resulting policies lies in promoting a shift towards more sustainable modes of transport, planning and providing infrastructure that supports such a shift, and by passing legislation that reduces emissions and promotes low-emission technologies in the various transport sectors. While a variety of measures are designed to reduce specific energy consumption, many are part of the general transport policy approach that involves reducing unnecessary motorized mobility, shifting traffic from roads to more environmentally friendly modes, and improving intermodal transport chains and interconnectivity.

Passenger transport

The latest projections (ARE 2004a, ARE 2006) for passenger (and freight) transport still show significant growth rates for the coming decades. Sustainable management of this growth represents a major challenge. Spatial development and infrastructure planning are the key factors influencing future emissions from the transport sector. The coordination of spatial planning and transport infrastructure development by concentrating population and transport growth in areas where non-motorized and public transport offer comparative advantages is a viable option to curb transport growth and urban sprawl. Switzerland has therefore

adjusted its spatial planning tools, with the development of agglomeration programmes (see below). At the same time, the approach of internalization of external costs in road passenger transport is currently being evaluated. New road pricing approaches are to be fleshed out and debated in public.

Switzerland has an excellent **rail infrastructure** that is permanently maintained, modernized and improved. The first phase of a major expansion of rail transport capacity RAIL 2000 was opened on 12.12.2004. It marked a milestone for Swiss public transport, as rail service levels increased by 12% from one day to the next (more trains, faster connections between Swiss cities). In particular, travel time between Zürich and Bern has been reduced by 20%. This leap in performance has increased the attractiveness of public transport and is expected to consolidate the strong position of rail transport in Switzerland. At the same time, work is progressing on the New Rail Link trough the Alps (NRLA). Although the difficult alpine geology has posed major challenges for the construction work, the first tunnel (Lötschberg) opened in 2008. The commissioning of the tunnel increased the capacity and attractiveness for both transalpine freight and passenger transport from Switzerland and northern Europe to Italy. The new St Gotthard link is expected to open in 2017. By improving connections to the European high-speed rail network, Swiss transport policy encourages the transfer of short-distance international traffic from air to rail. Efforts are being made to shorten overall travel times between Switzerland and the cities of Munich, Stuttgart, Paris and Lyon. Although there are severe budgetary constraints, the financing of the major rail infrastructure projects is secured on the basis of the 'FinÖV', a public transport fund, which draws revenues from the heavy vehicle fee (HVF, p.106) for rail infrastructure projects. The parliament has instructed the Federal Council in spring 2009 to start planning for a next step of modernization of the rail infrastructure, RAIL 2030.

Funding for development and maintenance of road infrastructure is provided through the **infrastructure fund**, which was launched in 2008. Over 20 years, it will provide CHF 20.8 billion in the following four areas:

- Completing the national motorway network: CHF 8.5 billion
- Eliminating congestion hotspots in the existing motorway network: CHF 5.5 billion
- Infrastructure for public and private transport in the agglomerations: CHF 6 billion, of which 2.56 billion will be devoted to urgent projects and 3.44 billion to agglomeration programmes
- Maintenance of main roads in mountain and peripheral regions: CHF 0.8 billion

Out of this fund, Switzerland runs an **agglomeration programme** aimed at providing financial resources for infrastructure projects that promote public and non-motorized transport in suburban regions and agglomerations. So far, 30 agglomeration programmes with integrated transport schemes have been submitted to the federal office of spatial development (ARE) for approval. These programmes include 37 agglomerations, covering 90% of agglomeration population or two thirds of the Swiss population. Further 13 programmes have been announced. Resources are allocated to projects leading to an efficient and sustainable transport system in cities and agglomerations. Priority is given to those projects where largest benefits are expected. Resources are to be released to the projects ready for implementation in 2011.

In order to enhance coordination between transport and spatial development, the federal authorities are developing a transport plan, including a strategy for infrastructure policy and the main road and rail infrastructure projects (Infras/Ecoplan 2006):

- Optimal capacity management of existing infrastructure, with the emphasis on sustainable spatial development – consolidating agglomerations and improving connectivity between Swiss cities and the European high-speed rail network. Top priority is assigned to improvements of the rail network.
- Regional priorities, particularly capacity problems in urban areas. There is a strong link to the agglomeration programmes.

- Improvement of the road network as part of the infrastructure fund in areas of high traffic density where road capacity is critical and the risk of congestion is rising
- Further extension of the rail network RAIL 2030, oriented towards increased capacity and improving critical links and nodes.
- Financing of future investments is only partly secured: on the basis of the national "FinÖV" system, funds for the transalpine rail tunnel (St Gotthard) and parts of the railway network expansion are allocated. Financing for programmes reducing bottlenecks on the road and on the rail will require additional specific taxes. The possibility of the internalization of external costs, for example via road pricing, may be considered.

Switzerland has developed further **programmes** aimed at specific parts of the transport sector:

- Leisure transport programme: The strategy paper highlights a very dynamic transport segment and proposes several measures to reduce motorized leisure transport, involving various stakeholders, especially sports event managers and tourism agencies (Swiss Federal Council 2009).
- Non-motorized transport: A similar strategy included in other programmes proposes several measures (including financial mechanisms) for increasing the share of non-motorized transport.
- Traffic telematics programme: This federal programme aims to optimize traffic flows and capacity by improving information systems and traffic management in congested areas, thereby enhancing road use efficiency and postponing infrastructure expansion projects (FEDRO 2005).
- Service centre for innovative mobility: Operated by the federal offices for spatial development (ARE), environment (FOEN) and energy (SFOE), the centre supports new, innovative mobility projects and represents a common point of contact for all interested parties. The activities of the service centre focus on the interfaces of the different transport modes and aim at improving performance and sustainability of the whole transport system. The service centre is operated as a pilot experiment. For the promotion of innovative projects a total of slightly more than CHF 1 million is available. In the first three calls the support of 18 projects was decided, of which 15 were implemented. In another 5 projects, which were delivered on the occasion of the recently ended fourth tendering round, the implementation will start by 2010.
  (*http://www.are.admin.ch/dienstleistungen/00908/index.html?lang=de*)

Emission standards: Switzerland is following the European path of reducing air pollutants by introducing stricter Euro emission standards for new vehicles. For passenger cars, the Euro 4 standard has been in force since 2006; Euro 5 since September 2009 and Euro 6 will be in force as of September 2014. With regard to reducing particulate matter (PM) and diesel soot emissions, particle filter trap systems have been introduced or are under discussion for various types of vehicles (city buses, construction machinery, etc.). The active promotion of filter systems is envisaged, e.g. via fiscal incentives for purchasing new or retrofitting old engines (on import taxes or at the cantonal level on yearly taxes).

Energy-saving programmes: In 2002, the association of Swiss automobile importers signed an agreement with DETEC to reduce the specific fuel consumption of the newly released motor car fleet by 24% between 2000 and 2008. SwissEnergy supported this effort by establishing a compulsory energy label for new motor vehicles in 2003, and by launching a special campaign raising public awareness. The average fuel consumption of new cars was 15.2% below 2000 levels in 2008. Because the target of the agreement was not reached, the Federal Council currently plans to amend the CO_2 Act and limit CO_2 emission levels for the new car fleet (see also p.97) according to EU regulations decreed in December 2008, which stipulates a target of 130g CO_2/km by 2015.

Environment label for new motor vehicles: In 2007, the Federal Department of Environment, Transport, Energy and Communications (DETEC) decided to further develop the energy label, which evaluates the energy efficiency of motor vehicles according to the categories A to G. Today's energy label should become a more comprehensive environment label in 2010, taking additional factors into account. In addition to the classification in categories according to their energy-efficiency, the new label will also consider ecological criteria (such as air pollution and noise). Under these schemes, a system of bonuses/penalties on new cars can be implemented. A bonus would reward consumers who purchase "green", fuel-efficient cars, with bonus payments to be financed by an increase in vehicle tax (i.e. in a revenue-neutral manner).

Measures at cantonal and communal level: The cantons are in charge of the implementation of the Ordinance on Air Pollution Control. Within the transport sector, the most important measures include speed reduction in city areas, parking space management and programmes for renewing bus fleets (fitting of CRT particle filters). Some of the cantons apply a weight-dependent motor vehicle tax, which provides an incentive to buy and use cars that are more fuel efficient. For example, the canton of Lucerne has a motor vehicle tax system that scales according to EURO emission standards, with rebates for fuel-efficient cars, since 1996.

Voluntary agreement on the use of biogas in the transport sector: In the year 2003 an agreement between biogas producers and gas distributors regulating the purchase of biogas was reached. Biogas is injected into the natural gas grid and marketed as motor fuel in pure or mixed form. Under this agreement, the biogas purchased by gas distributors is to account for at least 10% of all gas sold as motor fuel.

Mineral oil tax reduction on biofuels and natural gas: The amendment of the Mineral Oil Tax Act that came into force on 1.7.2008 provides tax incentives for low carbon fuels. A budget neutral tax reduction of 40 Swiss cents per litre of petrol equivalent for natural and liquefied petroleum gas (LPG) and complete tax exemption for biogas and other fuels from renewable sources are granted to biofuels fulfilling ecological and social criteria. Revenue losses are compensated by increasing tax rates on petrol. The required ecological criteria for tax exemption are: a minimum of 40% GHG reduction based on LCA; a net environmental burden not significantly exceeding the one of fossil fuels; the cultivation of biofuels must not endanger biodiversity, in particular rainforests. In contrast to other countries, Switzerland has no quotas for biofuels.

International context: In 2005, Switzerland ratified the Gothenburg Protocol to abate acidification, eutrophication and ground-level ozone. The implementation of this protocol and compliance with the prescribed national emission ceilings contributes to the reduction of ozone and secondary particulate precursors. It also contributes to avoiding GHG emissions from gases not regulated under the Kyoto Protocol.

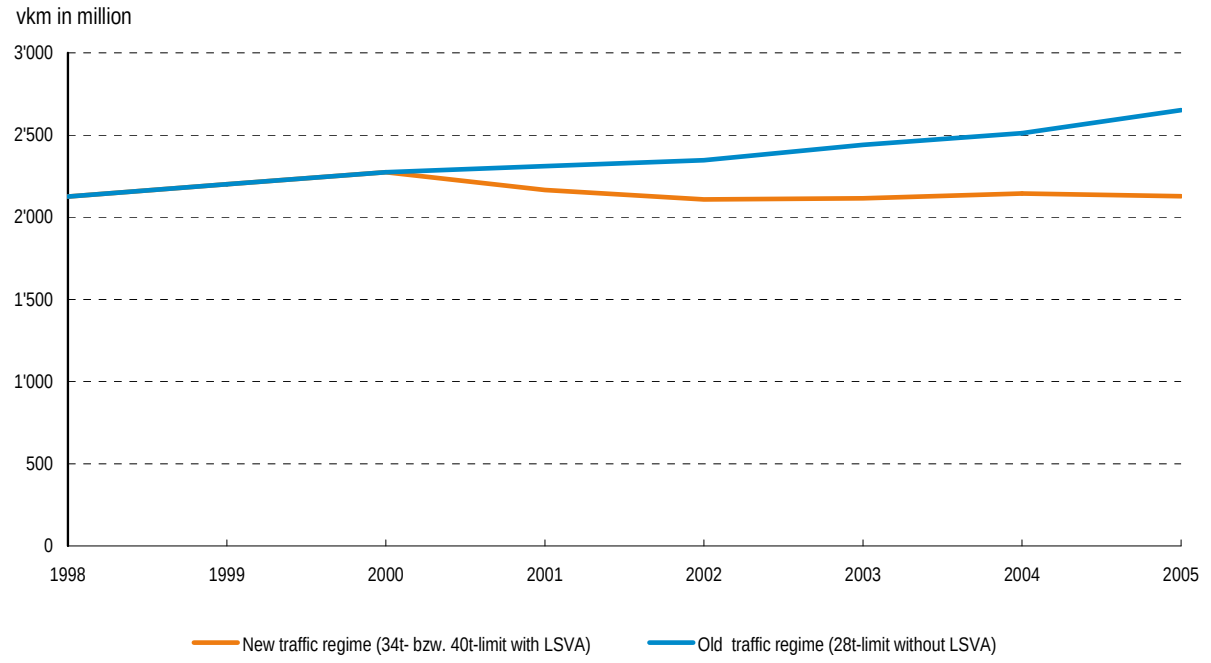
Freight / heavy goods transport

Switzerland's freight transport policy bases on article 84 of the federal constitution, which requires transalpine freight transport to shift from road to rail. The central policy element to reach this target is the heavy vehicle fee (HVF) combined with measures to improve competitiveness of international rail transport. The original goal was to limit transalpine road transport volume to 650`000 lorries per year by 2009. Although various measures have been implemented showing initial effects, the target will not be reached by 2009.

Heavy vehicle fee: The HVF is applied to passenger and freight transport vehicles of more than 3.5 tonnes gross weight. The fee is calculated according to three criteria: the kilometres travelled on Swiss roads, the vehicle specific maximum authorized gross weight, and the pollutants according to EURO classes. The HVF has been implemented in three stages: the first stage in 2001 introduced a fee of 1.6 Swiss cents per kilometre and tonne, accompanied by an increase in the general Swiss weight limit from 28 to 34 tonnes per truck. With the second stage in 2005, the rate was increased to 2.5 Swiss cents (average), together with an increase in the weight limit up to 40 tonnes. The final stage followed in 2008, after the opening of the Lötschberg railway base tunnel. Two thirds of the revenues are used to finance major railway infrastructure projects (such as the two base tunnels), and one third is transferred to the cantons.

Fig. 74 > Impacts of the new traffic regime

Development of vehicule kilometers (vkm) in the road freight transport in old and new transport regime



ARE (2008)

Evaluation of the heavy vehicle fee: Lower traffic levels, less air pollution, reduced GHG emissions: The impact of the new traffic regime (HVF and higher weight limits) was most clearly reflected by changes in traffic levels (truck-kilometres). Following a significant increase of 5–6% per year before the introduction of the fee, the number of kilometres travelled by heavy goods traffic (kilometre performance) decreased between 2001 and 2005 by 6.4% (Fig. 74). The fact that road transportation of goods increased in the same period by 6.4% proofs the effectiveness of the system: fewer trucks have transported more goods. Projections have shown that the number of kilometres travelled by heavy goods traffic would have been about 23% higher in 2005 if the old regulations had been retained.

The fact that the level of the fee depends on the maximum weight and emission standards of the individual lorry already prompted a significant renewal of the fleet in the year before the HVF was introduced. The reduction in emissions per vehicle combined with lower traffic levels lowered pollutants from heavy traffic (estimated based on model calculations). Reduced road freight transport emissions due to the new regime measured against increased rail transport results in a positive overall environmental balance, in particular with regard to air pollution. Air quality has improved by 10% (particle emissions) and 14% (nitrogen oxides) respectively, and CO_2 emissions have decreased by 6% (corresponding to 105'000 tonnes of CO_2 or 325 GWh) compared to the reference scenario (28t limit, no HVF).

Switzerland is following the European path of reducing air pollutants by introducing stricter **Euro emission standards for new vehicles**. For heavy goods vehicles, the Euro 5 standard has been in force since 2008; Euro 6 will be in force in 2013.

Additional measures to support modal shift of freight traffic from road to rail:
In addition to the HVF, the modal shift policy includes the following elements to promote public transport:

- Modernisation of rail infrastructure by 2030: The ongoing general refurbishment and extension of the rail network including two new base tunnels (NRLA: the Lötschberg (opened in 2007) and the Gotthard (planned to open in 2017)) will increase capacity and shorten travel times. This will increase competitiveness of rail und thus support the shift envisaged.
- To further increase productivity and competitiveness of rail transportation, Switzerland has been progressively implementing reforms (RailwayReform) in the regulations of the rail network and liberalizing the freight transport market, in compliance with the relevant EU directive. This improves inter-operability and the quality of transnational transport through increased access rights and competition between different operators. "RailwayReform II" will provide increased flexibility for the railway companies and greater entrepreneurial freedom, making rail transport more productive and attractive
- To bring down slot prices and to provide additional intermodal services (including an efficient truck on train service between Freiburg/Germany and Novara/Italy), Switzerland is funding such services.
- Thanks to sustained subsidies for truck-on-train transport, a further shift towards combined transport is expected. Total funding for the modal shift from road to rail amounts to over CHF 2.8 billion from 2001 to 2010. The subsidies for combined transport are secured until 2010. In the mean time, parliament has decided to subsidise combined transport further on.
- Measures mainly aimed at improving road safety (increased enforcement activities with regard to speed limits and driver rest times) potentially also work in favour of rail transport.
- The land transport agreement between Switzerland and the EU secures the Swiss policy and the modal shift efforts in the European context. The EU respects the Swiss policy objectives and the necessary measures taken (in particular the HVF). Efforts are underway to negotiate a possible introduction of an international transalpine transport exchange market. However, an agreement must include the entire region of the Alps and comply with regulations of the countries involved, the EU, and Switzerland.

Aviation

With respect to climate change, Swiss aviation policy is focused on international aviation, as the share of Switzerland's domestic aviation emissions is very small. Switzerland joined the International Civil Aviation Organization (ICAO) in 1947 and the European Civil Aviation Conference (ECAC) in 1955. Under the air transport agreement between Switzerland and the EU which came into effect on 1.6.2002, Switzerland adopted European civil aviation legislation that was in force when the agreement was concluded and is thus on an equal footing with EU members. In 2006, Switzerland joined the European Aviation Safety Agency (EASA). Switzerland's aviation legislation and policy is therefore shaped by ICAO and ECAC regulations, as well as by developments within the EU. Policy is to be co-ordinated with European aviation and transport policy. Switzerland's foreign relations are also governed by bilateral and multilateral agreements; bilateral aviation agreements were concluded with more than 130 countries.

In a fundamental report on Swiss aviation policy submitted on 10.12.2004, the Federal Council assessed the current state of Swiss aviation (Swiss Federal Council 2004). This report stresses a coherent, comprehensive and forward-looking aviation policy within a sustainable development framework. Parliament acknowledged the aviation policy report in 2005 and commissioned DETEC and the FOCA to identify necessary measures and to amend the relevant aviation legislation. The set of measures will be completed within the next few years. The report sets the framework for aviation within the overall national transport policy:

- Domestic transport relies predominantly on railway.
- Within Europe, aviation is supplementing the high-speed rail network.
- The aviation sector provides Switzerland with good intercontinental connections.

Sustainable development in the context of aviation policy has the following implications:

- Operating and external costs should be borne by the aviation sector itself
- Technological optimization of infrastructure and aircraft should be fully exploited.
- Sustainable transport policy should be coordinated and promoted with Europe.
- Adverse environmental impacts of aviation should be reduced to an acceptable level in the long term, and resources should be conserved.

In sensitive environmental areas (noise and pollution), Switzerland has enforced noise dependent operating restrictions and has developed incentive systems of its own (e.g. noise- and emission-dependent landing charges, emission ceilings at certain airports, noise classes for large and small aircraft). These are to be maintained and further developed. As a further element for aviation policy, the sectoral plan for aviation infrastructure was adopted on 18.10.2000 (FOCA 2000), demanding comprehensive environmental consideration when aviation infrastructure is planned, such as limiting emissions at and in the surroundings of airports, operational measures and airport charges, which take into account the different levels of pollutants emitted by aircraft.

Within the ECAC, EASA and ICAO, Switzerland strives for internationally coordinated measures to limit GHG emissions from aviation. In concrete terms, Switzerland applies and promotes airport emissions charges systems and works towards stricter internationally accepted emission standards for new aircraft engines. In 2008, the latest ICAO NO_x emission standard with a further 12% NO_x reduction came into force. Optimization for lower NO_x emissions around airports is correlated with lower cruise NO_x emissions for current technology. As fuel burn (CO_2) reduction may lead to an increase in NO_x emissions, the introduction of aircraft emission charges has caused engine manufacturers to work for lowest possible NO_x emissions in addition to the primary goal of fuel burn reduction. Therefore, the Swiss local emissions charges have contributed to the overall goal of limiting and mitigating climate impact from aviation, because of less high altitude cruise NO_x emissions emitted by new aircraft. Switzerland is supporting a further increased NO_x stringency for aircraft engines through the ICAO Committee on Aviation Environmental Protection. The degree of the new stringency and the applicability date will be decided in 2010. In spring 2010, major Swiss airports plan to change or newly introduce an emissions charges model based on the legally binding guidance from the Federal Office of Civil Aviation. The basis for the new model has been harmonised within the ECAC (recommendation ECAC 27/4). The model reinforces the polluter pays principle: The higher the absolute emissions, the higher the emissions charge per aircraft movement.

Switzerland is actively supporting work towards introduction of a new aircraft engine emission certification requirement for particulate matter, taking ultra fine particle mass and number into account. The work is in line with the introduction of supplemental particle number standards for vehicles in Europe in 2014. Apart from health considerations, control of particle number emissions from aircraft is important for global climate effects. The activity is coordinated with EASA, ECAC, the EC and ICAO. Major decisions about the metrics and the development of the certification standard are expected to be taken by the Committee on Aviation Environmental Protection of ICAO in 2010.

With respect to market based measures, Switzerland is currently exploring ways to integrate civil aviation into an emissions trading system in line with the European aviation and transport policy. According to the "Report on Swiss aviation policy 2004" (Swiss Federal Council 2004), the Federal Council intends to consider to what extent revenues from current taxes on kerosene in domestic aviation, amounting to some CHF 60 million per year, could in future be used, *inter alia*, to finance environmental protection measures relating to aviation. In addition, it continues to support Switzerland's active involvement in aviation policy at the European and the global level (particularly through the ICAO).

Tab. 22 > Summary of policies and measures in the transport sector

Name of policy or measure	Objective and/or activity affected	GHG affected	Type of instrument	Status	Implementing entity or entities	Estimate of mitigation impact, by gas (for a particular year, not cumulative, in 1'000 Gg CO_2 eq)					
						1995	2000	2005	2010	2015	2020
Inclusion of aviation in an ETS	Limit CO_2 emissions	CO_2	Market based	Implementation study	FOCA, FOEN	a	a	a	a	a	a
Aircraft engine emissions charges	Reduction of local and cruise NO_X emissions	Ozone	Market based	implemented, reinforced in 2010	FOCA, Major Swiss airports	a	a	a	a	a	a
Increase of aircraft engine NO_X stringency	Reduction of local and cruise NO_X emissions	Ozone	Technology (Engine certification requirement)	Planned	ICAO, EASA, FOCA	a	a	a	a	a	a
Introduction of particle mass and number standard for aircraft engines	Reduction of nano-sized soot	(Soot & contrails)	Technology (Engine certification requirement)	Planned	ICAO, EASA, FOCA	a	a	a	a	a	a
Heavy vehicle fee	Internalization of external costs	CO_2	fiscal	implemented	ARE	n.a.	n.a.	0.11	0.13-0.18	0.13-0.19	0.15-0.20
EURO emission standards	reduction of air pollutants		Technology	implemented	FEDRO	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.
Energy-saving programmes	CO_2 - emission reduction	CO_2	CO_2 emission limits, information campaign	planned	SFOE, FOEN	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Mineral oil tax reduction on biofuels and natural gas	CO_2 - emission reduction	CO_2	fiscal	implemented	DGC in collab. with FOEN	n.a.	n.a.	n.a.	0.10	0.10	0.10
Environment label for new motor vehicles	Reduction of energy consumption, noise and air pollution	CO_2, ozone	Information, market based	planned	SFOE, FOEN	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Compensation of CO_2 emissions in transport sector	CO_2 - emission reduction	CO_2	Market based, emissions trading	planned	DGC, FOEN	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

ARE/FOCA/SFOE

a: For domestic flights with a very low share on GHG emissions in absolute terms, the mitigation impact can not be quantified.

4.3.6 Industry (including HFCs, PFCs and SF6)

Switzerland has not developed specific policies in the industry sector, apart from the policies related to synthetic gases (described below). Industrial emissions of CO_2 are controlled under the CO_2 Act, with the main instrument being the CO_2 levy, the conditional exemption from the CO_2 levy, and the emissions trading amongst companies exempt from the CO_2 levy as discussed above in section 4.3.3.

Synthetic gases
The Ordinance on Chemical Risk Reduction (SR 814.81) provides for measures to control emissions of persistent substances with a high global warming potential (HFCs, PFCs, SF_6, NF_3, HFEs) in almost all sectors. Since the beginning of the 1990s, the Federal Council has been recommending the greatest restraint in the use of these gases, in line with its integrated product policy. However, their use has strongly increased until 2004, and in 2007 they represented around 1.7% of anthropogenic GHG emissions in Switzerland.

The effort made since 2003 to control **synthetic GHG emissions** under the generic name of "substances stable in the air" has shown its first positive effects. The regulation (based on the Ordinance on Chemical Risk Reduction), is focusing on three main lines of action: 1) to limit the use of substances stable in the air to those applications where there is no preferable alternative; 2) when such substances are used, to reduce emissions as far as possible; and 3) to endorse a voluntary binding agreement developed by the industry (SF_6 in the high-voltage equipment and other sectors). The share of all synthetic GHGs rose from 0.5% in 1990 to 1.7% in 2007. Thanks to the regulation, HFC emissions could be stabilised approximately at their 2004 level (Fig. 59 in section 3). The sharp rise in SF_6 emissions since 1997 could also be halted, however the SF_6 consumption shows a large annual fluctuation (Fig. 59 in section 3). PFC emissions experienced a massive drop since 1990, due to the discontinuation of aluminium smelting in Switzerland. PFC emissions have been increasing anew since 1996, due to their recent application in electronic fabrication, yet PFC emissions dropped by 23.1% since 1990 (Fig. 59 in section 3). Like SF_6, PFC emissions show a pronounced inter-annual fluctuation.

The emissions of fluorinated GHGs are expected to remain constant until approximately 2015, followed by a slow decrease. New provisions have been drawn up in consultation with the cantons and the industrial and commercial sectors concerned. They define a clear framework, allowing sectors to take strategic action promptly in order to limit atmospheric emissions of synthetic GHGs.

Areas affected
In the industrial processes sector, the use of synthetic GHGs (called "substances stable in the air" and defined as fluorinated VOCs with a half-life longer than two years, plus the non-VOCs SF_6 and NF_3) has been regulated in various areas through a climate-related amendment to the Ordinance of 9.7.1986 on Environmentally Hazardous Substances (revised in 1995 and 2003), which entered into force in stages between July 2003 and January 2004. This regulation was succeeded by the Ordinance on Chemical Risk Reduction of 18.5.2005. The regulations cover the following areas:

Compressed gas containers
The mechanism of compressed gas containers intrinsically involves the emission of the propellant gas. In this area, emissions of synthetic GHGs (mainly HFCs) can therefore only be limited by restrictions on use. An analysis of the current state of technology identified the following as the only applications for which exemptions are required: compressed gas containers for cleaning live electrical and electronic equipment, and polyurethane spray foam in certain situations where safety is critical. The state of technology will be defined in guidelines developed in collaboration with the professional circles concerned. For other applications where these substances may perhaps be required, e.g. for safety reasons, the state of technology is changing rapidly, and it seems more appropriate to use the option of granting temporary exemptions based on individual technically justified requests.

Furthermore, the Ordinance of 23.11.2005 on Aerosol Dispensers (SR 817.023.61) prohibits the use of HFCs or PFCs in most spray cans. It only allows the use of HFC-152a as a propellant in spray cans containing cosmetics and household products.

Foams

By 2010, in the absence of regulations, the plastic foams sector would have been likely to become one of the two main sectors emitting synthetic GHGs (mainly HFCs) in Switzerland as this sector is largely emissive (production, use, and disposal). However, the measures currently implemented in Switzerland (restrictions on use, disposal by incineration and recycling) to limit synthetic GHG emissions from plastic foams on the one hand and the general tendency of this industrial sector in Europe on the other hand, have led to the situation where foams without fluorinated gases account for practically the entire Swiss market. The Swiss regulation allows the use of synthetic GHGs (mainly HFCs) only in plastic insulating foams and under severe restraints: Synthetic GHGs can only be used if they offer significant advantages in thermal insulating efficiency in case of spatial constraints, or where non-flammability is required, in agreement with the current state of technology. However, since the technology is rapidly advancing, the state of technology and application criteria need to be clarified in guidelines developed and updated in collaboration with the producers and professional users, as well as with the cantonal enforcement authorities

Solvents

Solvents containing synthetic GHGs (PFC, HFC, HFE) are currently used almost exclusively by electronic and precision industry, in cases where sound alternative technology is not available. To reduce emissions, consumer goods containing such solvents have been banned and the current provisions of the Ordinance on Air Pollution Control (SR 814.318.142.1) applicable to professional uses have been slightly modified so that they cover all regulated substances. Consequently, synthetic GHGs will be subject to the same provisions as chlorinated organic substances, such as perchloroethylene. These regulatory provisions are accompanied by a 10-year deadline for bringing existing equipment into line.

Refrigerants

In 2010, without regulatory measures, mobile air conditioning, as well as commercial and industrial refrigeration would probably be the source of more than half the emissions of synthetic GHGs (mainly HFCs) in Switzerland. A mixed regulatory system was therefore implemented, comprising: (a) a timetable of specific bans for certain categories of household appliances (refrigerators, freezers, air conditioners), accompanied by a system of individual exemptions when no alternatives are available; (b) a ban on the use of synthetic GHGs in mobile air conditioners, coming into force when permitted by the state of technology; (c) an authorisation procedure, based on the state of technology and the quality of confinement, for fixed installations and for heat pumps working with more than 3 kg of synthetic GHGs; and (d) measures to reduce emissions (periodic checking for leakage, maintenance records, notification of installations) required for mobile and fixed installations containing more than 3 kg of refrigerant.

To ensure the transparency and proportionality of this relatively complex system, several technical guidelines relating to the relevant technology and to the implementation of the various measures to improve confinement have been developed in collaboration with the sector concerned, and with the cantonal authorities. Furthermore, it is planned to establish voluntary or regulatory agreements with the sectors affected, in order to encourage the recovery and recycling of refrigerants at lowest GHG emissions possible.

Fire protection

Since 1996 the supply and import of extinguishing agents made of synthetic GHGs and of appliances or stationary equipment containing such agents are banned. However, temporary exemptions are granted in cases where no viable alternatives are available.

SF_6 in electrical distribution equipment

The use of SF_6 is authorised in electrical distribution equipment that is hermetically sealed or constantly monitored, and which operates at more than 1 kV. This is governed by voluntary agreements established in

2003 by the high-voltage industry concerned. The level and the volume of emissions are limited to 1% of total amount used, and the recovery of SF_6 from decommissioned equipment is guaranteed.

Other application sectors
The use of PFCs and SF_6 in tyres, insulating windows and sport shoes is no longer authorised. Other uses are authorised insofar as there is no environmentally superior alternative and at minimal emission levels according to the best available techniques.

Furthermore, under Annex 1 of the Ordinance on Lists Regarding the Movement of Toxic Waste (SR 814.610.1), waste containing HFCs counts as special waste. Thus, the movement of such waste is controlled, and it must be treated by licensed enterprises in an environmentally sound manner.

Tab. 23 > Summary of policies and measures regarding synthetic gases (as of June 2009)

Most important measures implemented: Expected reduction of emissions growth for all synthetic GHGs: 550–1000 Gg CO_2 eq by 2015. Slow decrease anticipated after 2010. Values in () brackets are subject to a high degree of uncertainty

Name of policy or measure	Objective and/or activity affected	GHG affected	Type of instrument	Status	Implementing entity or entities	Estimate of mitigation impact / Gg CO_2 eq			
						Year	HFCs	PFCs	SF_6
Ordinance on Chemical Risk Reduction	Reduction in use and emissions of synthetic GHGs in all main sectors	HFCs, PFCs, SF_6	Regulatory Voluntary	implemented	FOEN, cantons	1995	-	-	-
						2000	-	-	0
						2005	0	0	65–100
						2010	250–300	2–3	(150–300)
						2015	(400–600)	(8–12)	(180–420)
						2020	(500–800)	(13–19)	(200–550)
Deposit on synthetic GHGs	Create financial incentives for proper disposal of synthetic GHGs	to be determined	Regulatory Voluntary	planned	FOEN	a	a	a	a

a: no estimates available yet.

4.3.7 Agricultural policy

According to the Swiss greenhouse gas inventory, agriculture emitted approximately 5.35 million tonnes CO_2eq in 2007. This corresponds to roughly 10% of total Swiss greenhouse gas emissions. Emissions in the agriculture sector are split into enteric fermentation (2.32 million tonnes CO_2eq), agricultural soils (2.10 million tonnes CO_2eq) and manure management (0.91 million tonnes CO_2eq). Use of machinery in agriculture and forestry adds 0.56 million tonnes CO_2, but this is accounted for in the energy sector (1A4). If land-use and land-use change activities are added, emissions increase by another 0.94 million tonnes CO_2 (FOEN 2009).

Total emissions from the agriculture sector were reduced by 10% from 1990 until 2007. The reduction is mainly a result of the reduced livestock (cattle declined from 1.86 million to 1.57 million) and of a reduced application of mineral nitrogen fertilizers (reduction from 75`000 tonnes to 57'900 tonnes), leading to a 7% reduction of the methane emissions and a 12% reduction of nitrous oxide. The reduction in methane emissions occurred before 2003; since 2004, emissions increase again slightly, as a consequence of increasing livestock numbers. Latest numbers of the Swiss Farmers Union show improvements of the greenhouse gas intensity of agricultural production: While emissions in 2007 were only slightly below 2002 (-0.8%), the inland food production increased by 6%, the dairy products even by 13%. Between 1990 and 2007, the overall decrease in CH_4 and N_2O emissions from the Swiss agricultural sector was around 550 Gg CO_2 equivalents, corresponding to a 13% share of the country's total reduction commitment (8%) under the Kyoto Protocol.

Various efforts have resulted in a positive effect on greenhouse gas emissions from agriculture. It is however hard to quantify each contribution individually. The reform of Swiss agricultural policy, which is ongoing since the early 90s, led to a reduction of regulated prices in favour of product-independent direct payments for public-interest and environmental services (SAEFL 2005i). These direct payments are tied to ecological standards. Thus, farmers only receive direct payments if they can demonstrate that an appropriate soil nutrient balance is maintained, a suitable proportion of farmland is managed as ecological compensation areas, a crop rotation system is in place, soil protection is given due consideration, crop protection agents are chosen and applied selectively, and livestock is kept in accordance with legal regulations and animal welfare requirements. Lately, a new policy instrument called resource programme has been added in the agricultural sector. Through this programme, the Swiss Confederation is subsidizing measures for more efficient use of natural resources in the agricultural sector. The target areas are resources such as nitrogen, phosphorous and energy, optimized pest control, protection and sustainable use of soils and biodiversity. In order to qualify for subsidies, measures must go beyond legal requirements, or the criteria for other funding programmes. Support is given to measures that need financial support in an introduction phase, but that will run without further payments afterwards. These payments are restricted to 6 years, within which new technologies or organizational structures should have reached a state that is self-sustaining.

Apart from the agricultural policies, also measures in other policy areas have an influence on greenhouse gas emissions in the agriculture sector. For example, the Water Protection Act (SR 814.20) puts a limit to the maximum amount of fertilizer per hectare, and provides the legal basis for supporting cleaning-up of sites polluted with agricultural material input. In the energy sector, policies such as the CO_2 levy, the tax exemption of biofuels or the payment of feed-in tariffs for electricity from renewable sources have led to a decrease in fossil fuel use, an increase in production of renewable energy, in particular the use of biomass to produce biogas.

Changes have resulted not only from policy instruments but also from improvements in efficiency and technological progress (increases in crop yields, milk yield and daily weight gains in livestock production). Furthermore, support is provided by the federal authorities in the form of targeted basic and applied research efforts, the findings of which are integrated into agricultural education and advice, thereby raising farmers' awareness of environmental concerns.

According to a recently published study, further progress is possible. However, the majority of technically available measures to reduce greenhouse gases is not yet fully developed for large-scale deployment and therefore involves substantial investments. On the other hand, the study has shown that – provided that further research efforts lead to the development of new and economical mitigation technologies – such technologies may contribute substantially to a future reduction in greenhouse gas emissions from the agricultural sector. Based on literature, there is significant mitigation potential, however, none are currently ready for a wide-spread market introduction. In particular with respect to methane emissions, which represent a large share of total agricultural emissions, new developments in feeding regimes look promising and further research is needed. Currently, several long-term studies are under way that look into CH_4 and N_2O emissions for different feeding regimes. Since 2009, data acquisition within the framework of the national agricultural environmental monitoring is based on single farms. These data will then allow identifying efficient farms and using them as benchmark models. Additionally, the potential of carbon sequestration in agricultural land use and land-use change and the production of renewable energy will deserve further attention.

Currently, a climate strategy for the agriculture sector is being developed. This strategy will address both the mitigation potential as well as vulnerability and adaptation issues. It covers actions aimed at reducing the greenhouse gas intensity of agricultural production and possible measures to adapt agricultural production to climate change.

In order to ensure that, in the future, agriculture will be in a position to provide the services for the common good set out in the Swiss constitution, competitiveness needs to be further improved. According to the

agricultural policy for the period up to 2011, basic conditions should be further developed to ensure that potential means of reducing costs and improving market performance, as well as ecological and social aspects, in the agricultural sector and the preceding and subsequent stages of food production are fully exploited. The key feature of this stage of the reform is a further reduction of 30% in budgetary expenditures for market price support (2008-11 in comparison with 2004-07). The savings are being used for direct payments for services (*e.g.* preserving culturally valuable landscape or animal welfare) and to compensate for difficult production conditions. All remaining export subsidies for agricultural commodities are to be eliminated by 1.1.2010, and customs duties on imported animal feed and cereals for human consumption are to be reduced.

Pending are a free trade agreement in the agrarian and food sector between Switzerland and the EU that should promote a more market-oriented production and an increased export segment of the Swiss agriculture. On the other hand, a recent paper passed by the Federal Council has shown that the agricultural sector does not sufficiently fulfil the services requested in exchange of the direct payments. Therefore, the system of direct payments will be developed further to better focus on these services in the future.

Tab. 24 > Summary of policies and measures in the agriculture sector

Name of policy or measure	Objective and/or activity affected	GHG affected	Type of instrument	Status	Implementing entity or entities	Estimate of mitigation impact, by gas (for a particular year, not cumulative, in CO_2 eq)					
						1995	2000	2005	2010	2015	2020
Ecological standards	Appropriate soil nutrient balance, suitable proportion of ecological compensation areas, crop rotation system, soil protection, selective appliance of crop protection agents, animal welfare requirements	CH_4, N_2O, CO_2	Requirement for direct payments	implemented	Federal Office for Agriculture FOAG	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.
Resource programme	Efficient use of natural resources	CH_4, N_2O, CO_2	Funding programme	implemented	Federal Office for Agriculture FOAG	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.

n.e.: not estimated.

4.3.8 Land-use change and forestry

There is a long tradition of forest protection in Switzerland. The first federal Forest Act came into force in 1876, but it only covered the Alpine region. Its aim was to put a halt to the depletion of forests, to manage the remaining forest areas in a sustainable way, and to promote afforestation. The Forest Act of 1902 covered the whole country. The Forest Act and an enabling overall economic development resulted in an increase of the forested area in Switzerland by nearly 50% compared to the mid 19th century. The Forest Act (SR 921.0) that came into force in 1993 reaffirms the long-standing Swiss tradition of preserving both forest area and forest as a natural ecosystem. It prescribes sustainable forest management, prohibits clearing, and bans deforestation unless it is replaced by an equal area of afforested land or an equivalent measure to improve biodiversity. The forested area is still increasing. The growing stock is estimated to have increased from less than 150 in 1880 to 359 m^3/ha in 2005.

In 2004, the national forest programme was published, outlining an action plan for 2004–2015. It specifies five priority objectives:

- The forest's protective function is guaranteed
- The economic viability of the forestry sector is improved
- The value-added chain for wood is strengthened
- Biodiversity is conserved
- Forest soils, trees and drinking water are not threatened

These objectives encompass that CO_2 removals by sinks and emissions by sources in the forests shall be recognized in terms of compliance with the Kyoto Protocol while making better use of the potential of forests for timber production and fuel wood through economic incentives and implementing new technologies. A study was carried out confirming that the contribution of the forest and wood sector to Swiss climate goals can be optimized by sustainable forest management warranting a high forest growth being harvested annually. The highest possible substitution effect can be achieved through the principle of cascaded use (Taverna et al. 2007). Taking into account the high growing stock, Swiss forest policy's climate related goal is to reduce CO_2 emissions by substituting fossil fuels rather than enhancing sink capacity. The sink potential of Swiss forests is dwindling. Among other reasons, this results from largely old forests, which have decreasing productivity and wood quality, so that a large proportion of mature trees need to be harvested in the near or more distant future.

In 2004, Swiss parliament decided to elect forest management as an activity under Article 3.4 of the Kyoto Protocol. Case studies were started in various regions of the country in order to provide the basis for national rules for assessing and accounting for removals by sinks and emissions by sources in the forest management sector. In November 2006, the Swiss government communicated in its initial report to the UNFCCC that Switzerland will be accounting for forest management under Article 3.4 of the Kyoto Protocol.

A revision of the Forests Act was prepared. One goal was to give forest owners the option of trading carbon credits on the basis of the sink service provided by their forests. However, the Swiss parliament rejected the revision of the Forests Act in March 2008. Thus, until further notice, forest owners cannot claim carbon removal units (RMUs) on this basis. Moreover, because use of wood becoming economically more attractive over recent years, carbon trading based on sink services is commercially less interesting. However, few forest owners are preparing to offer carbon credits on the basis of sinks provided by their forests on the voluntary market.

To implement the objectives of the national forest programme, FOEN has formulated its wood resource policy (FOEN 2008h) which is coordinated with the other relevant sectoral policies (e.g. energy policy, regional development policy). This wood resource policy defines, among other things, the direction to be taken by federal policy in relation to wood promotion on completion of the "Wood 21" wood promotion programme which was terminated at the end of 2008. Under this programme, a wood action plan is being started in 2009. The main focus in the implementation of the action plan lies on the ecologically and economically effective use of wood. With a view to the efficient use of wood, cascade use is prioritised, i.e. wood is used as material prior to its use for energy. In the case of energy use, greater overall efficiency of the conversion technology should be targeted.

Tab. 25 > Summary of policies and measures in the land use, land use change and forestry sector

Name of policy or measure	Objective and/or activity affected	GHG affected	Type of instrument	Status	Implementing entity or entities	Estimate of mitigation impact, by gas (for a particular year, not cumulative, in 1'000 Gg CO_2 eq)					
						1995	2000	2005	2010	2015	2020
Forest area conservation	No deforestation without replacement by afforestation of the same area	CO_2	legal (forest legislation)	implemented	FOEN and cantonal forest services	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.
Sustainable forest management	Harvesting volumes shall not exceed growth increment in the forests	CO_2	legal (forest legislation)	implemented	FOEN and cantonal forest services	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.
Wood 21	Increase of wood use as fuel	CO_2	Promotion campaign; information for planners and engineers	terminated	FOEN and forest industry	-	-	superseded by wood action plan			
Wood action plan	Increase of harvesting and of use to $8.5*10^6$ m^3/a	CO_2	Promotion campaign; information for planners and engineers	implemented	FOEN and forest industry	-	-	-	0.45 [a]	0.80[a]	1.20[a]

n.e.: not estimated
a: The effects of the wood action plan result from substitution for other materials or fossil fuels. In parallel there is a reduction in removals by sinks in the forest, which is not reflected in the figures.

4.3.9 Waste management

In 2007, about 3.58 million tonnes of combustible waste, (municipal solid waste, and combustible construction waste and sewage sludge) were incinerated in the 29 Swiss municipal solid waste incinerator plants (MSWI), almost all producing heat and electricity. As these plants have to guarantee the waste disposal, they can not control the waste input in order to reduce their CO_2 output. Therefore, there are only the following means of indirect CO_2 reduction at disposal:

- Increasing the energy efficiency of the incineration plants, i.e. increasing energy output of the MSWI will lead to a reduction in the consumption of fossil fuels or imported electricity from thermal power plants;
- Fully use waste energy for district heating and electricity production and thus substitute fossil fuel consumption;
- Optimisation of the metal recovery from the incineration residues: Bottom ash of the MSWI contain on average about 10% scrap iron and significant amounts of non-iron metals such as aluminium, copper, brass etc. The recovery of these metals is less energy-demanding than producing them from primary sources and therefore reduces fossil fuel use and related greenhouse gas emissions.

In order to promote these measures that lead to a more climate friendly operation of the incineration plants, the Swiss MSWI are introducing the so-called "MSWI-Climate-Charta".

The principal effort to reduce emissions from waste incineration, however, is to increase the recycling quantities. In 2007, a total quantity of municipal waste of 5.46 million tonnes was generated in Switzerland. 2.68 million tonnes or 49% were incinerated, and 2.78 millions tonnes or 51% were recycled, which corresponds to an increase since the last reference year (2003) of 3%.

Tab. 26 > Summary of policies and measures in the waste sector

Name of policy or measure	Objective and/or activity affected	GHG affected	Type of instrument	Status	Implementing entity or entities	Estimate of mitigation impact, by gas (for a particular year, not cumulative, in 1'000 Gg CO_2 eq)					
						1995	2000	2005	2010	2015	2020
Environmental Protection Act (EPA)	waste recycling	CO_2	legislation	implemented	FOEN	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.
Technical ordinance on waste (TOW)	interdiction of landfilling of combustible waste	CH_4, CO_2	legislation	implemented since 2000	FOEN	n.a.	0	0.03	0.11	0.16	0.18
MSWI-Climate-Charta	optimisation of energy production and metal recovery from incineration residues	CO_2	voluntary	adopted	association of MSWI-operators (VBSA)	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.

4.4 Policies and measures no longer in place

The policies relevant to mitigate climate change that have been developed over the past years are well established. Some of the measures implemented have been adapted over time, in order to better achieve the set objectives. The measures listed in the previous national communication are still part of the national portfolio.

4.5 Policies and measures leading to an increase in GHG emissions – rationale for such actions

As described in section 2.7, the current Swiss electricity production is virtually carbon free due to the high percentage of hydropower and nuclear power. Therefore, there is almost no potential to reduce CO_2 emissions by measures such as fuel switching in the power sector. Due to the scheduled decommissioning of the first nuclear power plant in 2019, other options for power generation, such as combined cycle power plants, are currently being considered to cover the increasing demand for electricity. However, according to a parliamentary resolution valid till the end of 2010 and the replacing legislative proposal currently being discussed, power plants are requested to fully compensate for their CO_2 emissions (see also 4.3.3).

4.6 Policies and measures – minimizing adverse effects

- Tax exemption for biofuels is limited to fuels that meet ecological and social criteria. The conditions are set out in such a way that biofuels do not compete with food production and are not causing degradation of rainforests or other valuable ecosystems. The Swiss Centre for Technology Assessment (TA-Swiss) has launched a study on the assessment of social and environmental impacts of the use of second generation biomass fuels. The aim of this study is to analyse the potential and risks involved in using second generation biofuels, i.e. assess different sources of biomass, production technologies and forms of energetic use, their potential and impact of complete value-added chains, and their ecological, economic and social impacts.
- The Swiss Academies of Arts and Sciences have started a project to assess possible conflicts and synergies between the expansion of renewable energy production and land

management. Many forms of renewable energy (solar, wind, water, biomass, geothermal) require considerable floor space and lead to changes in land use, ecosystems, and the views of places and landscape. Large-scale use of areas for energy production thus have to be planned considering the maintenance of ecosystem services, protection of biodiversity, or natural sceneries which are important for tourism. A project report is expected at the end of 2010.

- An assessment of conflicts and synergies between policies and measures to mitigate climate change and biodiversity protection has been made by the biodiversity forum and ProClim in 2008 (http://www.proclim.ch/Products/biodiv-klima08/). While there are several synergies in the area of ecosystem management and agriculture, conflicts exist concerning the use of renewable energies, be it the adverse effects of increased hydroelectricity generation on natural water flows or the impacts of other renewable energy systems on natural landscapes and ecosystems. The report gives recommendations on how to take advantage of synergies and how to detect conflicts in an early stage.
- Adverse incentives in the Swiss tax system are identified, with the aim of a gradual elimination of such negative incentives. For example, the Swiss tax system allows deductions for commuting, which acts as some sort of a subsidy for separating place of living from the workplace. Also, fuels for international aviation, for agricultural vehicles and public transport are tax exempt, thus, there is less incentive for economic fuel use.

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5 Projections and the total effect of measures

5.1 Projections

The projections have been updated and are no longer comparable to those given in NC4. For all sectors, new or updated models have been used to calculate future trends. For the commitment period 2008 – 2012 a special short-term econometric model is used, which is updated annually to take into account the most actual data available.

5.1.1 CO_2

Energy-related sectors
Starting point of all the scenarios presented in this report is the Swiss energy outlook (also known as Energy Perspectives 2035) accomplished by SFOE. The work was carried out from 2004 to 2006, and the final reports were published in 2007. The energy outlook is based on scenarios that reflect different changes in the basic conditions, and different effects of implemented and planned measures. The projections consist of forecasts of energy consumption in five demand sectors – private households, transport, industry, services & agriculture, and the energy transformation sector (electricity generation) (SFOE 2007c, 2007d, 2007e, 2007f, 2007g). Four main scenarios are calculated, each with various sub-scenarios. Scenario I defines the reference case with a continuation of the actual policy, Scenario II is called "strengthened collaboration" and defines a stronger climate policy without changing the current policy fundamentally. Scenario III ("new priorities") and IV ("towards the 2000 Watt society") are target oriented and discuss measures to reach a CO_2 reduction of 34 % (Scenario III) or 48 % (Scenario IV) between 2000 and 2035. Since the publication of the energy outlook in 2007, various updates of the reference scenario have been made concerning the socio-economic input variables, population, GDP growth, oil prices. This updated reference scenario served as an input to several models, which have been used to calculate the effects of measures (Ecoplan 2008a, 2009a). The scenarios in this report are based on the following economic and demographic assumptions:

Tab. 27 > Economic and demographic assumptions for the scenarios

	1990	2005	2010	2020	2030
Population (in millions) [1]	6.80	7.46	7.80	8.18	8.36
GDP real (prices 2005, billion CHF) [1]	379.6	449.8	478.1	559.1	605.4
Oil price real (prices 2005, US$/bl)[1]			55	55	70
Passenger traffic (billion person km) [2]		114.5	119.1	126.5	130.8
Heavy duty traffic (billion tonnes km) [2]		25.5	27.3	32.8	36.3

[1] Ecoplan (2009b), [2] SFOE (2007d)

- Swiss population grew by 0.9% per year from 2005 to 2008. Population projections have been revised and population growth for future years is expected to be higher than assumed in the energy outlook. From 2010 to 2020 the expected growth is 0.5%, from 2020 to 2030 0.2%, respectively.
- GDP projections have also been revised. From 2005 to 2008 a boom period with a growth of 2.9% per year was observed in Switzerland. 2009 and 2010 is expected to show a negative growth, from 2010 to 2020 a mean GDP growth of 1.6% per year is assumed, from 2020 to 2030 0.8%, respectively.
- The world market price (real prices) for crude oil is set to be constant until 2020 (USD 55/bl, 2005 prices; approximately USD 50/bl, 2003 prices) and steadily increases up to USD 70/bl in 2030. The prices for the other energy sources are derived from the price

for oil. Given the development of oil price levels during the last years, these assumptions are associated with significant uncertainties.
- In the transport sector, a further increase in passenger kilometres of 0.6% per year (2010 – 2020), and 0.3% per year (2020 – 2030) is assumed. Heavy goods traffic is assumed to grow by 1.8% per year from 2010 to 2020, and 1% per year from 2020 to 2030.

Scenario "with measures implemented"

The scenario "with measures implemented" (in Swiss terminology: "reference scenario") takes into account all the measures adopted by mid of 2009. It shows the future trends to be expected from the continuation of existing policies. This scenario includes the effects of the following measures and assumptions:

- "Energy 2000" programme and continuation of the "SwissEnergy" programme (with constant funding),
- Building refurbishment programme (2009: CHF 100 million; 2010 – 2012: CHF 200 million per year[9])
- CO_2 levy on heating fuel (CHF 12 per tonne CO_2 in 2008 and 2009, 2010 – 2012: CHF 36 per tonne CO_2[10]).
- reduced tax rates for alternative fuels and fuel use dependent motor vehicle taxes
- agreements with energy-intensive companies and car importers to enhance energy efficiency and reduce CO_2 emissions (no CO_2 tax on transport fuels),
- continuous tightening of energy requirements for buildings (SIA standard 380/1),
- heavy vehicle fee (HVF).

According to this scenario, overall energy consumption will decrease slightly from 2005 to 2030. A considerable shift from oil to gas was observed between 1990 and 2005, and it is assumed that this trend will continue. The sum of heating oil and natural gas (mainly used for heating purposes) had decreased slowly but continuously since 1995. Consumption of transport fuels increased between 1990 and 2005 but will show a slight decreasing trend in future. Electricity consumption will increase steadily by almost 1% per year.

Energy consumption for international air traffic increased from 48 PJ in 1990 to 68 PJ in 2000, but decreased thereafter to 51 PJ (2005). The future trend is uncertain: an increase is to be expected, without reaching the dynamic growth rate of the 1990–2000 period.

Non-energy CO_2 sources

The trends presented for the non-energy CO_2 and the other Kyoto gases are based on a study which was published in 2009 (Ecoplan 2009b).

The most important source in this category is the cement industry. After a sharp decline (38%) in clinker production between 1990 and 1997, production increased slightly and is expected to remain roughly constant until 2030. Other smaller CO_2 sources from industrial processes are expected to remain constant as well.

In the waste sector, CO_2 emissions are very small. All of the incineration plants in Switzerland are using the energy for power production and/or district heating and are included in the energy sector according the IPCC guidelines.

[9] The effect of the planned continuation of this programme until 2020 is included in the scenario "with additional measures".
[10] The effect of the planned continuation of the CO_2 levy is included in the scenario "with additional measures".

Forests and harvested wood products

Forests not only store carbon in biomass, but also deliver wood as a substitute for fossil fuels (energy substitution) and non-renewable construction materials (material substitution) like steel or concrete.

Carbon Capture in Swiss forests

Yearly CO_2 balances are calculated as the difference between yearly values of gross growth, harvested wood, mortality and changes in stock of dead wood as described in Switzerland's national inventory report (FOEN 2009). Since 1990, there has been a significant increase in the amount of dead wood due to the storms Vivian and Lothar and due to pine beetle infestation. A further increase in dead wood stock is very unlikely (FOEN 2009d). Therefore the amount of dead wood is assumed constant until 2020. Also gross growth is kept at the level determined between the second and the third National Forest Inventory (NFI). The amount of harvested wood is mainly driven by wood demand and wood prices, which are strongly depending on world's economic situation. When it comes to foreign trade, the competitiveness of the Swiss forestry sector and fluctuations in local currency play an important role. As a result of recent economic development, the increase of harvested wood observed since 2000 started to decline in 2006. This makes it very difficult to make any reliable predictions on the development of wood harvested in Swiss forests.

Swiss forest policy aims to promote higher harvesting rates in Swiss forests, with the carbon neutrality of wood expected to encourage demand for wood products. Under the national forest programme (see section 4.3.8) a wood action plan mainly focuses on the ecologically and economically effective use of wood.

To make projections of the development of wood production, a dynamical wood market model (Pauli et al. 2009) was used. Two scenarios, defining a lower and upper level, were used. They are defined by a relative increment of wood use until 2025 compared to 2005 and they both follow a linear increase:

- S1: trend-scenario with a predicted wood use of 8.2 million m^3 in 2025
- S2: scenario with increasing general energy costs and projected wood use of 8.6 million m^3 in 2025.

Both scenarios are based on market studies and expert knowledge. According to these two scenarios, Swiss forests will act as a net source of CO_2 in 2020 with net emissions ranging between 0.7 and 1.2 Mt CO_2 (Tab. 28). In 2005 Swiss Forests still acted as a net sink of CO_2 of -1.1 Mt CO_2.

Substitution effect due to the use of wood

Also the substitution effect of wood harvested in Swiss forests was derived from the model projections S1 and S2. The CO_2 effect of material and energy substitution within Switzerland and abroad was quantified following the methodology described in Taverna et al. (2007). It is expected that the total substitution effect from wood use will increase to a range of -4.7 to -5.0 Mt CO_2 in 2020 (Tab. 28). This is a difference of 0.9 - 1.2 Mt CO_2 compared to 2005.

Total CO_2 effects of Swiss forest sector

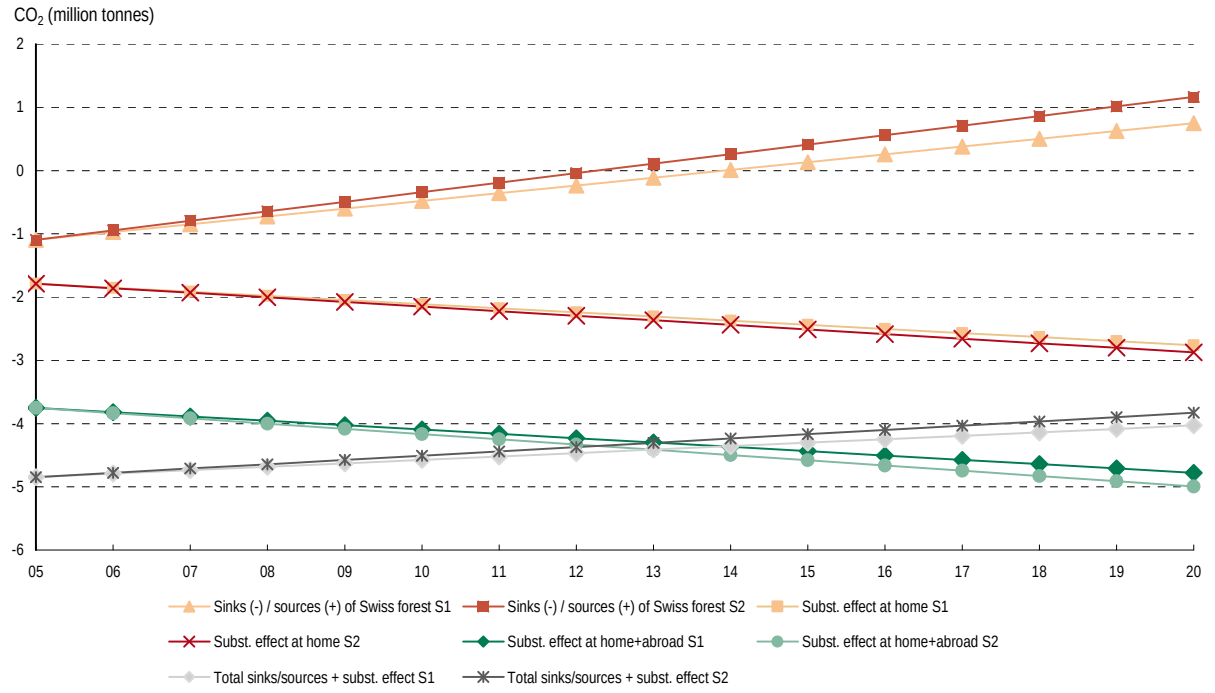
Fig. 75 shows the band of the CO_2 balance of Swiss forests as well as the CO_2 effect from wood use until 2020 as estimated by the scenarios S1 and S2. Swiss forests turn from a net carbon sink into a net CO_2 source until 2020. At the same time, an increase in wood demand implies an increase in wood use and thus results in an augmenting substitution effect. As Fig. 75 and Tab. 28 demonstrate, losses in carbon from biomass in Swiss forests are largely counterbalanced by the substitution effect from the use of wood.

Influence of future natural disturbances

In recent years, there has been a tendency towards increased storm damage and hot dry summer seasons, leading to high levels of bark beetle infestation. As a result of climate change, the incidence of natural disasters may remain high. Keeping dead wood stocks at a constant level, a certain risk of forest damage is already covered. A risk analysis based on data of the last decennia assesses a possible increment of yearly losses of living biomass due to storms and insect infestation to amount to 2.1 Mt CO_2 (FOEN 2009d) on average. During years with extreme events higher peaks of CO_2 emissions are possible.

Fig. 75 shows the contribution of the Swiss forest sector to climate mitigation. The CO_2 balance of biomass in Swiss forest and substitution effect from wood use within (at home) and outside Switzerland (abroad) is modelled for two different scenarios (trend scenario (S1) and increased energy cost scenario (S2), see above).

Fig. 75 > Contribution of Swiss forest sector to climate change mitigation



FOEN (2009d)

Tab. 28 shows the CO_2 balance of the biomass in Swiss forests and the substitution effect resulting from wood use. Values for 2020 from two model projections (Pauli et al. 2009): trend scenario S1 and scenario S2 with an increase of general energy costs. Values for 2005 are given for comparison. Positive values indicate CO_2 emissions. Negative values refer to forest sinks or avoidance of emissions due to substitution effect.

Tab. 28 > CO_2 balance of biomass in Switzerland

	2005 (million t CO_2)	Trend Scenario S1 2020 (million t CO_2)	Scenario increase general energy costs S2 2020 (million t CO_2)
CO_2 balance Swiss forests	-1.1	0.7	1.2
Substitution effect within Switzerland	-1.8	-2.7	-2.9
Substitution effect abroad	-2.0	-2.0	-2.1
Total substitution effect	-3.8	-4.7	-5.0
Total CO_2 effect from biomass in Swiss forests and wood use	-4.9	-4.0	-3.8
Possible additional losses due to climate change and natural disturbances	-	2.1	

Overview

Tab. 29 and Fig. 76 present an overview of the CO_2 emissions of the scenario "with measures". Total gross emissions will decrease approximately by 5% between 1990 and 2020, with a further 5% reduction between 2020 and 2030.

The energy sector is by far the most important sector for total CO_2 emissions. Within the energy sector, heating fuel used in "Other sectors" (residential, commercial and institutional buildings) was most important until 2007. This sector shows a steady decrease which continues in the future. In 2020 the CO_2 emissions will be 16% lower than in 1990.

In contrast, the transport sector showed an increase of 11.1% from 1990 to 2007, making it the most important sector in 2007. In the future, emissions from the transport sector are assumed to decrease only slightly. The increases achieved in energy efficiency are counteracted by the trend towards heavier and bigger vehicles, although in 2008, for the first time, this trend was broken. A slight independent trend towards increased use of natural gas and biofuels as transport fuels is assumed, triggered by an incentive system introduced in mid 2008. The trend towards more diesel vehicles continues. In 2020 and 2030 emissions from the transport sector are about 8% higher than 1990. Domestic aviation is assumed to remain constant at the emission levels of 2006. CO_2 emissions from international aviation departing from Switzerland are assumed to grow to 150% in 2020 relative to 2006, and to remain constant until 2030.

The emissions in the industry sector depend on economic growth. In parallel, energy is used more efficiently. These two factors are expected to drive the future development. In 2020, emissions will be about 5% lower than in 1990 with an additional 5% reduction from 2020 to 2030.

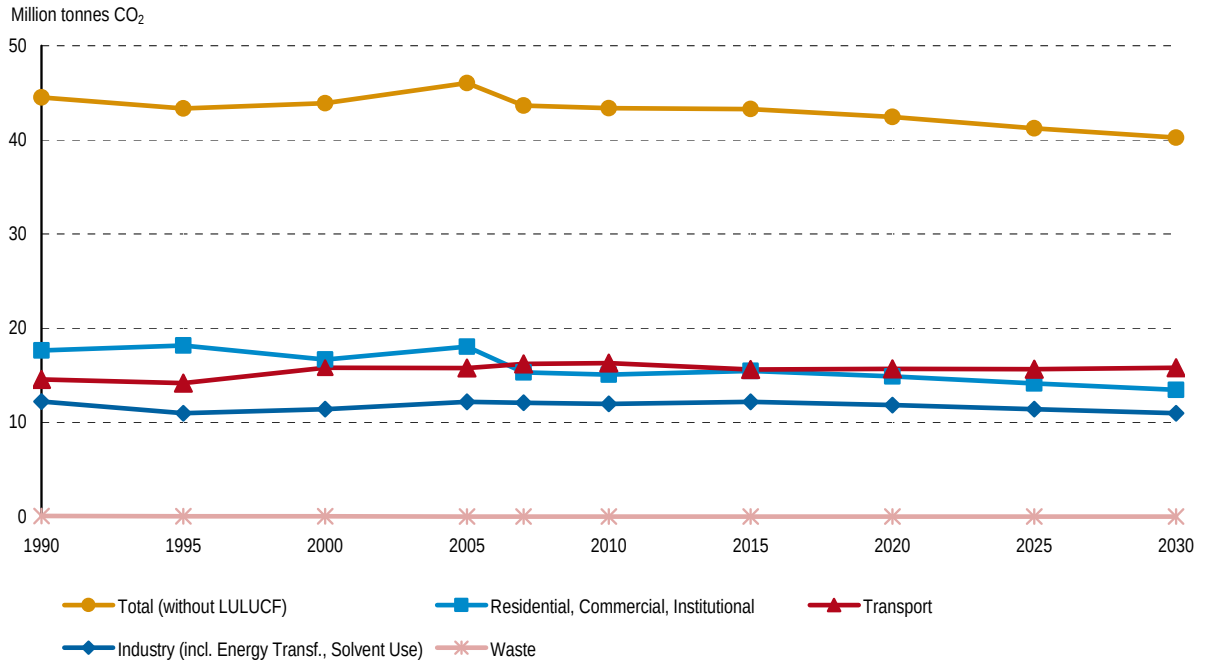
In contrast to many other countries, the subsector "Energy/Transformation" is of only minor importance in Switzerland. Electricity production is almost CO_2 free in Switzerland (about 60% hydro power, 40% nuclear power). A gap in electricity supplies is expected around 2020, when the first nuclear plant will have to shut down, having reached the end of its useful lifetime. The supply gap will be especially appreciable in the winter season and therefore corresponds almost exactly to the demand for heat. Several scenarios (fossil and non-fossil) are discussed in the energy outlook to close the expected supply gap (SFOE 2007g). Gas fired power plants are considered a possible option. There is a parliamentary initiative pending which states that CO_2 from additional fossil power plants has to be compensated by 100% (by projects in Switzerland and abroad). Therefore, the reference scenario supposes that the electricity supply in Switzerland will remain almost CO_2 free in the future. The CO_2 emissions reported and projected in this sector are mainly coming from waste incineration plants. The amount of municipal waste has remained roughly constant since the early 1990s, but as a result of greater amounts being burnt and due to waste import, CO_2 emissions increased by 34% from 1990 to 2007. Since 2000, landfilling of municipal solid waste has been prohibited in Switzerland, and it is expected that the amount burnt will remain stable in the coming years.

Tab. 29 > Inventory data and projections for CO_2 emissions between 1990 and 2030, scenario "with measures"

	CO_2 million tonnes										
		Inventories					Projections				
IPCC	Source/Sink Categories	1990	1995	2000	2005	2007	2010	2015	2020	2025	2030
Total	Emissions without LULUCF	44.50	43.32	43.90	46.04	43.64	43.4	43.3	42.4	41.2	40.2
1	All Energy	41.25	40.89	41.71	43.74	41.36	41.1	41.0	40.1	38.9	38.0
1A	Fuel Combustion	41.11	40.77	41.59	43.63	41.25	41.0	40.9	40.0	38.8	37.9
	1 Energy/Transformation	2.49	2.55	2.78	3.40	3.34	3.3	3.4	3.2	3.1	2.9
	2 Industry	5.95	5.39	5.75	5.81	5.80	5.7	5.9	5.6	5.4	5.1
	3 Transport	14.58	14.15	15.80	15.78	16.21	16.3	15.6	15.7	15.7	15.8
	4 Other Sectors	17.65	18.16	16.69	18.05	15.31	15.1	15.5	14.9	14.1	13.4
	5 Other (Off road)	0.44	0.52	0.58	0.59	0.59	0.6	0.6	0.6	0.6	0.6
1B	Fugitive Emissions	0.14	0.12	0.11	0.11	0.10	0.1	0.1	0.1	0.1	0.1
	2 Oil/Natural Gas	0.14	0.12	0.11	0.11	0.10	0.1	0.1	0.1	0.1	0.1
2	Industrial Processes	2.83	2.11	1.95	2.10	2.09	2.1	2.1	2.1	2.1	2.1
3	Solvent Use	0.36	0.28	0.22	0.18	0.18	0.2	0.2	0.2	0.2	0.2
4	Agriculture	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0
5	LULUCF	-2.36	-5.31	0.75	0.86	-0.65	0.7	1.4	2.1	(2.7)	(2.7)
6	Waste	0.06	0.04	0.02	0.02	0.02	0.0	0.0	0.0	0.0	0.0
1A3 ai	International Bunkers	3.07	3.65	4.66	3.49	3.92	4.4	5.0	5.6	(5.6)	(5.6)

Modified from Ecoplan (2009b)

Fig. 76 > CO_2 emissions by sector from 1990 to 2030, scenario "with measures"



Modified from Ecoplan (2009b)

5.1.2 CH_4

Agriculture

The projected emissions of methane and nitrous oxide from the agriculture sector are presented together. The data up to 2020 are derived from a recent study (Peter et al. 2009) which evaluates the effect of agricultural prices on greenhouse gas emissions of Swiss farming. The study considered three different price scenarios (high, medium, low). The scenario "high" corresponds to the expected price level following the implementation of the Swiss agricultural policy 2011. The scenario "medium" assumes prices as they are expected under current free trade conditions with the EU, whereas scenario "low" is based on average European prices during the low-price level of 2002-2004. From the producers' perspective, the scenario "low" can be considered the worst-case scenario, as agricultural prices are assumed to show an upward trend under current global developments.

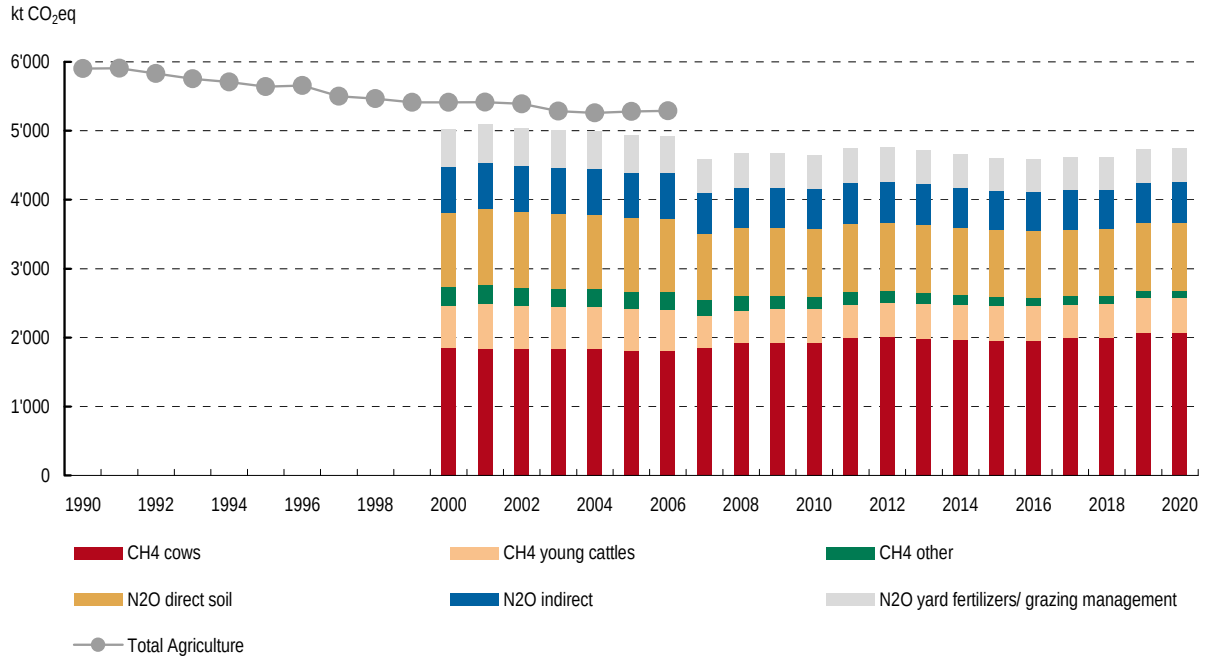
The model calculations show that emissions of agricultural greenhouse gases from 2006 to 2020 will decrease in all three scenarios, ranging form -3.4% for scenarios "high" and "medium" to -8.6% for scenario "low". In relation to the base year 1990, this corresponds to a cumulative reduction of 14% (high, medium) or 18.8% (low), as substantial reductions in greenhouse gas emissions have already been achieved form 1990 to 2006 due to the reduction of animal livestock numbers.

Basis for the projections used in this section of the national communication is the scenario "medium", as shown in Fig. 77. In this scenario, the dairy cattle stock increases by 20%, while mother cow husbandry is decreasing, resulting in a net increase of methane emissions of less than 20% for the category mature cattle (dairy cows and mother cows). In the model, methane emissions from young cattle (breeding cattle, fattening calves and fattening cattle) are declining markedly from 2006 to 2007. This reflects the fact that cattle fattening is suspended in the scenario "medium" and "low", and young animals are all used for calf-fattening (up to the age of 4 months), resulting in reduced methane emissions. In contrast to cattle fattening, calf-fattening does not lead to methane emissions, as according to the IPCC calves don't digest roughage in their rumen. Furthermore, livestock numbers of sheep, swine and poultry are reduced as well. This leads to diminishing methane emissions (mainly from manure storage), but also to reduced nitrous oxide emissions,

as less nitrogen is introduced into the system. The net effect leads to total agricultural emissions for 2020 that are slightly smaller than during the years 2000 – 2005. Changes in agricultural prices have thus different effects on the various emission sources. However, taken together, the overall emissions are relatively similar, especially for scenarios "high" and "medium", as increasing emissions from dairy cattle are (over-) compensated by decreasing emissions from animal fattening and arable crops.

Fig. 77 > Evolution of greenhouse gas emissions from the agriculture sector

Methane and nitrous oxide emissions according to the national greenhouse gas inventory (up to 2007) and the scenario „medium" of the agricultural model used to estimate future developments.



Modified from Peter et al. (2009)

The results of the current study are comparable with older projections. The dynamical economical model SILAS that had been used previously produced emission estimates for 2011, which have been linearly extrapolated to 2020 (Bretscher 2007), leading to a reduction of greenhouse gas emissions from the agriculture sector of 16% compared to 1990. In the fourth national communication, the estimated greenhouse gas emissions from the agriculture sector were reduced by 15.3% compared to 1990.

The actual development of the greenhouse gas emissions could conceivably deviate from the modelled emission, particularly if the prices, the political framework conditions or the available technologies differ from the assumptions on which the model is based. For example, swine-, poultry- and cattle- fattening could be maintained at the current level against the model projections, or the anticipated increase in performance of dairy cattle in the model could not materialize. Therefore, the projections need to be viewed considering the inherent uncertainties.

Waste

Municipal waste landfills are the second-largest source of methane emissions in Switzerland. Since 2000, landfilling of municipal solid waste has been prohibited in Switzerland. The existing sites will still emit methane in the future, but these emissions will continue to decrease, as Tab. 30 shows. The data come from a waste site model which is in line with the IPCC 1996 guidelines (activity data from Swiss waste statistics SAEFL 2004b and SFOE 2003; emission factors from SAEFL 1995a).

Other sources

Fugitive emissions from fuels are mainly losses from the gas distribution network (at present about 5% of total methane emissions in Switzerland). Despite the rapid increase in gas consumption, gas losses decreased from 1990 to 2007 due to constant upgrading of the network. In the future, a further but smaller decrease is expected. In the past, methane emission factors decreased in the transport sector but remained about constant in the other energy sectors. For the future, the emission factors from fuel combustion are taken to be constant. Therefore the emission is proportional to the energy use.

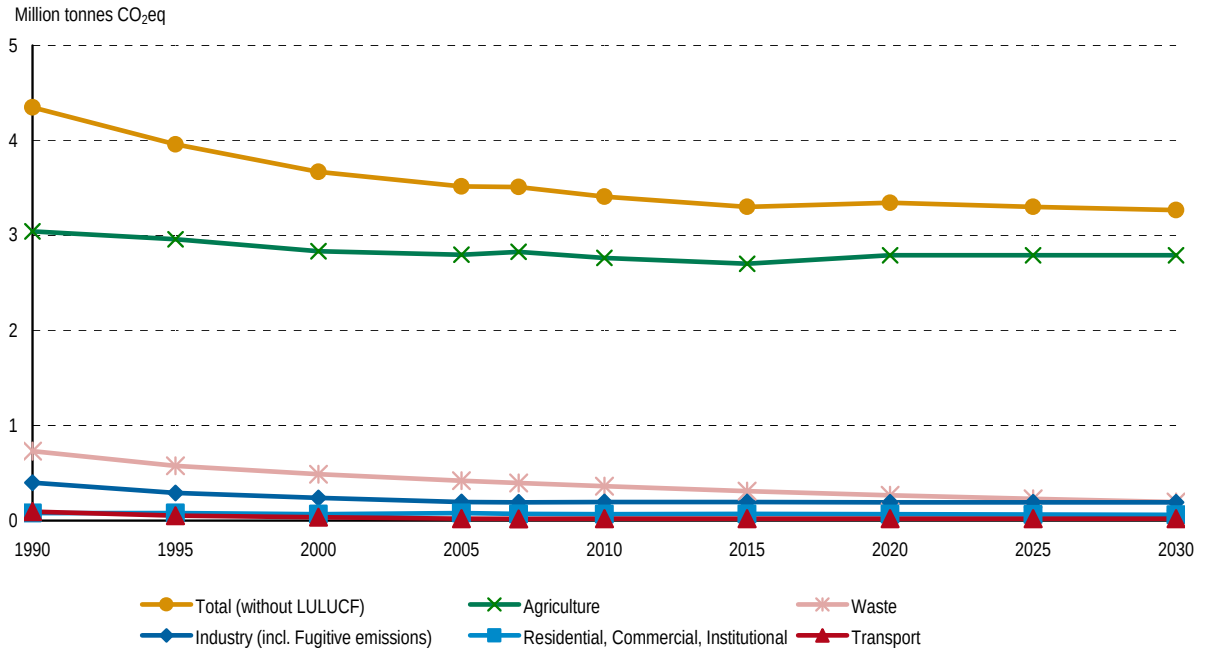
Overview

Tab. 30 and Fig. 78 show overall trends for CH_4. The most important sector is agriculture. From 1990 to 2007, emissions decreased by 7%. In the future, methane from agriculture will remain almost stable. In the waste sector as the second most important emitter, the emissions almost halved from 1990 to 2007 (ban of landfilling) and a further decrease is expected. In 2030 emissions will be less than a third of the 1990 emissions. In the energy sector a slight decrease is projected. Overall methane emissions will decrease by 25% from 1990 to 2030, but only 7% from 2007 to 2030.

Tab. 30 > Inventory data and projections for CH_4 emissions between 1990 and 2030, scenario "with measures"

	CH_4 million tonnes CO_2 equivalent										
		Inventories					Projections				
IPCC	Source/Sink Categories	1990	1995	2000	2005	2007	2010	2015	2020	2025	2030
Total	Emissions without LULUCF	4.35	3.96	3.67	3.52	3.51	3.4	3.3	3.3	3.3	3.3
1	All Energy	0.56	0.41	0.34	0.29	0.28	0.3	0.3	0.3	0.3	0.3
1A	Fuel Combustion	0.18	0.14	0.12	0.12	0.11	0.1	0.1	0.1	0.1	0.1
	1 Energy/Transformation	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0
	2 Industry	0.01	0.01	0.01	0.01	0.01	0.0	0.0	0.0	0.0	0.0
	3 Transport	0.09	0.05	0.04	0.02	0.02	0.0	0.0	0.0	0.0	0.0
	4 Other Sectors	0.08	0.08	0.07	0.08	0.07	0.1	0.1	0.1	0.1	0.1
	5 Other (Off road)	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0
1B	Fugitive Emissions	0.38	0.27	0.22	0.18	0.17	0.2	0.2	0.2	0.2	0.2
	2 Oil/Natural Gas	0.38	0.27	0.22	0.18	0.17	0.2	0.2	0.2	0.2	0.2
2	Industrial Processes	0.01	0.01	0.01	0.01	0.01	0.0	0.0	0.0	0.0	0.0
3	Solvent Use	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0
4	Agriculture	3.04	2.96	2.83	2.80	2.83	2.8	2.7	2.8	2.8	2.8
5	LULUCF	0.01	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0
6	Waste	0.73	0.58	0.49	0.42	0.40	0.4	0.3	0.3	0.2	0.2
1A3 ai	International Bunkers	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0

Fig. 78 > CH_4 emissions by sector from 1990 to 2030, scenario "with measures"



5.1.3 N_2O

Agriculture
See section 5.1.2 for the projections of the agricultural greenhouse gas emissions.

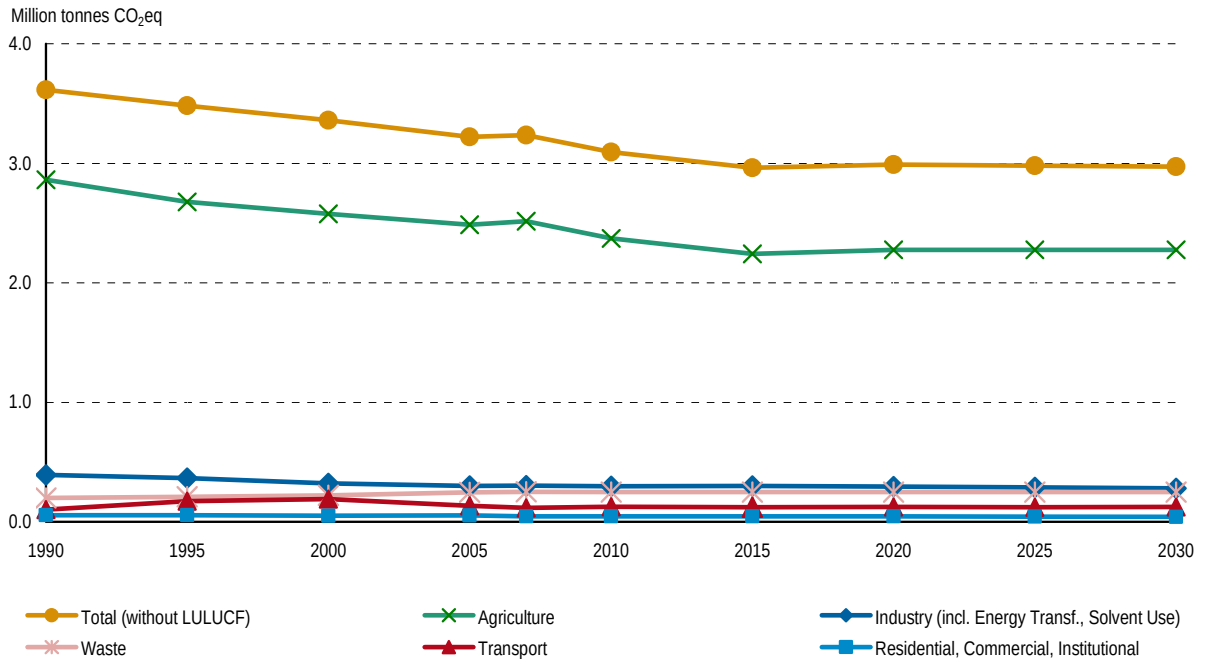
Other sources
Small amounts of N_2O are emitted by many other sources. In the transport sector, N_2O is a by-product of the catalytic conversion of exhaust gases. These emissions increased from 1990 to 2000 but decreased from 2000 to 2007 as a result of more efficient catalytic converters. In future, it is assumed that the emission factor will remain constant. Other minor sources of N_2O are wastewater handling and waste incineration, industrial processes, fuel combustion, medical treatment, etc. These emissions will follow the general trend of the underlying activity data, which are assumed to be more or less constant until 2030.

Overview
The main source of N_2O emissions is agriculture. It is responsible for about 80% of total N_2O emissions. Tab. 31 and Fig. 79 show that overall emissions are expected to decrease by 15% from 1990 to 2030 and by 5% from 2007 to 2030. In the energy and the waste sector no significant changes of N_2O emissions have been observed in past years and are not expected in the coming years.

Tab. 31 > Inventory data and projections for N_2O emissions between 1990 and 2030, scenario "with measures"

	N_2O million tonnes CO_2 equivalent										
		Inventories					Projections				
IPCC	Source/Sink Categories	1990	1995	2000	2005	2007	2010	2015	2020	2025	2030
Total	Emissions without Removals (and without Int. Bunkers)	3.61	3.48	3.36	3.22	3.24	3.1	3.0	3.0	3.0	3.0
1	All Energy	0.27	0.34	0.39	0.36	0.33	0.3	0.3	0.3	0.3	0.3
1A	Fuel Combustion	0.27	0.34	0.39	0.36	0.33	0.3	0.3	0.3	0.3	0.3
	1 Energy/Transformation	0.05	0.07	0.10	0.12	0.12	0.1	0.1	0.1	0.1	0.1
	2 Industry	0.05	0.04	0.04	0.04	0.04	0.0	0.0	0.0	0.0	0.0
	3 Transport	0.10	0.17	0.19	0.13	0.12	0.1	0.1	0.1	0.1	0.1
	4 Other Sectors	0.06	0.06	0.05	0.05	0.05	0.0	0.0	0.0	0.0	0.0
	5 Other (Off road)	0.01	0.01	0.01	0.01	0.01	0.0	0.0	0.0	0.0	0.0
1B	Fugitive Emissions	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0
	2 Oil/Natural Gas	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0
2	Industrial Processes	0.17	0.17	0.11	0.08	0.08	0.1	0.1	0.1	0.1	0.1
3	Solvent Use	0.11	0.09	0.06	0.05	0.05	0.1	0.1	0.1	0.1	0.1
4	Agriculture	2.86	2.68	2.58	2.49	2.52	2.4	2.2	2.3	2.3	2.3
5	LULUCF	0.01	0.01	0.01	0.01	0.01	0.0	0.0	0.0	0.0	0.0
6	Waste	0.20	0.21	0.22	0.25	0.25	0.2	0.2	0.2	0.2	0.2
1A3 ai	International Bunkers	0.03	0.04	0.05	0.03	0.04	0.0	0.0	0.0	0.0	0.0

Fig. 79 > N_2O emissions by sector from 1990 to 2030, scenario "with measures"



5.1.4 Other GHGs (HFCs, PFCs, SF_6)

Tab. 32 presents inventory data and projections for emissions of synthetic gases. The results are based on a bottom-up model which covers the period from 1990 to 2020 (Carbotech 2009). The model is based on import statistics and supplemented by available information from the associations and companies concerned. Most of the synthetic gases are used in products. For these applications, the model makes assumptions about product lifetime and emission factors for assembly, operation and disposal. The following trends are assumed for the projections:

- commercial refrigeration and mobile air conditioning: steady and decreasing after 2015
- stationary air conditioning: steady
- electrical equipment, solvents and foam blowing: steady
- aluminium production and use in aerosols and window insulation: decreasing.

The trend between 2010 and 2030 is uncertain, especially for the period after 2020. In the most important sectors (refrigeration and air conditioning), technological developments (e.g. use of CO_2 instead of HFC-134 as a refrigerant) may reduce HFC emissions. For PFCs and SF_6, as no major changes are expected, emissions are assumed to remain relatively stable after 2010.

Tab. 32 > Projected emissions of synthetic gases between 1990 and 2030, scenario "with measures"

Brackets indicate a high degree of uncertainty.

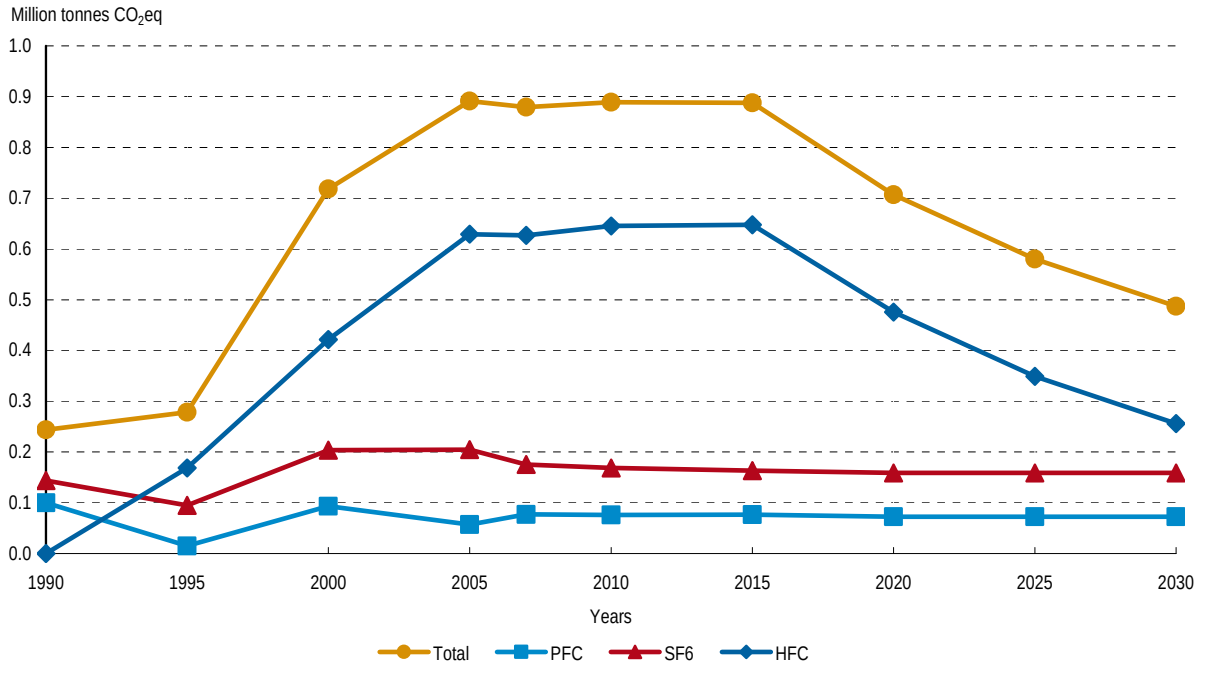
HFC, PFC, SF_6

Million tonnes CO_2 equivalents

	Inventories					Projections				
	1990	1995	2000	2005	2007	2010	2015	2020	2025	2030
HFC	0.00	0.17	0.42	0.63	0.63	0.6	0.6	0.5	(0.3)	(0.3)
PFC	0.10	0.01	0.09	0.06	0.08	0.1	0.1	0.1	(0.1)	(0.1)
SF_6	0.14	0.09	0.20	0.20	0.18	0.2	0.2	0.2	(0.2)	(0.2)
Total	0.24	0.28	0.72	0.89	0.88	0.9	0.9	0.7	(0.6)	(0.5)

Modified from Carbotech (2009)

Fig. 80 > HFC, PFC, SF6 emissions from 1990 to 2030, scenario "with measures"



Modified from Carbotech (2009)

5.1.5 Precursors

Trends and projections for NO_x

The Swiss NO_x emissions (NO and NO_2, expressed as NO_2 equivalent) decreased from 155.59 Gg in 1990 to 78.07 Gg in 2007, which corresponds to a decrease of 50%. Main contributor in 2007 is the energy sector with a share of 93% of the national total. The decrease of emissions in the energy sector is mainly due to the abatement of exhaust emissions from road vehicles and fuel combustion for domestic, commer-

cial and institutional heating. A successful reduction measure was the mandatory equipment of new passenger cars with three-way catalysts due to new emission standards in the late 80s and the subsequent adaptation of European emission standards (Euro 2, Euro 3, etc.).

In the period 1990–2007, the number of buildings and apartments increased, as well as the average floor space per person and workplace. Both phenomena resulted in an increase in the total area heated. Over the same period, however, higher standards were specified for insulation and for combustion equipment efficiency for both new and renovated buildings including low-NO_x standards, compensating for the emissions of all air pollutants (and GHG) from the additional area heated.

The decreasing trend is expected to continue. By 2020, the annual national total should reach 51.93 Gg, corresponding to 33% of the total in 1990. It is expected that the Gothenburg target for 2010 will be reached. The reduction should be achieved with improved emission technology for road vehicles (Euro 5, Euro 6) and domestic and commercial heating (better insulation of buildings, higher share of renewable energies).

Tab. 33 > NO_x emissions per NFR sector for 1990 and 2007 and projections for 2010, 2015, 2020

NO_X emissions	1990	2007	2010	2015	2020
Sectors	million tonnes	million tonnes	million tonnes	million tonnes	million tonnes
1 Energy	149.20	72.76	63.31	53.43	46.70
1A Fuel Combustion	*148.84*	*72.51*	*63.02*	*53.14*	*46.42*
1B Fugitive Emissions from Fuels	*0.36*	*0.25*	*0.28*	*0.29*	*0.28*
2 Industrial Processes	0.53	0.38	0.42	0.41	0.41
3 Solvent and other Product Use	0.01	0.01	0.01	0.01	0.01
4 Agriculture	5.41	4.56	4.33	4.21	4.14
5 LULUCF	NA	NA	NA	NA	NA
6 Waste	0.44	0.37	0.44	0.56	0.68
National total	155.59	78.07	68.51	58.62	51.93

FOEN (2009g)

Trends and projections for CO

The Swiss CO emissions decreased from 670.04 Gg in 1990 to 294.91 Gg in 2007, which equals a decrease of 57%. Main contributor is the energy sector with a share of 94.6% of the national total. The decrease of emissions in the energy sector is mainly due to the abatement of exhaust emissions from road vehicles and fuel combustion for domestic, commercial and institutional heating, as mentioned above for NO_x. The decreasing trend is expected to continue. By 2020, the annual national total should be reduced to 188.48 Gg, corresponding to 28% of the total in 1990.

Tab. 34 > CO emissions per NFR sector for 1990 and 2007 and projections for 2010, 2015, 2020

CO emissions	1990	2007	2010	2015	2020
Sectors	million tonnes	million tonnes	million tonnes	million tonnes	million tonnes
1 Energy	644.06	278.95	241.43	197.71	173.07
1A Fuel Combustion	*643.98*	*278.89*	*241.37*	*197.64*	*173.00*
1B Fugitive Emissions from Fuels	*0.08*	*0.06*	*0.07*	*0.07*	*0.07*
2 Industrial Processes	15.97	6.77	6.49	6.12	5.78
3 Solvent and other Product Use	0.02	0.02	0.02	0.03	0.03
4 Agriculture	7.28	7.28	7.28	7.28	7.28
5 LULUCF	NA	NA	NA	NA	NA
6 Waste	2.72	1.89	1.98	2.15	2.33
National total	670.04	294.91	257.20	213.28	188.48
FOEN (2009g)					

Trends and projections for NMVOC

The Swiss NMVOC emissions decreased from 283.24 Gg in 1990 to 94.66 Gg in 2007, which equals a decrease of 67%. Main contributors in 2007 are the sectors solvent and other product use (49%) and energy (32%). The NMVOC emissions from solvent and other product use have diminished since 1990 due to limitations enforced by the Ordinance on Air Pollution Control (Swiss Confederation 1985) and due to the introduction of the VOC tax in 2000 (Swiss Confederation 1997). In the energy sector, the decrease of emissions is mainly due to the abatement of exhaust, evaporation and cold-start emissions from road vehicles. The decreasing trend is expected to continue. By 2020 the annual national total should be reduced to 79 Gg, or 28% of the total in 1990. It is expected that the Gothenburg target 2010 will be reached.

Tab. 35 > NMVOC emissions per NFR sector for 1990 and 2007 and projections for 2010, 2015, 2020.

NMVOC emissions	1990	2007	2010	2015	2020
Sectors	million tonnes	million tonnes	million tonnes	million tonnes	million tonnes
1 Energy	121.70	30.39	26.09	21.43	18.91
1A Fuel Combustion	*101.01*	*24.44*	*20.17*	*15.86*	*13.70*
1B Fugitive Emissions from Fuels	*20.69*	*5.95*	*5.92*	*5.57*	*5.21*
2 Industrial Processes	15.00	10.94	8.83	8.61	9.30
3 Solvent and other Product Use	140.61	46.58	45.25	43.05	40.66
4 Agriculture	4.63	4.64	4.64	4.64	4.64
5 LULUCF	NA	NA	NA	NA	NA
6 Waste	1.29	2.12	2.26	2.49	2.71
National total	283.24	94.66	87.07	80.22	76.21
FOEN (2009g)					

Trends and projections for SO_x

The Swiss SO_x emissions (SO and SO_2, expressed as SO_2 equivalent) decreased from 40.98 Gg in 1990 to 13.64 Gg in 2007, which equals a decrease of 67%. Main contributor in 2007 is the energy sector with a share of 84.3% of the national total. Additional important contributors are industrial processes (14.5%). The limitation of sulphur content in fuels by the Ordinance on Air Pollution Control (Swiss Confederation 1985) led to a significant decrease of sulphur oxide emissions from heating (gas oil) and from diesel cars. A substantial substitution of heating oil by natural gas (its consumption almost doubled from 1990 to 2007) resulted in further reductions of sulphur emissions, see Tab. 36. A similar substitution of gas oil and even of heavy fuel oil by natural gas decreased the sulphur emissions in manufacturing industries. The decreasing trend is expected to continue. By 2020, the annual national total should be reduced to 8.79 Gg, corresponding to 21% of the total in 1990. It is expected that the Gothenburg target 2010 will be reached.

Tab. 36 > SO_x emissions per NFR sector for 1990 and 2007 and projections for 2010, 2015 and 2020.

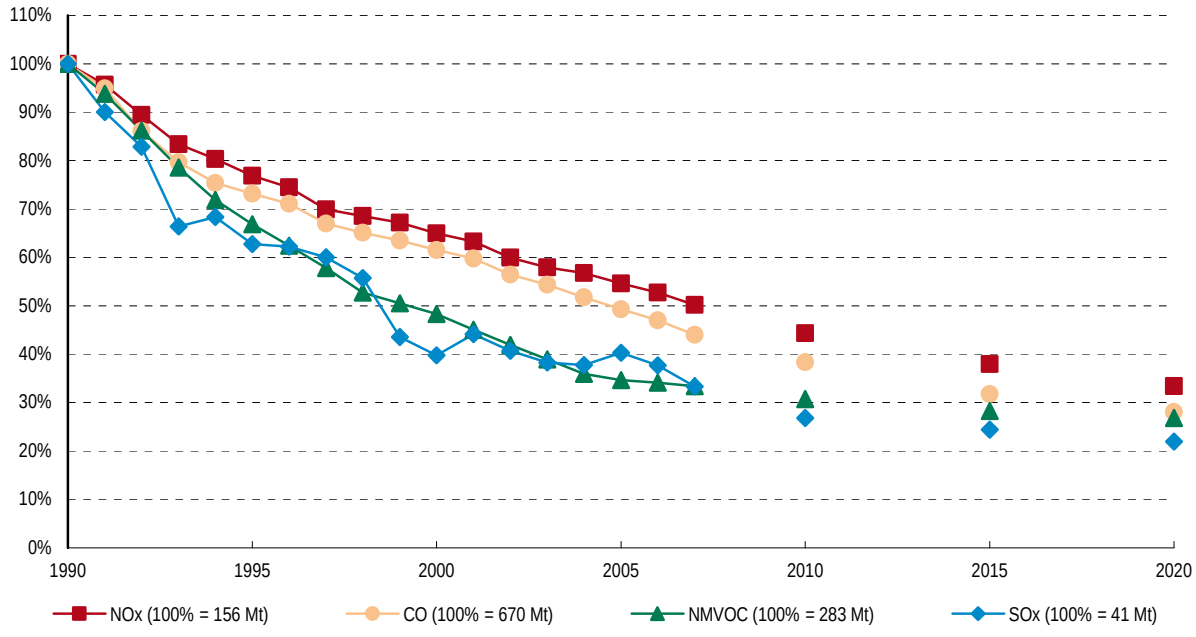
SOx emissions	1990	2007	2010	2015	2020
Sectors	million tonnes	million tonnes	million tonnes	million tonnes	million tonnes
1 Energy	36.72	11.51	8.98	7.37	5.46
1A Fuel Combustion	*36.53*	*11.22*	*8.66*	*7.06*	*5.14*
1B Fugitive Emissions from Fuels	*0.19*	*0.29*	*0.32*	*0.32*	*0.32*
2 Industrial Processes	4.01	1.98	1.83	1.82	1.80
3 Solvent and other Product Use	0.01	0.01	0.01	0.01	0.01
4 Agriculture	0.05	0.05	0.05	0.05	0.05
5 LULUCF	NA	NA	NA	NA	NA
6 Waste	0.21	0.09	0.40	0.93	1.47
National total	40.98	13.64	11.27	10.18	8.79

FOEN (2009g)

Overview

Emission trends for the air pollutants NO_x, CO, NMVOC and SO_x show a significant decline (Fig. 81). From 1990 to 2007, a strict air pollution control policy and the implementation of a large number of emission reduction measures led to a decrease of about 50% in emissions of air pollutants. The main reduction measures were abatement of exhaust emissions from road vehicles and stationary combustion equipment, taxation of solvents and sulphured fuels, and voluntary agreements with industry sectors.

Fig. 81 > NO_x, CO, NMVOC, SO_x emissions from 1990 to 2020



FOEN (2009g)

5.2 Aggregate effects of policies and measures

5.2.1 Scenario "without measures"

The scenario "without measures" estimates the evolution of greenhouse gas emissions from 1990 to 2020 in the absence of measures relating to climate and energy policy that have been taken since 1990. The development in the period 1990–2020 is presented in five-year steps. All of the greenhouse gases listed in the Kyoto-Protocol are taken into account, however, emphasis is laid on CO_2 emissions, and only rough estimates are made for the other gases. For this scenario, only those measures relating to energy and climate policy which were implemented in the period from 1990 to 2005 were taken into account. Measures that took effect after 2005, such as the CO_2 levy on heating fuels, the federal building programme, the domestic contributions of the Climate Cent Foundation, as well as new tax incentives in the transportation sector (tax exemption for biofuels, coordinated, nationwide introduction of consumption-based Cantonal taxes on motor vehicles) , are also taken into account (Tab. 37).

In order to estimate the development of emissions without measures for the period from 1990 to 2020, a three-stage, bottom-up process was selected. The reference scenario for the period from 1990 to 2020 corresponds to the actual greenhouse gas emissions up to the year 2005 and the expected emissions from 2010 onwards, as shown in the scenario "with measures"(see p.123).

In a next step, the effect of the measures taken since 1990 is estimated. All relevant measures in the fields of energy and climate policy since 1990 that were implemented through the year 2005 are taken into account, as well as the measures mentioned above (CO_2 levy on fuels, federal building programme, domestic contributions of the Climate Cent Foundation, and tax incentives in the transport sector). For the period 1990–2005, the effects are based on existing studies and literature. Since the measures were not introduced at the same time, the effect of individual measures spans different time periods. For the period 2010 to 2020, the estimated effects are based – where available – on prognoses and model calculations. Where no suitable basis exists, estimates are made under consideration of anticipated developments and assumed effects through to the year 2020.

Determining if and to what degree the demonstrated effects are actually attributable to these measures or if they are instead mainly a consequence of technological progress is a central challenge. Correspondingly, different additionalities ranging from 30% and 100% are used to derive an estimated effect on greenhouse gas emissions for each measure over the period 1990-2020 in five year increments. The various assumptions and data sources lead to a range of the estimated effects on greenhouse gas emissions for most of these measures.

Finally, the development of emissions without measures is estimated: The starting point for determining the development of emissions without measures is the reference scenario for the period 1990–2020 ("with measures"). The effects of individual measures are converted into CO_2 equivalents and added together. In order to avoid double counting, effects of overlapping measures are estimated and filtered out. The total emissions savings (i.e. negative emissions) of all measures are subtracted from the reference development, resulting in the scenario "without measures" for the period 1990-2020. The spread of the effects on greenhouse gas emissions gives insight into the imprecision and sensitivity of the estimates.

Tab. 37 gives an overview of policies and measures that have been analysed, with details on areas targeted, greenhouse gases affected, instruments used, status, and implementing entity. Tab. 38 gives an overview of the estimated emission reductions resulting from these measures. The effects, which are given as a range in some instances, are displayed in five-year increments over the period 1990–2020. For some measures, no estimate of effects could be made, as indicated in the table. In particular the effects of 'softer measures', e.g. the information campaigns carried out in the framework of EnergieSchweiz, are difficult to estimate. On the other hand, the effect of 'harder measures', such as the Ordinance on Air Pollution Control, are more easily measured. The effects of some measures were not considered quantitatively: This includes

measures such as forestry policy or Energie 2000, whose effects can only be described qualitatively, measures that had no effect on greenhouse gas emissions so far (e.g. the requirements on devices and plants under Art. 8 of the Energy Act), measures that have not yet been fully implemented (such as NRLA), and measures that are only aimed at a particular behaviour pattern in the populace (e.g. pure marketing actions).

The differentiation between measures are not always evident. Wherever possible, double counting was avoided (e.g. the effects of the Cantonal building programme and the agreements of the EnAW with trade and industry were not accounted for under EnergieSchweiz). There were, however, measures that were promoted and implemented by several offices and agencies whose effects cannot be easily classified.

The total estimated emissions savings from the measures investigated is rather small for the first years and then increases to 1.9 million tonnes CO_2 equivalents in 2005 (Tab. 38). For the year 2010, the estimated effects show a substantial increase to 4.5 million tonnes CO_2 equivalents. The rate of increase then slightly decreases. In the year 2020 a total annual reduction of around 5.9 million tonnes of CO_2 equivalents is estimated.

The average estimated emissions savings for the measures investigated are presented in Fig. 82. Although a comparison of the effects of the various measures is easily possible, due consideration has to be given to the large qualitative differences and inhomogeneities in the estimates that hamper such a comparison.

Fig. 83 shows the greenhouse gas emissions "without measures" in comparison to the reference scenario "with measures". The range of the scenario "without measures" increases over time. In the year 2005, it spans from 1.66 to 2.25 million tonnes CO_2 equivalents, and in the year 2020, from 5.05 to 7.36 million tonnes CO_2 equivalents, reflecting the increasing uncertainty in the estimates.

In spite of uncertainties and gaps in the data, it can be asserted that the measures taken in Swiss energy and climate policy since 1990 have proven effective and have contributed to the stabilisation of Switzerland's greenhouse gas emissions. The development of greenhouse gas emissions in Switzerland would have been significantly higher without the measures taken since 1990: in the year 2010, the estimated effect of the implemented policies and measures comes to 4 to 5 million tonnes of CO_2 equivalents, in 2020 to 5 to 7 million tonnes of CO_2 equivalents (econcept 2009). The ex-post analysis of energy policy (SFOE 2008c) produced comparable estimates of effects.

Tab. 37 > Overview of measures considered in the scenario "without measures"

Name of policy or measure	Objective and/or activity affected	GHG affected	Type of instrument	Status	Implementing entity
Agreements with trade and industry	Emission reductions to obtain exemption from CO_2 levy	CO_2	voluntary/negotiated	implemented, ongoing	EnAW, audited by FOEN/SFOE
Agreement with Cemsuisse	Reduction of CO_2 emission to obtain exemption from CO_2 levy	CO_2	voluntary/negotiated	implemented	BAFU, Cemsuisse
Requirements on fossil-fuel operated power plants (Art. 6 Energy Act)	Increased use of renewable energy sources	CO_2	legislation	implemented	SFOE, cantons
Requirements on devices and plants(Art. 8 Energy Act)	Increased energy efficiency	CO_2	legislation	implemented	SFOE, cantons
Voluntary measures within EnergieSchweiz	Reduction of greenhouse gas emissions	CO_2, N_2O	voluntary	implemented	SFOE
CO_2 levy	Promotion of energy efficiency and less CO_2 intensive energy sources	CO_2	fiscal	implemented	FOEN
Federal building programme	refurbishment of buildings, promotion of renewable energy	CO_2	financial	implemented	FOEN/SFOE
Climate cent	Mitigation projects within Switzerland	CO_2	negotiated	implemented	Climate Cent Foundation
Cantonal building programme	supplementary to national building programmes	CO_2	financial	implemented	Cantons/ SFOE
Building codes (MuKEn modules)	energy consumption of buildings	CO_2	legislation	1992 model ordinance MuKEn 2000 MuKEn 2008	Cantons in coordination with SFOE
Ordinance on Air Pollution Control and incentive tax on VOC	Protection of the environment, emission reduction of air pollutants	various, mainly NMVOC	legislation, fiscal	implemented	FOEN
Heavy vehicle fee (HVF) and supporting modal shift policies	Reduction of transalpine traffic, increased transport rates on rail	CO_2	fiscal, financial and infrastructure	implemented	ARE
Agglomeration programme	Improvements to public transportation	CO_2	financial and infrastructure	implemented	ARE/ cantons
Energy label for passenger cars, voluntary agreement with auto-schweiz	Reduce average fuel consumption of new cars	CO_2	voluntary	implemented	auto-schweiz in collab. with SFOE
Promotion of sulphur-free transport fuels	Reduction sulphur-containing fuels	CO_2	fiscal	implemented	FOEN
Tax incentives for low-emission vehicle and biofuels	Promotion of low-consumption vehicles	CO_2	financial	ongoing process of implementation in the cantons	Cantons
Synthetic greenhouse gases	Reduction of the use of synthetic greenhouse gases in all sectors	HFCs, PFCs, SF_6	legislation	implemented	FOEN, cantons
Agricultural policy		CH_4 N_2O	-	-	FOAG
Technical ordinance on waste, ban on landfilling combustible waste	Reduction of methane emissions	CO_2, CH_4	legislation	implemented	FOEN
Forestry policy and Wood 21	Sustainable forest management, increased use of wood as fuel	CO_2	legislation, information	implemented	FOEN

econcept (2009)

Tab. 38 > Estimated effect of measures taken since 1990

Measures	Emission reduction per year (million tonnes CO_2 equivalents)							Reference
	1990	1995	2000	2005	2010	2015	2020	
Agreements with trade and industry	-	-	-	0.10 – 0.14	0.38 – 0.50	0.45 – 0.60	0.45 – 0.60	Infras 2008b, EnAW 2003-2008, Weisskopf-Partner 2009
Agreement with Cemsuisse	-	-	n.d.	n.d.	n.d.	n.d.	n.d.	-
Requirements on fossil-fuel operated power plants (Art. 6 Energy Act)	-	-	n.d.	n.d.	n.d.	n.d.	n.d.	-
Requirements on devices and plants (Art. 8 Energy Act)	-	-	n.d.	n.d.	n.d.	n.d.	n.d.	-
Voluntary measures within EnergieSchweiz	-	-	-	0.39-0.48	0.55 – 0.82	0.45 – 0.75	0.45 – 0.75	Infras 2002b-2007b, Interface 1999
CO_2 levy	-	-	-	-	0.70	0.35	0.35	Swiss Federal Council 2005, estimates FOEN
Federal building programme	-	-	-	-	0.30	0.70	0.70	Swiss Federal Council 2009a, estimates FOEN
Climate Cent	-	-	-	-	0.20	0.10	0.10	DETEC 2009, estimates FOEN
Cantonal building programme	-	-	0	0.06 – 0.11	0.17 – 0.29	0.17 – 0.29	0.17 – 0.29	EnergieSchweiz 2006b-2008b, econcept 2006, Energie-Schweiz 2008c
Building codes (MuKEn modules)	0	0.24– 0.32	0.5 –0.66	0.74 –1.05	0.62 –1.11	0.77 –1.43	1.33 –2.17	AWEL 2003, SFOE 2004a, SFOE 2007c-d, SFOE 2007i, EnDK 2008
Ordinance on Air Pollution Control and incentive tax on VOC	0	0.04	0.07	0.09	0.12	0.12	0.12	FOEN 2008, FOEN 2008i
Heavy vehicle fee (HVF) and supporting modal shift policies	-	-	-	0.11	0.13 – 0.18	0.13 – 0.19	0.15 – 0.20	ARE 2002a, ARE 2007a, Swiss Federal Council 2007.
Agglomeration programme	-	-	0.02– 0.04	0.07 –0.14	0.12 – 0.23	0.17 – 0.33	0.22 – 0.43	AFV 2005
Energy label for passenger cars, voluntary agreement with auto-schweiz[a]	-	-	-	i.e.	i.e.	i.e.	i.e.	SFOE 2005a
Promotion of sulphur-free transport fuels	-	-	-	n.d.	n.d.	n.d.	n.d.	-
Tax incentives for low-emission vehicles and biofuels	-	-	-	-	0.10	0.10	0.10	estimates FOEN
Synthetic greenhouse gases	-	-	0	0.07 –0.10	0.40 – 0.60*	0.59 – 1.03*	0.73 – 1.37*	FOEN 2009
Agricultural policy	-	-	-	-	n.d.	n.d.	n.d.	-
Technical ordinance on waste, ban on landfilling combustible waste	-	-	0	0.03	0.11	0.16	0.18	FOEN-Model, FOEN 2008
Forestry policy and Wood 21	-	-	-	n.d.	n.d.	n.d.	n.d.	-
Total of estimated effects	0	0.28 –0.36	0.59 –0.77	1.66 –2.25	3.90 –5.26	4.26 –6.15	5.05 – 7.36	
Average effects	0	0.32	0.68	1.94	4.48	4.99	5.89	

econcept (2009)

- : Measure does not exist

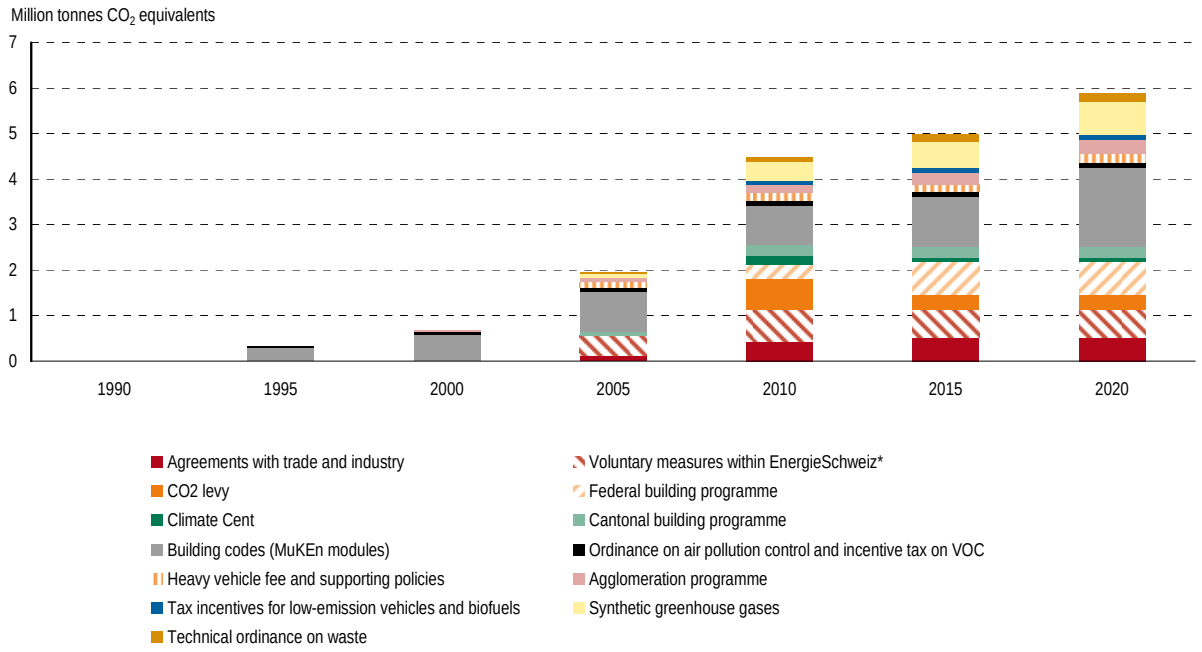
n.d.: no data

i.e.: included elsewhere. E.ECH: Effects under EnergieSchweiz taken into account

a: Included under effects of EnergieSchweiz

*: Values are highly uncertain. The lower value is taken for the average effects

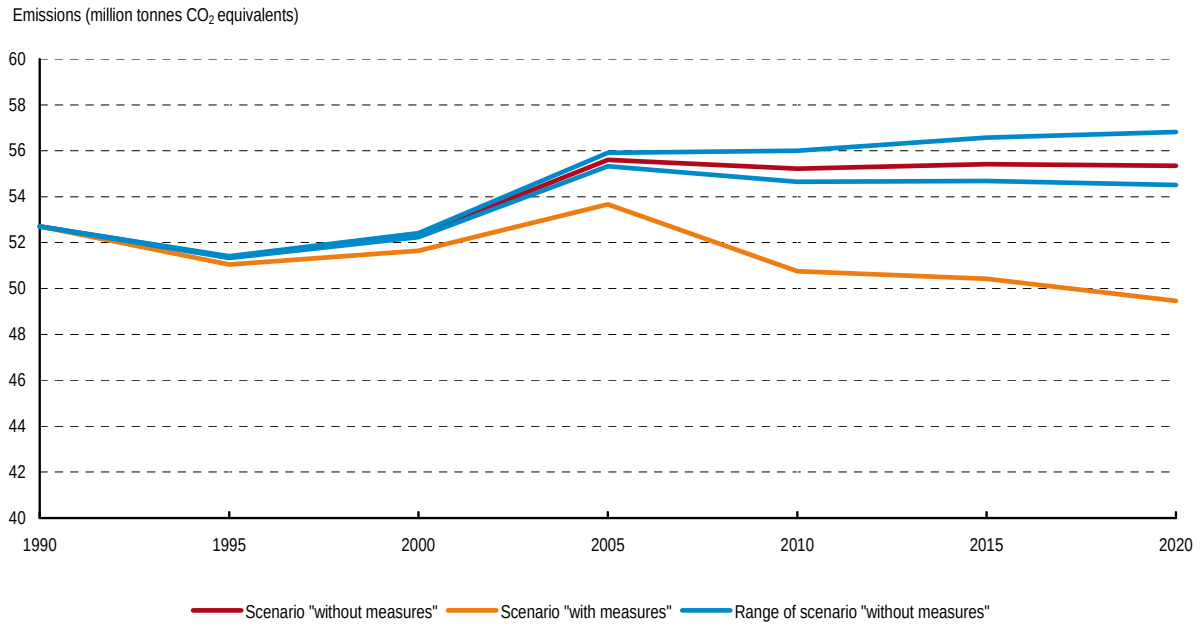
Fig. 82 > Estimated emission reduction for each measure for the period 1990–2020



econcept (2009)

*: Estimates for voluntary measures within EnergieSchweiz are without the effect of Energie2000, the agreements with trade and industry, and the Cantonal building programme.

Fig. 83 > Scenario "without measures" in comparison to the reference scenario "with measures"



econcept (2009)

5.2.2 Scenario "with measures"

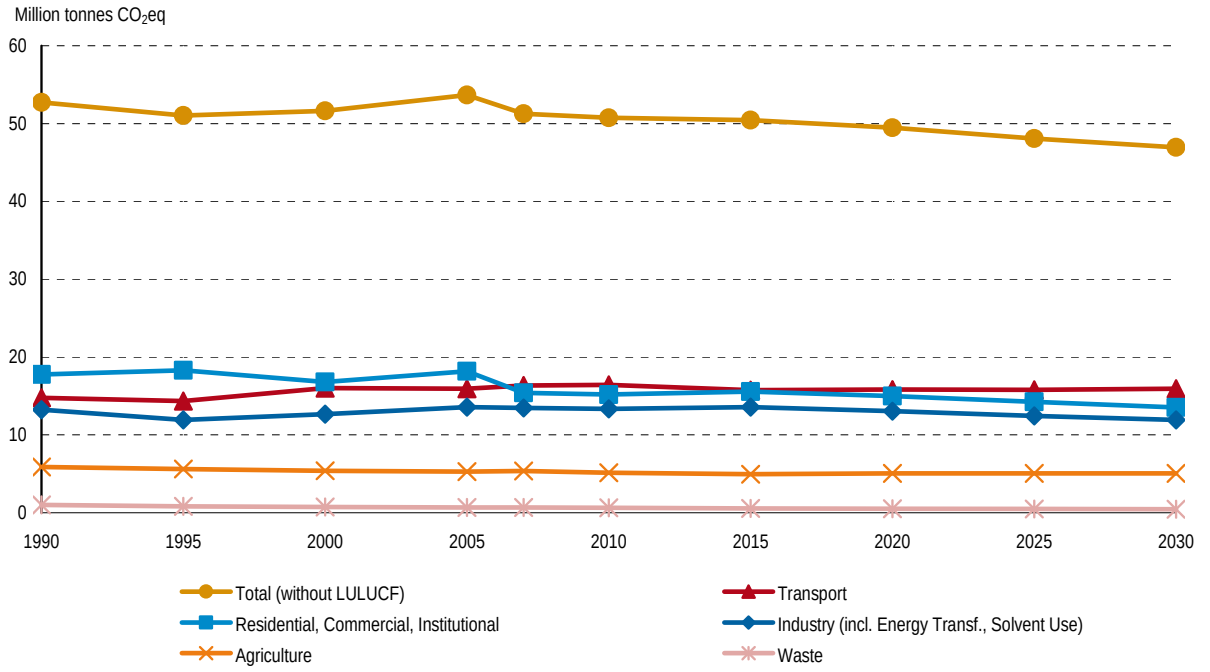
The aggregate effects of current policies and measures on GHG emissions are illustrated in Tab. 39, Tab. 40 and Fig. 84, Fig. 85, and Fig. 86. The figures shown are the CO_2 equivalent emissions of CO_2, CH_4, N_2O, HFCs, PFCs and SF_6. The 2020/2030 projections are based on the study by ecoplan (2009a) taking into account the measures introduced between 2005 and 2008 (CO_2 levy, energy action plan, building renovation programme, incentives for biofuels; see section 5.1.1 Scenario "with measures implemented"). The projections for 2010 are taken from an econometric short-term model (ecoplan 2009b) which was developed to cover the commitment period 2008 – 2012. This model will be updated every year after having the emission data of the past year available. The short-term model is capable of introducing year to year changes in input variables (e.g. negative GDP growth for 2009). The long-term model uses smoothed input data and cannot reflect short-term effects. The projections show an overall reduction of 3.2 million tonnes between 1990 and 2020, corresponding to 6.2% and 5.7 million tonnes between 1990 and 2030 (10.9%) For this period, CO_2, CH_4 and N_2O decrease by about 10%, 25% and 18%, respectively. Emissions of synthetic gases increase by a factor of 2.

Tab. 39 > Total GHG emissions by sector between 1990 and 2030, scenario "with measures"

Brackets indicate a high degree of uncertainty

	Total GHG emissions million tonnes CO_2 equivalents										
		Inventories					Projections				
IPCC	Source/Sink Categories	1990	1995	2000	2005	2007	2010	2015	2020	2025	2030
Total	Emissions without LULUCF	52.71	51.04	51.65	53.66	51.26	50.7	50.4	49.5	48.1	47.0
	% change to 1990		-3.16%	-2.01%	1.81%	-2.75%	-3.7%	-4.3%	-6.2%	-8.8%	-10.9%
1	All Energy	42.09	41.65	42.43	44.39	41.97	41.7	41.6	40.7	39.5	38.5
1A	Fuel Combustion	41.57	41.26	42.10	44.11	41.69	41.4	41.3	40.5	39.2	38.3
	1 Energy/Transformation	2.55	2.62	2.89	3.53	3.46	3.4	3.5	3.4	3.2	3.0
	2 Industry	6.01	5.44	5.80	5.86	5.86	5.8	5.9	5.7	5.4	5.1
	3 Transport	14.77	14.38	16.02	15.94	16.35	16.4	15.8	15.8	15.8	16.0
	4 Other Sectors	17.79	18.30	16.81	18.18	15.43	15.2	15.6	15.0	14.3	13.5
	5 Other (Off road)	0.45	0.53	0.59	0.60	0.60	0.6	0.6	0.6	0.6	0.6
1B	Fugitive Emissions	0.52	0.39	0.33	0.28	0.28	0.3	0.3	0.3	0.3	0.3
	2 Oil/Natural Gas	0.52	0.39	0.33	0.28	0.28	0.3	0.3	0.3	0.3	0.3
2	Industrial Processes	3.26	2.56	2.79	3.08	3.06	3.1	3.1	2.9	2.8	2.7
3	Solvent Use	0.47	0.37	0.28	0.23	0.23	0.2	0.2	0.2	0.2	0.2
4	Agriculture	5.90	5.64	5.41	5.28	5.35	5.1	4.9	5.1	5.1	5.1
5	LULUCF	-2.34	-5.29	0.75	0.86	-0.65	0.7	1.4	2.1	(2.7)	(2.7)
6	Waste	0.99	0.82	0.73	0.68	0.66	0.6	0.6	0.5	0.5	0.5
1A3 ai	International Bunkers	3.10	3.69	4.71	3.52	3.96	4.5	5.0	5.6	(5.6)	(5.6)

Fig. 84 > Total GHG emissions by sector from 1990 to 2030, scenario "with measures"



Tab. 40 > GHG emissions by gas between 1990 and 2030, scenario "with measures"

Brackets indicate a high degree of uncertainty

Total GHG emissions

Million tonnes CO_2 equivalents

	Inventory					Projections				
Gas	1990	1995	2000	2005	2007	2010	2015	2020	2025	2030
CO_2	44.50	43.32	43.90	46.04	43.64	43.4	43.3	42.4	41.2	40.2
CH_4	4.35	3.96	3.67	3.52	3.51	3.4	3.3	3.3	3.3	3.3
N_2O	3.61	3.48	3.36	3.22	3.24	3.1	3.0	3.0	3.0	3.0
HFC	0.00	0.17	0.42	0.63	0.63	0.6	0.6	0.5	(0.3)	(0.3)
PFC	0.10	0.01	0.09	0.06	0.08	0.1	0.1	0.1	(0.1)	(0.1)
SF_6	0.14	0.09	0.20	0.20	0.18	0.2	0.2	0.2	(0.2)	(0.2)
Total	52.71	51.04	51.65	53.66	51.26	50.7	50.4	49.5	48.1	47.0

Fig. 85 > CO_2 equivalent emissions from 1990 to 2030, based on scenario "with measures".

Emissions in million tonnes CO_2 equivalent

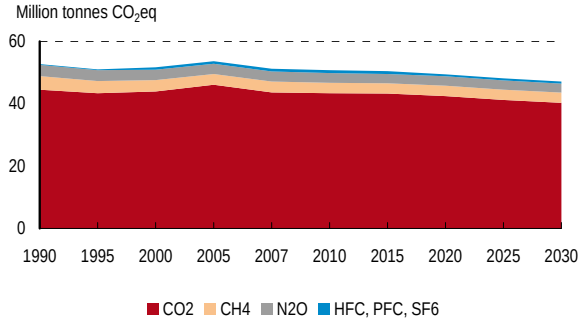
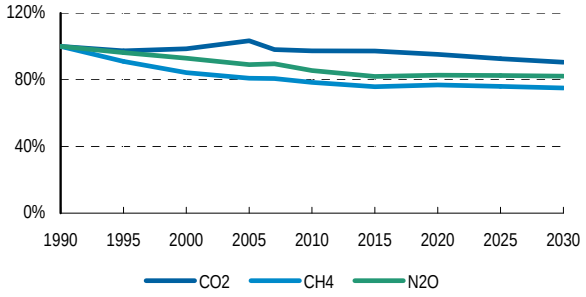


Fig. 86 > CO_2 equivalent emissions from 1990 to 2030, based on scenario "with measures". Synthetic gases not shown.

Index 1990 = 100%



Kyoto Protocol target

Under the Kyoto Protocol, Switzerland's target for CO_2 equivalent GHG emissions in the first commitment period (2008–2012) is 48.57 million tonnes per year – a reduction of 8% below 1990 levels (see Initial Report, Swiss Confederation 2007). Switzerland decided to account for forest management (Art. 3.4 KP), and Switzerland will make use of the flexible mechanisms. However, no public funds are assigned for this purpose. CO_2 credits are solely acquired by the private sector, such as the Climate Cent Foundation and companies submitted to the emissions trading scheme.

The most recent projections are presented in Tab. 41, according to which the Kyoto target can be reached. However, projections always involve uncertainties (see sensitivity analysis), so policy options are required to make allowances for alternative future developments: In case of a shortfall, Switzerland could resort to intensified use of the flexible mechanisms (i.e. buying more emission certificates). Should the Kyoto target be exceeded, Switzerland could carry over emission allowances to a second commitment period or buy fewer emission certificates.

Tab. 41 > Kyoto target

Gross and net GHG emissions during the commitment period 2008 - 2012

Kyoto Protocol emissions (million tonnes CO_2 equivalent)	
Kyoto target (assigned amount units per year, average 2008–2012)	48.57
Total projected gross GHG emissions (average 2008–2012)	50.86
Use of Kyoto mechanisms (CDM)	*-2.2*
Forest Management (Art. 3.4 KP)	*-0.35*
Net GHG emissions	*48.31*

FOEN (2009e)

Sensitivity analysis

For the commitment period 2008 - 12, a sensitivity analysis is carried out every year, with the following factors being varied: economic growth, winter temperatures (influencing the use of heating fuels), effect of measures, fossil fuel prices, price relation Switzerland-Germany (as indicator for tank tourism), and export growth (FOEN 2009e).

The sensitivity analysis indicates a margin of ±1.8 million tonnes of CO_2 equivalent for the commitment period mean (±3.5%). This means that also a target shortfall may occur during the period 2008 to 2012. This sensitivity analysis will be updated every year during the period 2008 – 12.

5.2.3 Scenario "with additional measures"

In August 2009, the Federal Council put forward a revised CO_2 Act setting reduction targets and the necessary policy instruments for the post-Kyoto period 2012 to 2020. Subject to an optional referendum after adoption by the Swiss parliament, the revised CO_2 Act should become effective as of 2013.

According to the draft, Switzerland shall reduce its greenhouse gas emissions by 20% by 2020 below 1990 levels. If other countries – especially the most important trading partners of Switzerland – decide to intensify their reduction efforts, Switzerland is willing to increase its reduction target to minus 30%, analogous to the EU.

In order to reach the reduction target of minus 20% in 2020 compared to 1990, the revised CO_2 Act comprises the following additional policy measures:

- Continuation of the CO2 levy on heating fuels (CHF 36 per tonne CO2 in 2013, possible increases in 2016 and 2019 up to a maximal amount of CHF 120 per tonne CO2)
- Building renovation programme (subsidies with a total amount of CHF 200 million per year), funded by specifically allocated revenues from the CO_2 levy on heating fuels
- Emissions trading system (ETS) for energy-intensive companies with annual reduction of the emission cap by 1.74%
- Emission performance standards for new passenger cars (in the current proposal, the fleet average to be achieved by all newly registered cars by 2015 should not exceed 130 g CO_2/km)
- Obligation for producers and importers of fossil fuels to offset 25%-30% of CO_2-emissions by CO_2 credits (mainly from CDM-projects)
- Deposit or advanced disposal fee for synthetic greenhouse gases (HPC, PFC etc.), extension of the voluntary agreement on SF_6 with the high voltage industry

If these measures turn out to be insufficient to reach the reduction target, the Federal Council can introduce a subsidiary CO_2 levy on transport fuels up to a maximal amount of CHF 120 per tonne CO_2. In case of the more ambitious 30% reduction target, three of the above-listed instruments are tightened:

- CO2 levy on heating fuel (CHF 60 per tonne CO2 in 2013, maximal amount of CHF 180 per tonne CO2)
- Emissions trading system (ETS) with annual reduction of the emission cap by 2.9%
- Obligation for producers and importers of fossil fuels to offset 40%-45% of CO_2-emissions from the transport sector

Tab. 42 shows the estimated reduction potential of the additional measures by 2020. The effects of the CO_2 levy on heating fuel, the building renovation programme, the emission standards for new passenger cars and the deposit/advanced disposal fee on synthetic greenhouse gases are entirely domestic, whereas parts of the effects of the ETS and presumably the entire effect of the obligation of the CO_2-compensation are offset outside Switzerland via the flexible mechanisms.

Tab. 42 > Estimated reduction potential of additional measures

Additional measures	Estimated annual reduction potential by 2020 (million tonnes CO_2 equivalent)	
	Reduction target minus 20%	Reduction target minus 30%
CO_2 levy on heating fuels (additional effect 2013-2020)	0.7	2.5
Building renovation programme (additional effect 2013-2020)	1.5	1.5
CO_2 emission standards for new passenger cars	1.5	1.5
Emission Trading System (domestic effect)	0.5	0.7
Deposit / advanced disposal fee for synthetic greenhouse gases	0.1	0.1
Total effect of additional domestic measures	*4.3*	*6.3*
Emissions Trading System (CDM)	0.3	0.7
CO_2-compensation of fossil transport fuels, "Climate cent": compensation of traffic emissions (CDM)	3.7	6.1
Total	*8.3*	*13.1*
Total emissions "with additional measures"	41.2	36.4
Total emissions reduction compared with emissions of 1990	-22%	-31%

FOEN (2009f)

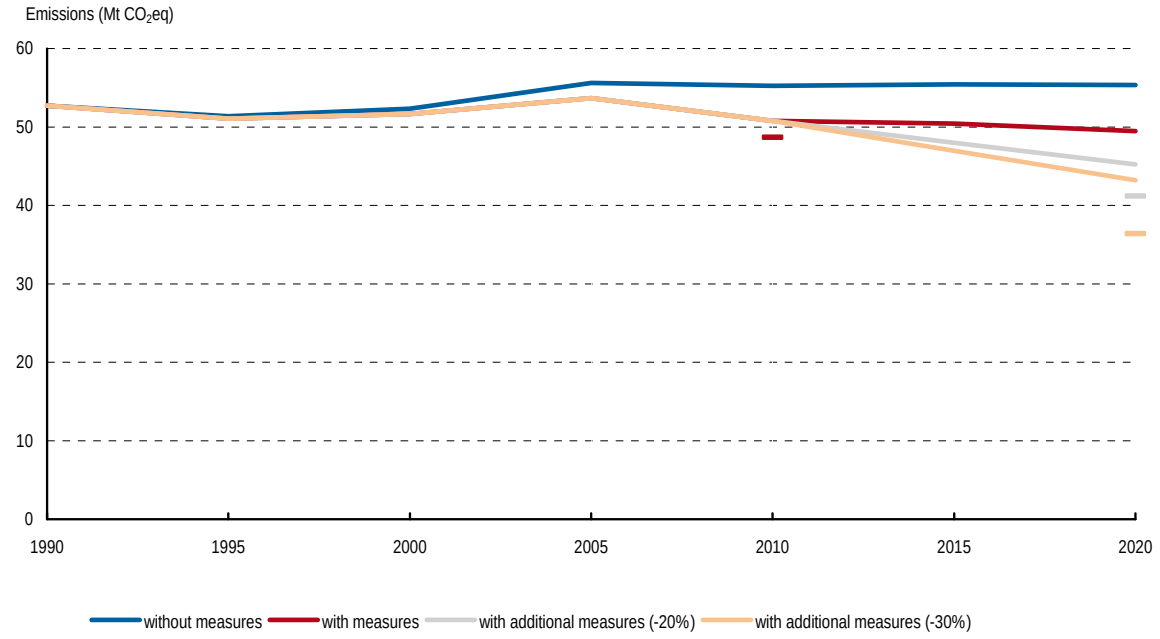
The planned measures are expected to be sufficient to reach the target of minus 20%, respectively minus 30%, by 2020. According to the simulations, the CO_2 levy on heating fuels needs to be increased to a level of maximum CHF 110 per tonne CO_2 (target of minus 20%), or CHF 180 (target of minus 30%). If the oil price rises up to 100 US dollar per barrel (instead of the constant price of 55 US dollar underlying the calculations), the CO_2 levy at CHF 36 per tonne CO_2 (respectively CHF 100) is sufficient to reach the reduction target.

The economic effects of the suggested reduction measures will be moderate and no serious structural effects will result. The reduction of the GDP until 2020 is estimated to amount to -0.2 to -0.4%. In case of a higher reduction target of minus 30% the GDP could decrease by -0.3 to -0.7%. The welfare effects are of similar magnitude – according to the simulations they will vary between -0.3 to -0.6% (target of minus 20%) and -0.5 to -0.6% (target of minus 30%). Positive secondary effects will occur especially in the form of reduced emissions of air pollutants. This effect in 2020 will amount to approximately 0.04 to 0.06% of GDP.

The scenarios "without measures", "with measures" and "with additional measures" (2 subscenarios) are presented in Fig. 87. The changes in emissions from 1990 to 2020 are: without measures + 5%, with measures -6%, and with additional measures -14% and -18%, depending on the subscenario. The reduction targets of -20% and -30% will be reached by complementary use of the flexible mechanisms through the compensation requirements imposed on fossil transport fuels.

Fig. 87 > Total GHG emissions for different scenarios from 1990 to 2020

Estimated emissions for different scenarios form 1990 to 2020. The lines correspond to the domestic emissions. Use of the flexible mechanisms to purchase emission certificates is part of the Swiss mitigation strategy. The combined effect of domestic and supplementary emission reductions is marked with bold bars in 2010 and 2020.



Several studies on greenhouse gas reduction scenarios as well as energy perspectives were published in the past years. McKinsey&Company Switzerland (McKinsey&Company 2009) quantified abatement costs for different measures and thus injected a basis for the ongoing intensive debate concerning the economic and technical feasibility of different reduction targets. The McKinsey study aimed at offering a fact base and a uniform data set for policy makers, corporate leaders and academics for discussing priorities of emission reductions.

Furthermore, the Swiss Academies of Arts and Sciences presented the scientific view on the future development of energy supply and demand (Swiss Academies of Arts and Sciences 2007). The Road Map Renewable Energy Switzerland of the Swiss Academy of Engineering Sciences (SATW 2006) examined the technically available potential of renewable energies in Switzerland, and how this potential could be fully exploited. Both publications have been written by scientists, aimed at the Swiss economy, administration, and politics to proactively face the global challenge of energy demand and supply.

5.3 Supplementarity relating to Kyoto mechanisms

The Swiss government is not directly purchasing assigned amount units (AAUs) from other parties or investing into CDM and JI projects. However, the government has mandated the Climate Cent Foundation to procure CO_2 credits. It is the major buyer of certificates in Switzerland. The expected reductions during the commitment period are:

- 2.1 Mt are achieved through domestic measures; including emissions trading among companies exempted from the CO_2 tax, which are allowed to offset a maximum of 0.4 Mt by foreign CO_2 credits. The amount credited against companies' commitments eventually depends on the quantity of emissions covered by the scheme. The use of flexible mechanisms is generally restricted to 8% of the total allowances allocated to

these companies. For new entrants and large emitters without reduction potential it is limited to 30%. With a total allocation of approximately 3.2 Mt of allowances per year, the quantity of CO_2 credits in the scheme should therefore not exceed 0.4 Mt of CO_2 per year. The use of CO_2 credits from flexible mechanisms by companies is monitored in the national registry as part of the compliance review.

- 2.0 Mt (maximum) may be acquired abroad by the Climate Cent Foundation.
- 0.35 Mt is expected from forest sinks. Switzerland has selected forest management under Art. 3.4 KP. The cap defined in the Marrakech Accords for this activity is set at 0,5 Mt C (1.8 Mt CO_2) per year.

The reduction commitment of 8% compared to 1990 levels corresponds to 4.2 Mt CO_2eq per year, out of which 2 to 2.4 Mt may be achieved by the flexible mechanisms.

5.4 Methodology for GHG emission projections

5.4.1 Energy outlook

The Swiss energy perspectives are based on **bottom-up models**. Energy demand is determined using separate models for private households, industry, transport, services/agriculture and electricity supply, as briefly described below. Cost analyses are worked out separately for each model, enabling the economic effects of individual measures to be assessed for different energy prices, and taking account of the assumptions concerning the degree of implementation of measures and instruments.

Households
Driving factors are the number of flats and households; size and use of flats (permanently occupied or holiday flat); type, age and use of the building; type and technical standard of heating installations and water-heating equipment; the provision of households with electrical appliances and their energy properties and useful lifetime; lighting.

Industry
Fifteen sectors of industry and six sub-sectors were studied, taking into account the number of employees, net industrial production, added value, energy prices, the energy reference area, installations, etc. Thirteen energy sources were distinguished, and 143 industrial production processes were investigated (e.g. cooking and blanching in the food processing industry or pressing of sections, tubes and bars in the metalworking industry).

Transport
The transport sector is segmented into on-road traffic (passenger and freight traffic), off-road traffic (rail, water, aviation, other vehicles), and off-road non-traffic (agriculture and forestry, construction machinery and equipment). Tonne-kilometres, passenger-kilometres, vehicle-kilometres, specific energy use, and substitution effects (e.g. mode of driving, modal shifts between private and public transport) were determined on the basis of model estimations. The model is focusing on on-road traffic, as it is by far the greatest consumer of energy. Off-road emissions are assumed to remain constant.

Services and agriculture
The model for energy demand in the services sector is split into heat and electricity. Various domains were investigated (e.g. retail trade; wholesale trade; banking and insurance; hotel trade; schools; hospitals and homes; buildings in the transport sector; agriculture; culture and sport; other public buildings; auxiliary buildings).

Electricity supply
With a bottom-up approach, the electricity production of the existing power plant park (hydro power, nuclear power, combined heat-power plants, waste incineration plants, renewables, electricity import) is

projected, taking into account the life-time of the power plants. Various scenarios for future electricity supply and their costs are compared.

Sensitivity analysis
Sensitivity analysis was a major part of the Swiss energy outlook (SFOE 2007d). The sensitivity was calculated for GDP growth, energy prices, and climate variation. A 0.5% higher GDP growth per year will lead to a CO_2-emission increase of 3.7% in 2030 (1.4 Mt). Higher prices for fossil fuels (45 % higher end-user prices for light fuel oil, 30% for natural gas, 15 % higher transport fuel prices) will lead to a reduction in CO_2 emissions of 6.9% by 2030 (2.6 Mt). Although the effect of short-term fluctuations in energy prices was not estimated, it will be less than that of permanently higher energy prices. A warmer climate (increase of mean temperatures by 2 °C in Switzerland until 2050) will lead to a reduction in CO_2-emissions by 3.4% (1.3 Mt).

5.4.2 Econometric short-term model

For the commitment period 2008 – 12 a special short-term model to calculate emissions was developed (Ecoplan 2009b). The model concentrates on energy related CO_2 which is responsible for almost 80 % of total GHG emissions. The model was developed in 2008 and will be updated annually. The first update took place in 2009. It is an econometric model based on time series analyses of data from 1975 to 2008.

Two independent variables are defined: CO_2 from heating fuel and CO_2 from transport fuel. An extensive set of dependent variables was tested. The final models are based on the following variables:

a) Independent variable: CO_2 from heating fuel
   Dependent variables:
   - CO_2 from heating fuel of past year
   - Heating degree days
   - Heating degree days of past year
   - Gross domestic product (GDP)
   - Price of heating fuel
   The model has an adjusted R-square of 0.80.

b) Independent variable: CO_2 from transport fuel
   Dependent variables:
   - Gross domestic product (GDP)
   - Gasoline price
   - Diesel price ratio between Germany and Switzerland (tank tourism indicator)
   - Structure variable 1993 (for structural change in CO_2 growth around 1993)
   This model has an adjusted R-square of 0.57

The effects of recently introduced measures which will be in effect in 2009 to 2012 and which are not included in the econometric model are estimated by expert judgement (FOEN 2009e).

Tab. 43 > Input variables for GHG perspectives for the commitment period 2008 - 12

Actual data is used for 2007 and 2008. For 2009 – 2012 estimates are shown (*in italics*).

	Reference scenario				
	GDP growth real	Price heating fuel nominal	Gasoline price nominal	Diesel price ratio Germany/Switzerland	Heating degree days
	%	CHF/100l	CHF/l	%	Grad
2007	3.6	92.2	1.68	109	3101
2008	1.6	90.3	1.79	104	3347
2009	*-2.7*	*70.0*	*1.6*	*104*	*3285*
2010	*-0.4*	*70.0*	*1.6*	*104*	*3276*
2011	*1.6*	*70.0*	*1.6*	*104*	*3266*
2012	*1.6*	*70.0*	*1.6*	*104*	*3257*

FOEN (2009e)

5.4.3 Methods to calculate the scenario without measures

The applied methodology corresponds to a bottom-up approach. The emissions savings from the individual measures (negative emissions) are subtracted from the reference scenario, providing a quantitative estimate of the scenario without measures. The procedure at the level of individual measures is easy to understand and transparent. At any time, additional measures can be included into the scenario without measures.

The selected methodology allows the inclusion of existing estimates of the effects of individual measures. Many of these estimates are more comprehensive and more detailed than those that could have been carried out in the framework of the present study. Additionally, the bottom-up approach allows a differentiated overview as well as a contrasting view of the effects at the level of individual measures. The measures can be aggregated, for example, at the level of gases or sectors. Since the assumptions and estimates are undertaken at the level of the individual measures, the quality and uncertainty of the estimates at the level of each measure is known.

One weakness of the chosen methodology is the inconsistent data basis resulting from the inclusion of different models and studies, that are not based on the same assumptions . This applies both for the estimation of the effects as well as for the magnitude of the additionalities. The estimated effects for each measure are of different quality and precision. The considerable uncertainties in some estimates, must always be taken into account when interpreting the results, in particular when the effects of different measures are compared quantitatively.

5.4.4 Agricultural model

Projections in the agricultural sector are made with the agricultural economic optimization model S_INTAGRAL (Peter 2008). The recursively dynamic linear optimization model represents agricultural production structures based on economically rational behaviour. In order to reduce the complexity of the analysis, several simplifying assumptions are made (see Tab. 44)

Tab. 44 > Assumptions for the model-based assessment

Assumption	Explanation
System boundary: conventional agriculture	The model represents the system of conventional agricultural activities, without special crops. This result's in a systematic underestimation of agricultural greenhouse gas emissions of the order of 6% (336 kt CO_2 eq) compared to the national greenhouse gas inventory.
Direct payments according to AP 2011	The direct payments are based on the direct payments system of agricultural policy 2011 (AP 2011) and are the same in all three price scenarios.
Exogenous producer prices	Agricultural producer prices are exogenously given (according to the price scenarios HIGH, MEDIUM, LOW). They are unaffected by the produced quantities and are assumed constant over the time period 2007 to 2020. The transition from the actual price level in 2006 to the target level in the model scenarios HIGH, MEDIUM, LOW are made in a single step from 2006 to 2007.
Predetermined domestic market potential	The effects of population growth and demographic change upon consumption and consumer behaviour are not considered in this analysis and in the specification of the domestic market potential.
domestic demand for agricultural products is totally elastic	Eventual shifts of market shares due to cheaper imports (e.g., as a consequence of a reduced border protection) are not quantified in the sectoral supply model S_INTAGRAL and therefore not considered in this analysis.

After Peter et al. (2009)

5.4.5 Modelling the economic impacts of Swiss climate policy

In order to assess the economic impacts of different proposed climate policies until 2020, FOEN commissioned two studies with different models and approaches. On the one hand, the studies should provide an estimate as to how high a CO_2-levy on heating fuels would be necessary in order to reach the reduction targets. Furthermore, an estimate of the ETS-price, the price increase on fossil transport fuels due to the compensation duty for producers and importers of fossil transport fuels and the world certificate price in 2020 was of interest. On the other hand, the studies should investigate the economic impacts of the proposed climate policy on GDP, welfare, various types of households as well as imports, exports and output differentiated by sectors.

Ecoplan 2009 (SwissGEN)
The SwissGEN model is a single-country dynamic (Ramsey) computable general equilibrium model (top-down). It assumes optimizing behaviour with perfect-foresight. Consumer demand is determined by budget-constraint intertemporal optimization, and producers combine intermediate inputs and primary factors at least cost subject to given technology.

In all production activities, agents are assumed to produce under constant returns to scale. The nesting structure takes actual estimates of elasticities into account. Companies face markets that are perfectly competitive with free entry and exit. As a consequence, their price of output equals their marginal cost which makes earning pure profits impossible for any activity. Agents considered in the SwissGEN model are industries and investors, 14 household types (according to income and subdivided into active population and retired persons), foreigners and government. The model is closed with the rest of the world using the Armington approach.

The model has a highly disaggregated production sector (24 sectors). The energy sectors are oil, gas and electricity. The oil sector produces three different goods: fuels, crude and heating oil. Capital is mobile between sectors and there are no adjustment costs. The expenditure of the government is growing over time with a constant growth rate. The governmental budget is balanced by levying a lump-sum tax.

The model is calibrated to a baseline scenario that is consistent with GDP forecasts of the Swiss State Secretariat for Economic Affairs and consistent with the energy demand and CO_2 forecasts of the Swiss Federal Office of Energy.

Tab. 45 > Sectors and greenhouse gases in SwissGEN

Non-energy sectors	NACE	Energy goods/sectors
Agriculture	1-5	Natural gas
Mining	10-14	Electricity
Food	15	Heating Oil
Textile	17	Fuels
Paper	21	Crude Oil
Chemicals	24	
Cement	26	
Metals	27	
Metal production	28	Greenhouse gases
Machinery	29	CO_2-emissions
Accessory	30,31,32,33	
Printing	22	
Other Industry	16,18,19, 20,23,25,34,35,36,37	
Construction	45	
Trading	50, 51, 52	
Hotel	55	
Transport	60, 61, 62	
Communication	63, 64	
Financial services	65, 66	
Other services	40,41,70,71,72,73,74,90,91,92,93	
Public sector	75, 80, 85	

Ecoplan (2009a)

The model has the following features:

- CO2 tax on non-exempted industries and household demand with a redistribution of tax income according to labour costs to the sectors and lump-sum transfers to the households.
- Emissions trading scheme for CO_2 allowances for the exempted sectors with a mix of grandfathering and auctioning.
- Exogenous implementation of technical change in fuel use of cars.
- Implementation of the Swiss building renovation programme (subsidies to the housing sector) and its impact on the energy efficiency of heating systems.

EPFL 2009 (GEMINI-E3, MARKAL-CHRES and MARKAL-CHTRA)

In the second study, a coupling of a top-down and two bottom-up models has been performed. An aggregated version of GEMINI-E3, a dynamic-recursive multi regional CGE model that represents the world economy in 6 regions and 18 sectors has been used as a top-down model.[11] For Switzerland, the numbers of sectors have been extended to 29 in order to represent the transportation sector more precisely. GEMINI-E3 is built on a comprehensive energy-economy data set, the GTAP-6 database, which provides a consistent representation of energy markets in physical units and a detailed social accounting matrix for a large set of countries or regions and bilateral trade flows between them. Tab. 46 shows the sectors, regions and greenhouse gases that have been included.

[11] The complete GEMINI-E3 represents the world economy in 28 regions (including Switzerland) and 18 sectors. All information about the model can be found at http://gemini-e3.epfl.ch/.

Tab. 46 > Sectors, greenhouse gases and regions in GEMINI-E3

Non-energy sector	Energy sectors
Agriculture	Coal
Forestry	Crude oil
Mineral products	Refined petroleum
Chemical rubber plastic	Electricity
Metal and metal products	
Paper products publishing	Greenhouse gases
Rail passenger transport	CO_2
Other public transport	CH_4
Road commercial passenger transport	N_2O
Road goods transport	Fluorinated gases
Road goods own transport	
Pipeline	Regions
Water transport	Switzerland
Air transport	European Union (as of 2008)
Consuming goods	Other European and Euro-Asian countries
Equipment goods	Japan
Services	USA, Canada, Australia and New Zealand
Rail infrastructure	Rest of the world, mainly developing countries
Road infrastructure	
Water transport infrastructure	
Air transport infrastructure	
Other transport help, support and intermediaries	
Dwellings	

For the bottom-up analysis, the energy models MARKAL-CHRES and MARKAL-CHTRA have been used, describing the residential system and the transportation system respectively. They are based on the Swiss MARKAL model developed at the Paul Scherrer Institute (PSI), being restricted to technologies related to the residential and transportation sectors and treating final energy as being imported with exogenous prices. The models contain 173 respectively 184 technologies using different energy sources (coal, oil, diesel, gasoline, gas, electricity, wood, pellets and district heat). The energy demand segments are shown in Tab. 47. Resource costs and potentials and technology costs, potentials, and characteristics vary over time.

MARKAL models are perfect-foresight bottom-up energy-system models that provide a detailed representation of energy supply and end-use technologies under a set of assumptions about demand projections, technology data specifications, and resource potential. The backbone of the MARKAL modelling approach is the so-called reference energy system (RES). The RES represents currently available and potential future energy technologies and energy carriers. From the RES, the optimization model chooses the least-cost combination of energy technologies and flows for a given time horizon and given end-use demands.

Compared to previous studies, the coupling procedure linking the models has been amended to allow GEMINI-E3 to calculate taxes according to given emission profiles. The models are run alternatively while the coupling variables are exchanged between the models, until a defined threshold on the variation of the taxes is reached. An additional optimization allows estimating a discount on energy saving technologies which is used to model the building programme in which the government helps home owners to refurbish their houses. Restrictions can also be imposed at the technology level in the MARKAL models.

Tab. 47 > Demand segments in MARKAL

MARKAL-CHTRA demand segments	MARKAL-CHRES demand segments
Domestic Aviation	Cooling
International Aviation	Clothes Drying
Road Bus	Clothes Washing
Road Commercial Trucks	Dish Washing
Road Three Wheels	Other Electric
Road Heavy Trucks	Room-Heating SFH existing building
Road Light Vehicles	Room-Heating SFH new building
Road Medium Trucks	Room-Heating MFH existing buildings
Road Cars	Room-Heating MFH new buildings
Road Two Wheels	Hot Water
Rail Freight	Cooking
Rail Passenger	Lighting
Domestic Navigation	Refrigeration
International Navigation	
Sceia et al.(2009)	

Through the exchange of the coupling variables, the coupling procedure ensures the link between the three models. The coupling variables are the fuel mixes of both residential and transportation sectors, the investments in those sectors, the energy prices, taxes and the transport demands. The prices of energies from GEMINI-E3 are used to control the price variations in the MARKAL models. Moreover, the fuel mixes and investments simulated by the MARKAL models are used to control the energy uses and spending in equipment and services in GEMINI-E3. On top of that, in order to allow for an adequate modelling of the substitution between the various transport sectors, the demand segments in the MARKAL-CHTRA model could not be assumed to be independent as in the case of the residential sector. Therefore, the evolution of the production of the various transportation sectors in GEMINI-E3 is used to control the variation of the transport demand segments in MARKAL-CHTRA.

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6 Impacts, vulnerability assessment and adaptation

section 6 is divided into three parts. The first part (section 6.1) focuses on the impacts of global climate changes on the characteristics of climate and weather in Switzerland. The consequences for natural systems that are linked to temperature and precipitation are described. The second part (section 6.2) looks at the effects of climate change on systems of immediate social or economical importance, in particular at the manner in which the functioning and performance of these systems is affected. Besides the risks and challenges linked to changes in the climate system, new opportunities arising from such changes are documented as well, as far as they are known and relevant. The third part (section 6.3) elaborates on the options available and the steps undertaken to deal with the risks, challenges and opportunities, as identified in the second part.

Regarding observed trends in climate variability, climate extremes and climate change, the Federal Office of Meteorology and Climatology MeteoSwiss operates a high resolution atmospheric observation network and provides homogenized temperature and precipitation data meeting international monitoring and quality standards (see section 8.3 Systematic observation). These data form the basis for assessing extent and impacts of changes in climatic parameters to date.

With regard to expected impacts of climate change on Switzerland, sections 6.1 and 6.2 draw to a large extent on the findings of a report prepared by the Swiss Advisory Body on Climate Change (OcCC 2007) which documents the present state of knowledge. The following box gives a brief description of the methodological approach applied in the calculation of the temperature and precipitation scenarios underlying that report.

National scenarios: Regional temperature and precipitation projections for Switzerland
The OcCC report builds on a regional temperature and precipitation scenario for Switzerland (Frei 2004). Calculations from the EU project PRUDENCE served as the basis. Uncertainties regarding the physical understanding (model uncertainties) were derived from the variance of the results of 16 different model combinations for Europe. These combinations resulted from joining two medium IPCC emissions scenarios (SRES A2 and B2), four different global climate models and eight different regional climate models in varying ways. Regarding the impact of the emission trend, the results on the regional scale were assumed to show a similar variance as the results on the global scale, based on the most important IPCC emission scenarios. The underlying data and statistical analyses are described in more detail in Frei (2004).

In a second step, the sensitivity of the results to changes in international emission trends was taken into consideration. The analysis revealed that even drastic actions to reduce emissions will not have a major impact on scenario results before 2050 but will have an important influence on the development in the second half of the 21st century.

The main results of the OcCC scenario calculations, which serve as the common climatological basis for most impact and vulnerability assessments presented in this section, are presented in Fig. 88 and Fig. 89 below.

6.1 Observed and expected changes in climatic and hydrological conditions

6.1.1 Temperature

Observed changes

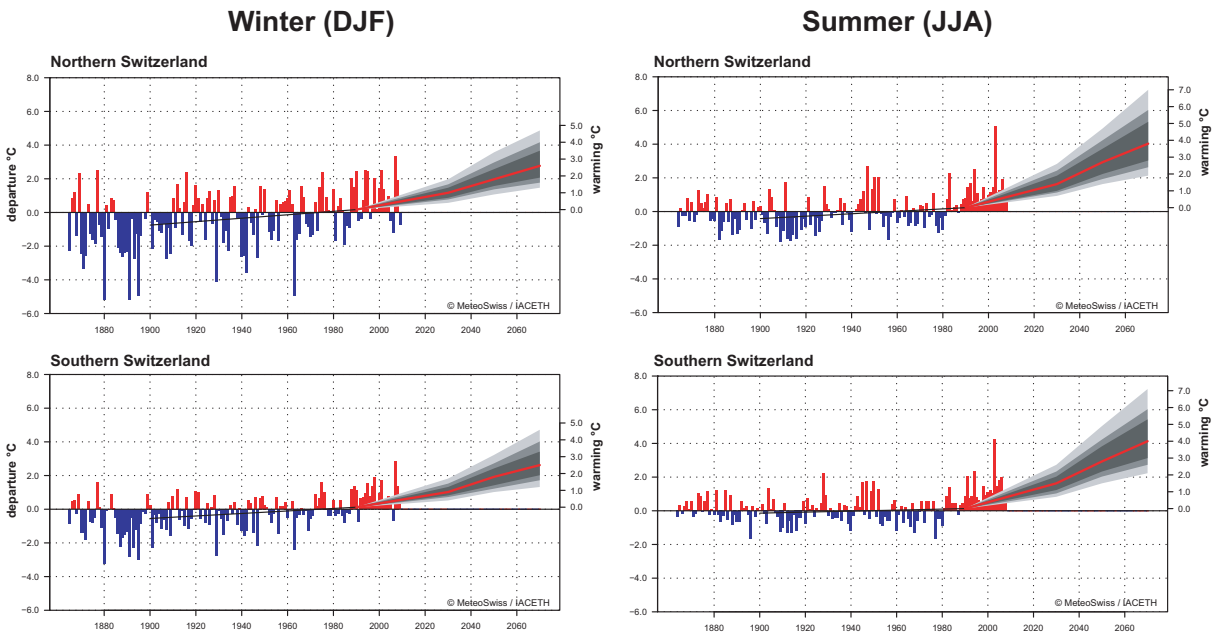
Climate measurement series of ground-level temperatures in Switzerland date back to the mid-19th century. The mean annual temperature has increased by 1.6 °C between 1864 and 2008 with respect to 1961-1990 average conditions. Over the past 100 years (1909-2008), mean annual temperatures increased by 0.12-0.19°C per decade, with no distinctive regional differences. Temperature increase has accelerated substantially in recent decades (see section 2.5, Fig. 17 and Fig. 18 and OcCC (2007, 2008) for further details).

Expected changes

Mean temperature projections for the years 2030, 2050 and 2070 have been calculated for the northern and the southern side of the Alps (Frei 2004). The results for winter and summer are graphically shown in Fig. 88 together with observed temperature anomalies from 1864 to 2008. Until 2050, warming is expected to be similar on the northern and on the southern side of the Alps. According to the mean estimate (median value), temperatures will increase in northern Switzerland by 1.8 °C in winter and 2.7 °C in summer. Corresponding values for southern Switzerland are +1.8 °C in winter and +2.8 °C in summer. For the transitional seasons, warming is expected to be similar to the trend projection for winter (spring: +1.8 °C on the northern and the southern side of the Alps; autumn: +2.1 °C on the northern side of the Alps, +2.2 °C on the southern side of the Alps).

Fig. 88 > Observed temperature anomalies and projected changes in mean temperature

Observed 1864-2008 temperature anomalies with respect to the 1961-1990 average, and projected changes in mean seasonal temperature for the period 1990-2070 (in °C). Winter data refer to the months December to February, summer data refer to the months June to August. Positive anomalies (warmer than average) are shown in red, negative ones (cooler) in blue. The red line presents the projected trend in mean temperature, the grey areas indicate the uncertainty in the projection (5-95% confidence intervals).The black line denotes the linear trend from 1901-1990.



MeteoSwiss/IACETH

6.1.2 Impacts on the cryosphere

Freezing level

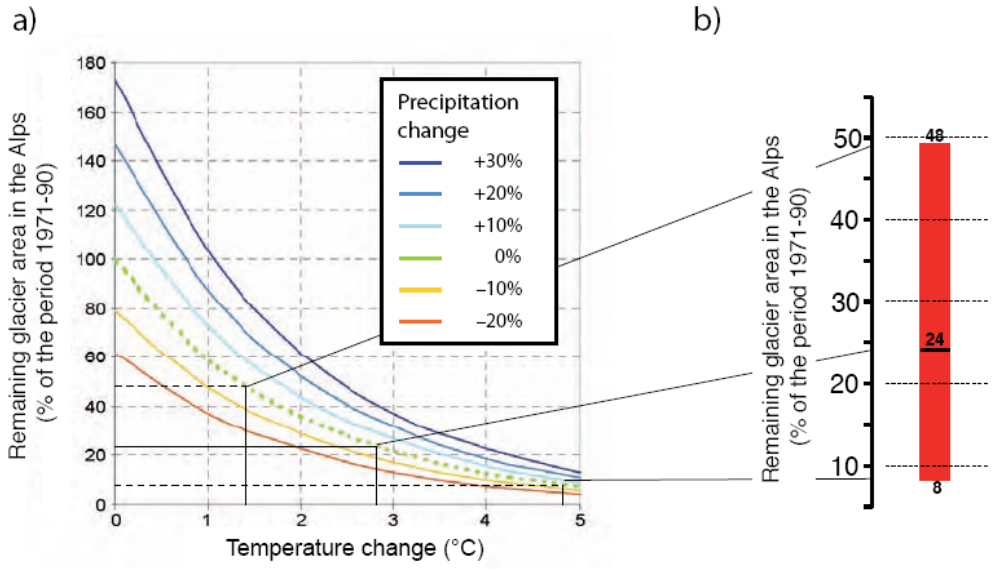
In wintertime, the seasonal freezing level (altitude, where surface air temperature is 0°C) has risen by about 200 m per degree of warming from approximately 600 m in the 1960s to approximately 900 m in the 1990s (Scherrer and Appenzeller 2006). If warming in winter continues as expected, the freezing level will further rise by about 180 m until 2050 in case of moderate warming (+0.9 °C), by about 360 m in case of medium warming (+1.8 °C), and by about 680 m in case of strong warming (+3.4 °C) (OcCC 2007). The freezing level roughly corresponds to the height of the snow line (the lower limit of the snow cap).

Glaciers

The retreat of glaciers is the most visible change in the Alps resulting from global warming. A recent analysis has revealed that 12% of the volume of Swiss glaciers was lost since 1999 (Farinotti et al. 2009). Model calculations of the expected glacier retreat in relation to the reference period 1971-1990 are shown in Fig. 89. They were calculated for a warming in summer between 0 and 5 °C and a change in annual rainfall between –20% and +30%. According to the OcCC climate scenario, the area covered by alpine glaciers will diminish by about 75% in case of medium warming by 2050. In case of moderate warming the loss in glacier area will still be as much as 50% and in case of strong warming it will reach 90%, respectively. The relative losses will be smaller than average for large glaciers and larger than average for small glaciers. Many small glaciers are likely to disappear.

Fig. 89 > Expected retreat of glaciated areas in the Alps

Left-hand side (a): Change in alpine glaciation following an increase in summer temperature by 1 to 5 °C and a change in annual rainfall between –20% and +30%.
Right-hand side (b): Remaining glaciation for moderate, medium and strong warming assuming no change in precipitation. For medium warming, glaciated areas will decrease by about 76% until 2050.



OcCC (2007), adapted from Zemp et al. (2006)

Permafrost

The warming of permanently frozen ground (permafrost) in the high mountains is a slow process with long-term implications. The warming described in the OcCC climate scenario will cause thawing of ice-rich rock faces in shady slopes at 2000 to 3000 m a.s.l., causing complete unfreezing in some places. Warming of the outer 50 meters of frozen rock faces, which has already been caused by the temperature rise in the 20th century, will penetrate into greater depths, thereby increasing thermal imbalance. In the surroundings of

summits and ridges such effects will be particularly pronounced as the heat may penetrate from different sides. Continued warming of the ground surface and propagation of existing thermal anomalies to greater depths increases the probability of large-scale mass movements from slopes at high altitudes.

6.1.3 Precipitation

Observed changes

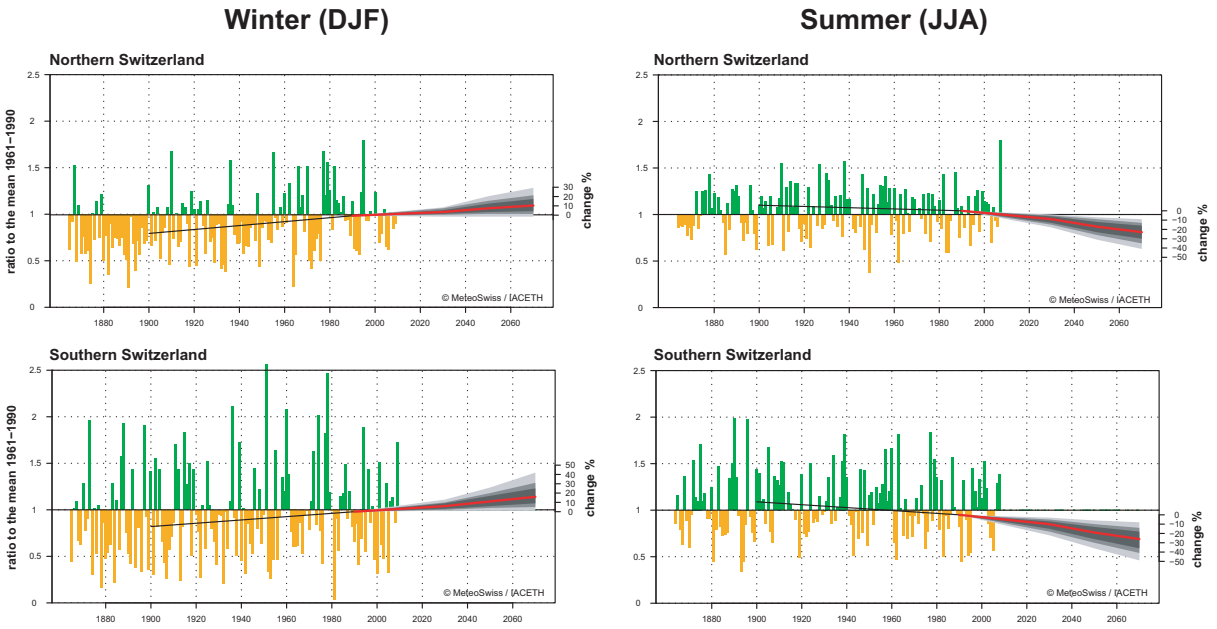
In Switzerland, systematic recording of precipitation began in the middle of the 19th century. Compared to long-term changes of mean temperatures, trends in mean precipitation are less distinct. For a number of stations a significant increase in precipitation is found in winter and spring (+2.7 to +3.1% per decade, see OcCC 2008). For summer and autumn no significant trends are detectable. Nevertheless, precipitation trend characteristics for the last 50 and 30 years show some differences to the long-term record characteristics. Further details may be found in section 2.5 and in OcCC (2007).

Expected changes

Projections of mean precipitation for the years 2030, 2050 and 2070 have been calculated for the northern and the southern side of the Alps (Frei 2004). The results for winter and summer are shown in Fig. 90 together with the observed precipitation anomalies from 1864 to 2008. Mean seasonal precipitation is expected change similarly north and south of the Alps. An increase in mean winter precipitation of 8% compared to 1990 is expected north of the Alps by 2050 (11% south of the Alps), and a decrease of 17% in summer (19% south of the Alps) with respect to 1990 values. In spring and in autumn the trends for precipitation are small. The magnitude of uncertainty is largest for trends in summer.

Fig. 90 > Observed precipitation anomalies and projected changes in mean precipitation

Observed 1864-2008 precipitation anomalies with respect to the 1961-1990 average and projected changes in mean seasonal precipitation for the period 1990-2070. Winter data refer to December to February, summer data refer to June to August. Positive anomalies (wetter than average) are shown in green, negative ones (drier) in orange. The red line presents the projected trend in mean precipitation, the grey areas indicate the uncertainty in the projection (5-95% confidence intervals).The black line shows the linear trend from 1901-1990.



MeteoSwiss/IACETH

6.1.4 Impacts on the hydrological cycle and water resources

In comparison to other regions of the world, Switzerland is in a favourable situation, having about 5'560 m^3 of water available per year and inhabitant (Germany 1'305 m^3, the Netherlands 690 m^3, Israel 115 m^3 per year and per inhabitant). Ample precipitation as well as the balancing effect of snow cover and melt water from glaciers will ensure sufficient water resources in the coming decades. Nevertheless, long-term changes in snow cover and glaciation will have irreversible effects on run-off regimes. In addition, shorter-term impacts may be significant, in particular with regard to extreme events (see section 6.1.5) and for sectors with high dependence on water (see sections 6.2.2 to 6.2.4).

The changes in the hydrological cycle and water resources can be summarized as follows: Due to the rising temperatures, less precipitation is expected to fall as snow at low to medium altitudes. As a consequence, the extent of the snow cover will decrease, the snow line will rise, and the glaciers will retreat, resulting in a shift in discharge regime at a given altitude towards regimes traditionally encountered at lower levels. This implies smaller differences between maximum and minimum values of mean monthly run-off and earlier peaks in mean monthly run-off by about one month. On the Swiss central plateau and in the very south of Switzerland, small and medium-sized watercourses will dry up more frequently, in particular in summer and autumn and in areas where glaciers have disappeared. Natural replenishment of groundwater will decrease accordingly.

Evaporation will generally increase as a result of warming. In combination with a decrease in total annual rainfall, the annual run-off will decrease as a consequence, in particular in the south. This will happen in spite of the temporary contribution of additional melt water by retreating glaciers.

6.1.5 Impacts on extreme events and natural hazards

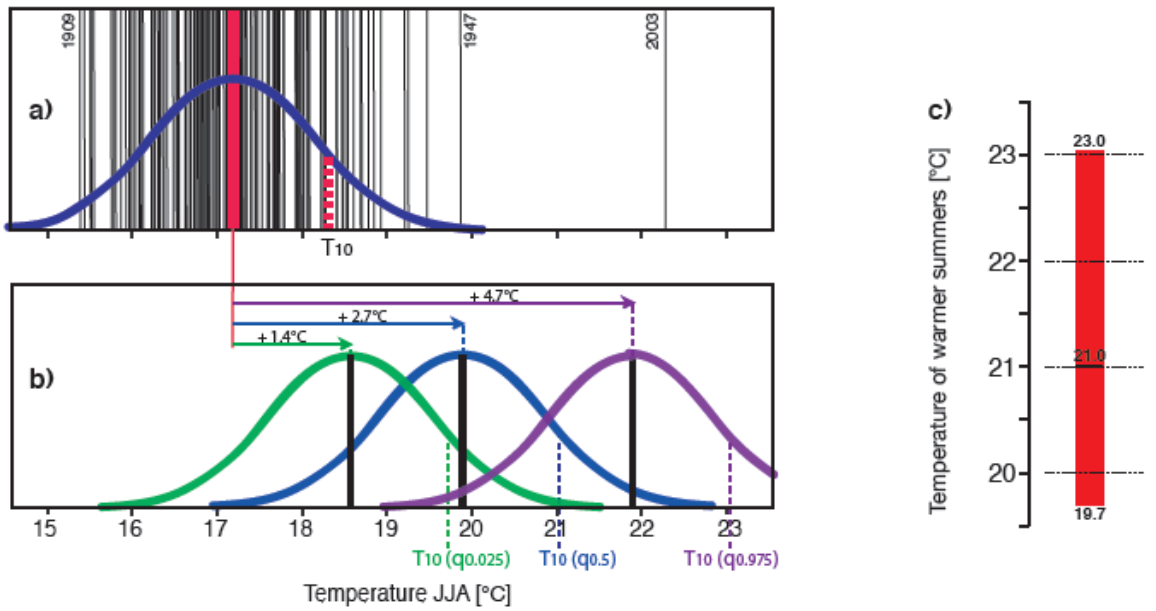
Scenarios of the trends of frequency and intensity of extreme events are still very uncertain. Due to their limited number, statistical trends of extreme events are difficult to establish (Frei and Schär 2001). So far, they have been detected for a few categories of extreme events only. The following compilation documents trends where these are statistically significant based on past observations or where confidence in the understanding of the climate system is sufficiently good to make meaningful predictions of future trends.

Temperature extremes
Temperature extremes show the most distinct trend. With a rise in mean summer temperatures, higher temperatures will also occur during hot spells (Fig. 91) (Schär et al. 2004). Climate models show a more significant increase in absolute maximum temperatures than in mean daily maxima. According to the OcCC climate scenario, conditions as during the summer 2003 heat wave will still be rare events in case of moderate warming, but will occur every few decades in case of medium warming, and every few years in case of strong warming. Extremely hot summers will occur more frequently if, additionally, year-to-year variability of summer temperatures increases, as various climate simulations suggest.

By contrast, the frequency of cold spells and the number of frost days have already declined and will continue to decline. In winter, the daily temperature variability is likely to become smaller because minimum temperatures are projected to rise more strongly than mean temperatures. This effect is expected to be particularly pronounced in areas where the snow cover diminishes as a result of warming. The change in risk of late frosts (i.e., frosts that occur after the beginning of the vegetation period) is uncertain since the vegetation period will start earlier in the year too, along with changing temperatures.

Fig. 91 > Distribution of mean summer temperatures

a) Probability distribution of summer temperatures 1864-2003 (each summer is represented by a vertical bar).
b) Expected shift in the distribution of summer temperatures in 2050 for the three OcCC scenarios (corresponding to increases in mean summer temperature of 1.4 °C (green), 2.7 °C (blue), and 4.7 °C (purple), respectively, relative to average temperatures observed to date).
c) Temperature range of the three scenarios for a hot summer occurring once every 10 years (represented as T_{10} in graphs a and b, dashed lines). For comparison: the mean summer temperature in Switzerland for the period 1864-2003 was about 17.2 °C (thick red line in panel a).



OcCC (2007), adapted from Schär et al. (2004)

Precipitation extremes

According to OcCC (2007), analyses of global and regional climate models show that the mean precipitation intensity and the frequency of heavy and extreme precipitation events may increase in central and northern Europe in winter. At altitudes above 2000 m, more frequent heavy precipitation events in winter would lead to higher amounts of snowfall in short periods of time. This may increase the danger of avalanches. An increase in heavy precipitation in central Europe may also occur in spring and autumn. For summer, the situation is less clear. Although the models show a distinct decrease in average summer rainfall, the extreme value with a return period of 5 years increases slightly.

Sizeable parts of Switzerland are in an area of increased hail risk, which bears a considerable damage potential. Since 1940, general weather situations that are responsible for extreme hail events have clearly increased. However, it is not clear if the more frequent occurrence of these weather situations is related to climate change.

Floods, landslides and debris flows

According to OcCC (2007) an increase in precipitation intensity and the rise in snow line bring about the potential for more frequent floods, landslides and debris flows. However, the actual incidence of these natural hazards is determined by other processes, some of which are also affected by climate change. Factors influencing the formation and magnitude of floods, landslides and debris flows are soil moisture, soil cover, snowmelt, discharge regime, topography, and size of catchment areas.

The temperature increase will cause more frequent changes between snowfall and snowmelt, leading to more frequent run-off of accumulated precipitation on the alpine border. Since evaporation is small in

winter, no noteworthy compensation effects are expected. In small catchment areas of the Swiss central plateau and in the Alps, the biggest floods usually occur in summer after short but heavy thunderstorms. It is inconclusive whether a change in frequency will occur and in what direction.

A recent expert assessment (KOHS 2007) concludes that to the north of the Alps and at altitudes up to 1'500 m a.s.l. the size and frequency of winter and spring floods is likely to increase. In contrast, summer floods on the central plateau are expected to become smaller. To the south of the Alps, floods tend to become more severe in all seasons except for summer. Due to rising precipitation intensities, landslides are expected to become more frequent in winter and spring.

Drought
In agreement with the decrease in average summer rainfall and the number of rainy days, extremely dry periods might last longer and occur more frequently. The combination of decreasing rainfall and higher evaporation may result in a decrease of the soil water content at the regional level. The availability of river water to compensate for lacking precipitation is reduced in summer and autumn due to reduced river run-off in areas where glaciers have disappeared (see section 6.1.2) (OcCC 2007).

Wind storms
The scenarios for storms are very uncertain. Some models indicate that the frequency of storms is likely to decrease in central Europe. At the same time, the intensity of storms will probably increase (Swiss Re 2006). Generally the tracks of cyclones and storms are expected to shift polewards, which would reduce the probability of Switzerland being hit.

6.1.6 Impacts on natural ecosystems and biodiversity

Biological diversity - the natural wealth of the Earth – encompasses ecosystems, species, and genes that build the basis for life and prosperity of mankind, providing e.g. food, medicine, fuel, fertile soil, and drinking water. However, biodiversity has been under pressure for many years. In the future, current factors affecting biodiversity will be increasingly superimposed by the effects of climate change. Not only the number but also the composition of species will change in the mid- to long-term, since individual species react differently to changing climatic conditions. Many of these changes are irreversible. On the one hand, hitherto existing species will disappear, on the other hand, foreign plant and animal species will immigrate from warmer regions and potentially outcompete local species, which play a key role in the overall food chain. The latter may act as vectors affecting human health or introduce new pests against which local species have no defence mechanisms. New species may also interbreed, thus affecting the genetic diversity. The Swiss flora and fauna is expected to gradually shift towards the characteristics of flora and fauna in lower-lying and more southern areas. Species bound to cooler living conditions with little opportunity for migration to appropriate areas will be particularly affected by rising temperatures. Coupled with the pre-existing pressures, these climate-related effects will challenge Switzerland's present approach to biodiversity conservation.

In its latest publication, Biodiversity Monitoring Switzerland reports that impacts of climate change are being observed even within short time frames (BDM 2009). The findings are based on eight years of intensive monitoring of vascular plants, butterflies, birds, mosses and snails. Formerly absent species such as Mediterranean butterflies, dragonflies and bird species are now extending their habitat into Switzerland. Typical alpine vascular plants have shifted their distribution in the uphill direction during the past few years. The number of plant species on alpine sample plots has increased. The upward moving species may compete with, and crowd out, species, which traditionally have occupied territories at higher altitudes.

According to recent research, about 100 invasive alien insect species are established in European forests (Mattson et al. 2007). Mostly, these were introduced via global trade but their subsequent establishment in forests is often the result of higher temperatures. A well-documented example for the establishment of alien plant species in Swiss forests is the chusan palm (*Trachycarpus fortunei*) in the canton Ticino (Walther et

al. 2007). Certain species like camphor tree (*Cinnamomum camphora*) or tree-of-heaven (*Ailanthus altissima*), douglas fir (*Pseudotsuga menziesii*) and robinia (*Robinia pseudoacacia*) will have a higher potential to spread under dry conditions. In the canton of Valais, the pine (*Pinus sylvestris*) is increasingly replaced by downy oak (*Quercus pubescens*) (Rigling et al. 2006). Downy oak is more resistant to drought and seems to thrive under conditions of increased potential evapotranspiration, as observed over the last 20 years (Weber et al. 2008).

Vast evidence of the impact of changing climatic conditions on plants stems from phenological observations. There are numerous indications for shifts in the phenological phases of plant development like the start of blossoming, flushing of leaves, length of the vegetation period and start of leaf fall in autumn (Defila and Clot 2001). The shift is particularly marked since the 1980s when a significant upward trend in average temperatures was registered in Switzerland (see section 2.5).

Higher temperatures have led to an extended vegetation period, in particular in spring. For the observed change in vegetation, mild winter temperatures and less frequent late frosts are most relevant (Menzel et al. 2003). There are indications that the physiological reaction of plants to the extended vegetation period is different in the Swiss lowlands and in the Alps (Swiss lowlands: 21 days earlier onset of the spring in 2002 compared to 1951; Alps: 17 days). In comparison with plants living at lower altitudes, alpine plants, which are adapted to a rougher climate, are more sensitive to a relative increase in temperature and show stronger reactions (Defila 2006).

Another indication for more favourable growth conditions at higher elevations is the upward shift of the tree line which has been found in Switzerland (Gehrig-Fasel et al. 2007). Correspondingly, in the hot and dry year of 2003, increased growth was found at altitudes above 1'200 m a.s.l. whereas tree growth in the lowlands was reduced due to limited water availability (Dobbertin 2005).

Even though overall trends in the future development of climate are well established, it is very difficult to predict the resulting evolution of natural forest composition. Uphill and south-north migration velocity is different for individual plant species as are the reactions of plants to enhanced temperatures and reduced water availability. The effects of climate change on pests and diseases are another important factor increasing the uncertainty of any predictions on the development of the forests.

Even under the most modest climate change scenario, impacts on biodiversity in Switzerland are expected to increase. Changes in ecosystem structure and functioning including unexpected outcomes are likely to become apparent. An illustrative example is the regular larch budmoth peaks which recurred every eight to ten years until 1981. Since then no peak events have been recorded (Esper et al. 2007). It is yet unclear whether the absence of peak events is an indication for a new balance under changed climatic conditions or whether it signals a state which is detrimental to the development of larch forests.

6.2 Vulnerability of the environment, economy and society

6.2.1 Biodiversity

Climate change is expected to affect species composition, distribution, their cycles, synchronicity, the overall genetic diversity and the provision of ecosystem services. This will have a direct bearing on the future role of ecosystems for society in the areas of animal and plant species used for food production, genetic resources and biochemical substances for medical purposes, pollination, water purification, soil fertility and prevention of soil erosion, as well as landscape appearance for tourism.

Society draws on biodiversity as a vital resource. However, biodiversity is not given adequate recognition and ecosystems are often heavily exploited. Currently, projects addressing this issue are carried out globally and at the pan-European level, putting a monetary value on biodiversity and ecosystem services (The Economics of Biodiversity and Ecosystem Services).

6.2.2 Forests and forestry

Climate change will enhance the vulnerability of forests and impair their functions in different ways. According to the Swiss Forests Act, the importance of forests in Switzerland mainly lies in its protective function against natural hazards, its productive function (e.g. wood, drinking water), and its social functions (e.g. for recreation purposes).

Protective function
In mountainous and hilly areas, forests often play an important role in protecting settlements, traffic infrastructures and cultivated land from erosion, landslides and rock fall. Rapid climate change and more intensive extreme events may impair the stability of natural or semi-natural ecosystems, thereby reducing their protective functions. In Switzerland 43% of forests are forests with protective functions against natural hazards (Duc et al. 2010). The most important forest features determining the protective properties against avalanches are the slope, the stand density, and the existence of forest gaps. According to these criteria, 80% of the forests have medium to high protective effects against avalanches. Less than half of the evaluated forest stands assure sufficient protection against rock fall. Forest management should aim to avoid gaps in forests and to regulate the stand density in order to achieve stable stands. Problems for protective forests arising from climate change are the appearance of large gaps originating from storm events, insect outbreaks, or dieback as a consequence of drought.

Productive function
The productive function of Swiss forests is potentially affected by several climate related developments: Dry and hot periods lead to the weakening of trees. Such periods increase the susceptibility to insect attacks and pests and promote the outbreak of diseases. This is even more so if climate change leads to the spread of new varieties of potentially damaging organisms (Engesser et al. 2008). A well-known example is the massive outbreak of bark beetle (*Ips typographus*), which is favoured by weakened trees caused by drought and the presence of fresh dead wood. Additionally, mild winters have proven favourable for the survival of not only the adult but also the larvae of bark beetles. In such instances, an exceptional second or third generation may develop in the course of one year. Also forest fires are affected by drought. In regions like the dry valleys of the canton of Valais, the drought-induced dieback of pines enhances the amount of dead wood in forests and therefore the risk for forest fires.

Social functions
Forests and trees as elements of the natural landscape have important social functions. They are of great recreational value to the population and contribute to an attractive scenery. The changes in forest ecosystems and altered recreation demands of tourism may raise new challenges for forest conservation and sustainable forest management.

6.2.3 Agriculture

The climate is one of the most important limiting factors regarding the cultivation and the yield of crops as well as livestock husbandry. In Switzerland, due to the climatic conditions, arable farming is restricted to lower altitudes whereas animal feed production on permanent grassland occurs at a climatically much wider range and predominates at higher altitudes. In the near future, along with market reform measures, the structure of Swiss agriculture is expected to change considerably (see section 4.3.7). However, the outcome of this process is quite uncertain. Thus, the direct consequences of climate change on future agricultural products and production in Switzerland, including the indirect consequences due to the climatic changes in other countries, are difficult to assess.

Under present conditions, a moderate warming of less than 2 to 3 °C would probably have a positive overall effect on Swiss agriculture. The productivity of meadows and the potential crop yield of many cultivated plants will increase as a result of the longer vegetation period, provided that the supply of water and nutrients is sufficient. This will also be beneficial for livestock farming.

If temperature rises by more than 2 to 3 °C by 2050, the disadvantages will outweigh the advantages of warming. The increase in heat waves and drought periods is particularly problematic. Thus, high altitude areas will gain in importance as ecological buffers for livestock husbandry. During the vegetation period water scarcity will become more frequent. Faster plant development will result in harvest losses for cereals and grain legumes. The risk of damage for arable crops and of yield loss in animal feed production will increase. Weeds and insect attacks are expected to occur more often as will damages caused by extreme events. Yield stability in general will be reduced. More frequent heavy precipitation events will aggravate soil erosion. Additionally, new pests and diseases can occur or persist and changes in the established trophic interactions (e.g. between pests and parasitoids or predators) could take place.

6.2.4 Hydropower generation

In the Alpine region, climate change will lead to a seasonal balancing of run-off regimes. River water levels will increase in winter and spring (more rainfall) and decrease in summer and autumn (less rainfall, less melt water, increased evaporation). Low water levels in summer and autumn will limit hydroelectric power production by run-of-river power stations on the central plateau. On the other hand, these power stations can profit from increasing run-off in winter and spring, when capacities of turbines are not fully used today.

Due to the overall reduction of surface run-off, hydropower production is expected to decrease by a few percent in the coming decades (Piot 2005). Glacier retreat and permafrost degradation will substantially increase the sediment transport in rivers, which will have implications for the management of reservoirs, and ultimately affect hydropower production as well. Run-of-river power stations may be more frequently challenged by increased solid material transport (in particular wood debris) connected to floods.

6.2.5 Tourism

In Switzerland, tourism is the economically most important sector directly affected by climate change. The rising snow line in winter implies that ski resorts in the foothills of the Alps may not operate profitably in the future. With climate change progressing, the altitudinal threshold for snow-reliability will continue to rise. The share of ski resorts with non-reliable snow conditions is expected to increase considerably (Abegg et al. 2007). Destinations dependent on glaciers as tourist attractions will be affected as glacier retreat continues. Other changes in natural scenery (rivers running dry in late summer, lack of wintery atmosphere in the absence of snow) may further reduce the attractiveness of some alpine tourist areas.

Changes in natural hazards are another element relevant to mountain tourist destinations. Melting permafrost destabilises ground conditions. This may affect infrastructures which are placed at high altitude. Buildings, masts of cable cars, avalanche barriers etc. are vulnerable when anchored in permafrost ground (Müller et al. 2003). However, initial surveys indicate that to date the number of installations directly affected by this phenomenon is quite limited. A related problem is the frequency of rock fall and debris flows which will increase due to the combination of melting glaciers, melting permafrost, rising snow line and more intense precipitation. This may present an additional risk to climbers and hikers at high altitudes. Furthermore, the increasing threat to traffic routes from extreme events may lead to more instances where access to individual tourist resorts in the Alps is limited.

On a larger spatial scale and in the medium run, the highest winter tourism stations in the Alps, many of which are located in Switzerland, will have an advantage over competing stations at lower altitudes, as the latter will suffer first from declining snowfall (OECD 2007). New opportunities for the tourism sector may arise by changing conditions in summer. Pleasant temperatures at higher altitudes and a tendency towards less rainfall may contribute to market the alpine region as a summer holiday destination. At the same time, numerous places at lakes and rivers might become an alternative to seaside holiday resorts at the Mediterranean Sea, which tend to lose attractiveness as excessive heat and drought conditions become more frequent. However, more tourists in summer will not compensate for the loss of income of mountain resorts in winter. At present, these resorts heavily depend on winter tourism to maintain profitability.

6.2.6 Health

The increase in intensity of heat waves in combination with high tropospheric ozone concentrations represents the greatest direct risk that climate change poses to people's health in Switzerland. The potential extent became clear in the heat wave of 2003 when almost 1000 cases of death were attributed to the extraordinary heat. The temperature increase as well as more frequent heat waves will intensify the urban heat island effect.

Additional casualties are to be expected from the increase of other extreme events such as floods, mudslides and, possibly, storms. Extreme events may entail severe psychological consequences for the directly affected population, the importance of which is often underestimated.

Another important health risk of climate change is the occurrence of vector-borne diseases. It is still highly uncertain what future developments are to be expected. In Switzerland, the dissemination of malaria or dengue fever is quite unlikely. However, some vector-borne diseases, such as *West Nile virus*, occur more often. In a warmer climate, some parasitic vectors may change their host or new vectors may appear. In the case of diseases transmitted by ticks, global warming may affect the distribution of the vectors, the infection rate and the season in which the vectors are active.

6.2.7 Infrastructures

With ongoing population growth, economic development, and urban sprawl on the one hand and very few extreme events causing severe damage from the early to the late 20th century on the other hand, more and more buildings have been placed in exposed areas. Accordingly, the damage potential of floods, mudflows, landslides or winter storms has become much larger. Climate change adds a new risk to this situation as the frequency and magnitude of extreme events increases.

The impact of climate change on the functioning of public utilities, in particular water supply and sewage disposal, and the vulnerability of transport infrastructures have been assessed on the basis of recent extreme events. Experience has shown that, under present conditions, water supply can be considered as secure in quantitative as well as qualitative terms. With regard to sewage disposal, rising temperatures, dry spells, but also heavy precipitation may require adaptation of the operation of sewage plants. Generally, transport infrastructures seem to profit more from milder winters than they suffer from higher maximum temperatures, however, they are vulnerable to floods, mudflows and landslides.

6.2.8 Insurance business

Even if the results of scientific studies have become increasingly consistent and comprehensive, there are still considerable uncertainties with regard to the impact of climate change on the development of losses. For example, it is not known to what extent climate change has contributed to the increase in losses over the past 30 years. The separation of different socio-economic and climatological influences turns out to be particularly difficult as the functional chain from natural hazard to damage represents a complex process that is difficult to model. There is particular need for research in the consideration of future damage due to extreme events.

According to a study by Swiss Re and ETH Zürich (Swiss Re 2006, Frei et al. 2006), winter storms represent the largest loss potential for Europe and the second largest for Switzerland, where only loss potential from floods is higher. Several climate models were coupled with an insurance loss model and future damage by winter storms was examined. Results indicate that by the end of the 21st century (2071-2100), total losses in Europe could increase by 20 to 70% (compared to the reference period 1961-1990). In Switzerland, an average increase in losses due to winter storms by about 20% (0 to 50%, depending on the climate model) is expected.

6.3 Adaptation

6.3.1 Development of a Swiss national adaptation strategy

The impacts and vulnerabilities described in sections 6.1. and 6.2 illustrate the breadth of natural and anthropogenic systems affected by climate change. In order to prevent or diminish adverse effects and to take advantage of positive effects of climate change, it is necessary to implement adequate adaptive measures. So far, due to the lack of an explicit, overarching mandate at the federal level, this has happened on an ad hoc basis often in reaction to observations or events at the sectoral level. The most prominent example is the protection against natural hazards, where strategies and measures have been developed long before climate change became an issue. During the last years, however, awareness has risen that adaptation to climate change needs an integrated approach involving all stakeholders at all institutional levels. Switzerland therefore intends to include adaptation as well as mitigation into its future climate legislation. This process was initiated in parallel with the revision of the CO_2 Act (see section 4.3.3).

Available research results, e.g. within the framework of the National Centre of Competence in Research on Climate (NCCR Climate), indicate that adaptation measures are necessary, possible and beneficial in various interacting and overlapping fields of action such as water management, rural development, agriculture, the energy sector, tourism and health. While most measures are implemented at the local to regional level, it will be the task of the federal government to provide common reference material/data, guidance and financial support to facilitate exchange of information and experience, and to take the strategic lead in order to assure a coherent, coordinated approach to adaptation. In order to do so, the Swiss Federal Council mandated the Department of Environment, Transport, Energy and Communications (DETEC) to analyse the risks posed by climate change and to develop a national adaptation strategy until summer 2010.

A survey conducted by the Federal Office for the Environment within the federal administration has led to an initial list of additional measures to be taken into account in the context of the national adaptation strategy. It also helped to identify important information gaps. In particular, the availability of high-resolution regional scenarios for climate (including occurrence of weather extremes) and hydrology was highlighted as an important prerequisite for substantiation of approaches to adaptation at the regional scale and sectoral level. Furthermore, the survey indicated that significant financial resources will be needed for the implementation of measures. However, compared to the estimated cost of inaction (Ecoplan 2007), adaptation will cost only a fraction and has multiple benefits which are going far beyond the reduction of risk in relation to climate change.

The elaboration of the national adaptation strategy will include the following steps:

- improvement of assessment and planning tools, e.g. by means of high-resolution observational data and high-resolution climate scenarios;
- sectoral/regional assessment of climate change impacts, risks and opportunities;
- definition of adaptation goals;
- prioritising among possible fields of action according to the risk assessment.
- formulation of sectoral strategies for fields of action with high priority;

The overall goal will be to achieve the best possible adaptation given the resources available.

Within the framework of the NCCR Climate research programme, new high-resolution regional climate scenarios are being calculated and will be made available by 2011. It will be essential to secure updating of this information on a regular basis. The Federal Office of Meteorology and Climatology MeteoSwiss will undertake the task of coordinating the periodical calculation of climate change scenarios at the regional level and make the results available to authorities, economy and the public, provided that associated climate research is funded. Scenarios on the regional impacts of climate change on hydrology and water resources are currently being developed as well (see section 6.3.4).

The following sections describe the actual state in the various fields of action, where strategies or measures relevant to adaptation to climate change have been assessed, developed or implemented so far.

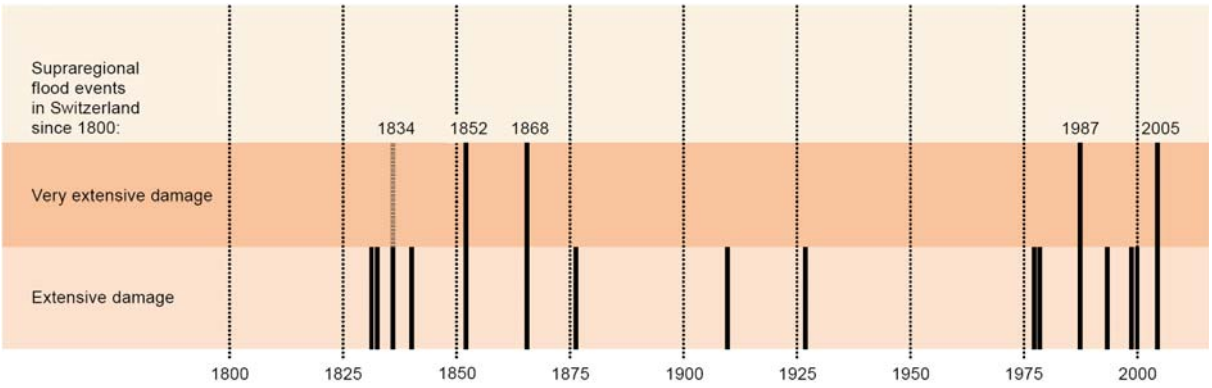
6.3.2 Strategy to improve protection against natural hazards

After a 100 year period between 1875 and 1977 during which only two major floods occurred, Switzerland experienced several catastrophic flood events during the last three decades (Fig. 92). This apparent increase in frequency of extreme floods since the 1970s coincided with significant investments that have been made in fundamentals, planning and protective measures in the area of natural hazard prevention. Nevertheless, the total annual loss resulting from floods, landslides and debris flows has increased substantially since 1972 (Fig. 93).

The extreme hazard events that took place over the past 20 years, together with rising public awareness in the area of the environment, have strongly influenced Switzerland's strategy on natural hazards. The result is the implementation of a strategy for protection against natural hazards that builds on a holistic approach. According to this new philosophy, the maintenance and extension of existing hazard protection structures or their adaptation to altered circumstances is no longer sufficient. Instead, these activities are integrated into the planning and coordination of all spatially-relevant activities. The implementation of this integrated risk management approach (Fig. 94) and the management of residual risks are the main challenges for the coming years.

Fig. 92 > Major supra-regional flood events since 1800

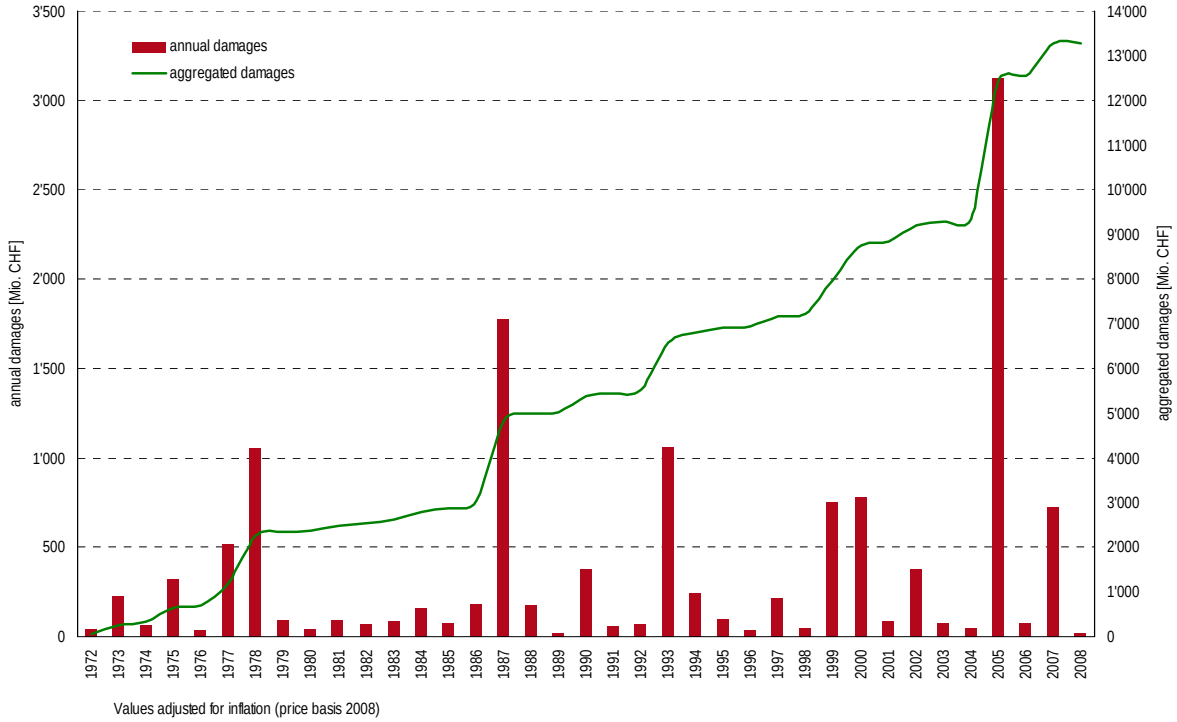
Since the early 19th century, there have been 16 extensive or very extensive floods necessitating supra-cantonal intervention. Nine of these occurred during the last 30 years. In today's monetary terms, the damage caused by major floods totals between CHF 500 million and several billions.



DETEC (2008)

Fig. 93 > Damage caused by floods, landslides and debris flows since 1972

Development of total annual loss (red bars, scale to the left) and aggregate loss (green line, scale to the right) of floods, landslides and debris flows in Switzerland. Over a period of 36 years (1972-2008), average annual loss is on the rise.



WSL/FOEN

Based on the philosophy of integrated risk management, effective damage reduction will only be achieved if all participants assume responsibility in their area of action and all measures that contribute to risk reduction are taken. Thus, gaps in the implementation of suitable action to protect from natural hazards and false incentives which lead to inaction must be identified and eliminated.

Several institutions collaborate in the integrated risk management: In 1997, the Swiss Federal Council created PLANAT, the National Platform for Natural Hazards, which is responsible for coordinating concepts in the field of prevention against natural hazards (*www.planat.ch*). In terms of insurance against fire and natural hazards, Switzerland has a system that is regulated via the private sector as well as via the government. In 19 cantons, insurance coverage is provided by public building insurance companies (Kantonale Gebäudeversicherung, KGV). In the remaining cantons, private insurance companies are responsible for insuring buildings against natural hazards. In the case of an imminent natural hazard, the civil defence is responsible for warning and alarming the population, and – jointly with the fire brigade – for recovery after the incident.

Fig. 94 > Cycle of integrated risk management

Preparedness, response and recovery complement each other and must be closely coordinated. This requires comprehensive hazard information which lies at the centre of the cycle of risk management.

DETEC (2008)

The aims of the Swiss strategy for protection against natural hazards are the following.

- Within one generation (20 – 30 years) a consistent level of safety for human life, infrastructure and relevant assets is achieved throughout Switzerland; the chosen level of safety should be sustained in the long term. People are able to live their lives without being concerned about natural hazards. The principles of sustainability are observed as part of this process.
- Existing risks are reduced to an acceptable level.
- The emergence of unacceptable new risks is hindered through suitable preventive measures (planning measures, use of appropriate construction methods and techniques etc.).
- The relevant hazards are known for the entire living space. The necessary hazard maps covering the entire country are made available by 2011 (in 2009, 60 % of hazard maps were completed).
- The protective measures undertaken are appropriate, the protective structures are robust and cases that exceed the design load are taken into consideration. Buildings and industrial plants are constructed in a way that takes natural hazards, including extreme events, into account and display an acceptable level of vulnerability.
- The population is familiar with the significant natural hazards in its region; it is prepared for hazard events and behaves in an appropriate way during a hazard event so as to minimise the loss of human life and material assets.
- The options for individual prevention are facilitated through optimised forecasting and alerting.
- The defence forces have prepared an emergency plan and practise it periodically.
- The implementation of integrated risk management is associated with proportionate land-use restrictions. Possible and likely developments including changes due to climate change are taken into account (adaptability of the measures to an altered hazard situation).

For all flood protection concepts developed since the 1990s, the previously applied design parameters proved to be no longer sufficient. Based on statistical analyses of flood events, new design values were calculated. For example, based on the analysis of the time series that included recent events, the statistical run-off values for the river Engelbergeraa in the cantons of Obwalden and Nidwalden had increased by 50%.

It is not yet possible to directly link such developments to climate change and to predict the influence of ongoing climate change on natural hazard processes in detail. The sensitivity of natural hazard processes to the effects of climate change, in particular the effects of climate change on the occurrence of extreme events, needs further analysis. Nevertheless, experts assume that the number of extreme events is likely to increase as a result of climate change. In particular, peak flows and volumes and solid matter transport in the Alpine region will increase if, as predicted, the permafrost border shifts 180-680 m upwards within 50 years.

The expected increase in damage potential as well as the possibility of more frequent floods require higher protection against floods. A possible answer to prevailing uncertainties are so-called no regret measures, such as, for instance, sustainable flood protection: Renaturalisation and broadening of rivers will reduce the risk of severe flooding and help minimizing the risks of intensified flood intensities, and even in case of unchanged flood intensity, these measures are beneficial, e.g. for river ecosystems.

Adaptation of current protective measures to changed requirements due to the possible effects of climate change will pose a major challenge. A series of major flood protection and silvicultural structures need to be modernised in the near future, as they no longer meet today's design and technical requirements. Securing the financial means for the high cost of implementation represents one of the key problems.

6.3.3 Weather hazard alerts

In 2007, the federal government tasked the responsible agencies to improve the hazard warning and alarm system of Switzerland. One project includes the development of a common internet platform on natural hazards like avalanches, floods or storms (GIN, *www.gin-info.ch*). The Federal Office of Meteorology and Climatology MeteoSwiss provides the relevant meteorological data and information. The main users are the natural hazard specialists of the cantonal authorities. They evaluate and mitigate risks of natural hazards and advise the operational management of civil protection. The GIN platform is being tested in 2009 and will be operational in 2010.

In 2008, MeteoSwiss set COSMO-2, a high resolution numerical weather model covering the alpine domain with a grid spacing of about 2.2 km, operational. In case of high-impact weather or incidents in nuclear power plants, alerts are issued on the basis of this model. Professional users of other federal agencies may extract specific information from this model in their field of operation (e.g. flood alerts).

The "single official voice" principle for natural hazard alerts, including the weather hazard alerts of MeteoSwiss, is being realized together with other federal agencies. New legislation will be established in 2009. One of the key elements of this legislation is the compulsory dissemination of the alerts from the federal agencies via the appropriate channels (e.g. TV, radio). To the extent possible, alerts under the "single official voice" principle will be in a unified format with consistent alert levels.

MeteoSwiss recently revised and improved its production chain of weather hazard alerts. Different types of weather hazard alerts are issued for 138 regions, 24 lakes and 18 airports, 24 hours a day, 7 days a week, in four different languages (English, German, French, Italian). While the federal and cantonal authorities are served through protected and highly secure dissemination channels, the broad public may subscribe to the free SMS broadcast system of MeteoSwiss. The relevant internet site is *www.meteoswiss.ch* > danger.

6.3.4 Hydrology and water resources

Although there is a broad qualitative understanding of the impacts of climate change on the hydrological cycle, quantitative data are largely lacking. In order to improve this situation and to provide the necessary data for the various sectors that depend on water resources, the project CCHydro (Effects of climate change on water resources and water courses in Switzerland) was launched in 2007. The project will provide scenarios with a high temporal and spatial resolution for the water cycle and discharge processes for the different climate regions, altitudes and geomorphological conditions in Switzerland. Based on this, analyses of the changes in extreme flow values (high and low water), the seasonal distribution of water resources (regimes), groundwater infiltration and soil water content, and, possibly, watercourse quality (physical and chemical parameters) will be carried out.

Beside this hydrological research that will improve the database, a broad national research programme "Sustainable Water Use" (NRP 61, *www.nfp61.ch*) was established. It will provide the scientific basis and develop methods for sustainable management of water resources that are under increasing pressure. NRP 61 will determine the effects of climate and social changes on these resources and identify the risks and future conflicts associated with their use. The NRP 61 will develop strategies for ensuring sustainable and integrated water resources management also in the future.

Regarding the changes in high water, low water and groundwater recharge, the German federal states Baden-Württemberg and Bavaria have already made projections, which are also relevant to Switzerland. These projections are based on model calculations carried out as part of the German KLIWA project (Climate Change and Consequences for Water Management).

The Rheinblick2050 project was launched in 2008 by the International Commission for the Hydrology of the Rhine basin (CHR) in consultation with the International Commission for the Protection of the Rhine (ICPR). The aim of this project is to develop consistent joint climate and discharge projections for the Rhine catchment areas. This will help estimating future changes in the hydro-meteorological regimes in the Rhine catchment area and demonstrate, in turn, how such phenomena influence hydrological and hydraulic processes. The project is expected to provide data for the planning period up to 2050.

Regarding water resources management, five main issues have to be addressed: to manage the increasing temperature in rivers and lakes, to deal with sewage disposal under lasting low flow conditions, to redesign the lake regulation schemes taking into account the changed hydrological regimes, to introduce quantitative water management plans where needed, and to establish a better legislative base for an integrated water management approach. Most of these topics will be based on the results of the above mentioned research. A first draft of recommendations and guidelines for an integrated river basin management in Switzerland has been published earlier this year (Aschwanden and Pfaundler 2009).

6.3.5 Biodiversity

In September 2008, the Swiss parliament mandated the Federal Office for the Environment to develop a new and overarching national biodiversity strategy. This strategy will set the framework for biodiversity conservation over the next decades. Climate change is one of the pressures on biodiversity that the strategy will address, since even under the most modest climate change scenario, impacts on biodiversity in Switzerland are expected to increase. Changes in ecosystem structure and functioning as well as unexpected interactions between species are likely to become more common.

Given the role of climate in triggering shifts in the distribution of species and habitats, the national biodiversity strategy will place a particular focus on safeguarding the gene pool and habitat connectivity. By reinstating the connectivity of habitats the potential for adaptive changes in ecosystems shall be increased, the resilience of ecosystems safeguarded and thus the long-term provision of ecosystem services secured.

6.3.6 Forests and forestry

Over the coming decades, changing climatic conditions and extreme weather events will affect forests in different ways, even though the mode of transition is unclear. Forest management under uncertainty is the future challenge for silviculture.

Valuable indications on ongoing and possible future developments are provided by the periodic forest inventory of Switzerland and the monitoring networks on plant phenology and biodiversity (see 6.1.6). Based on these empirical data, regions with accelerated modifications can be identified. These will be the "hot spot" regions for forest adaptation measures. The forest inventory of Switzerland allows comparing actual forest composition and natural forest composition under changed climatic conditions. In regions with large differences between actual composition and expected future composition, the adaptation demand is high, even today.

However, information on adequate adaptation measures under new and fast changing conditions is scarce. Thus, in the framework of the "forest and climate" research programme (see section 8.2.5 on forest research) the scientific basis to derive recommendations for adaptation measures will be elaborated.

In recent years, some Swiss cantons have published guidelines for operational adaptive forest management under climate change. The overall recommendation is the strengthening of silviculture in respect of site-specific natural conditions and the enhancement of species diversity. This will strengthen the resistance of forest stands and trees and distribute and minimize potential risks.

In the long term, the composition of many Swiss forests will change. This will be the combined result of changing climatic conditions and case-by-case human intervention induced by the impacts of climate change, e.g., afforestation with better adapted tree species after storm, fire, drought events or insect calamities. It is expected that the share of deciduous trees will increase and coniferous trees decrease. This will have consequences for the timber industry, which is mainly equipped for processing softwood.

6.3.7 Agriculture

By means of an adequate choice of cultivated plants, cultivation methods and farm management, agriculture will be able to adapt to a moderate rise of mean temperatures. The demand for irrigation will increase in many regions. As evidenced in the summer of 2003, the management of water shortages needs particular attention, as conflicts arise between the various users that depend on water from small and medium-sized rivers and groundwater. Efficient use of irrigation water will become an issue of increasing importance.

Measures such as plant breeding and the evaluation of different varieties will contribute to the adaptation to changing conditions. In order to better distribute the risk of harvest failure, a diversification strategy aiming at a varied mix of cultivated crops should be envisaged. Such a strategy could also help to counteract pests, whose damage potential is likely to increase. In addition, insurance coverage of yield loss due to extreme weather conditions is expected to gain importance.

Adaptation measures suited to changing climatic conditions are required in livestock husbandry as well. Animals must be protected from high temperatures through suitable barn ventilation and shade. Breeding aims should also be examined.

Various research projects have been launched or are in preparation at the agricultural and other research institutes with a view to filling knowledge gaps. The topics covered include irrigation requirements and optimisation possibilities in food and fodder crops, the link between warming and the use of uncompetitive species for the revegetation of vineyards, and the establishment of bio-climatic bases for pest prognoses in fruit growing. The influence of increased temperatures on crop quality, the effects of farming on natural hazards, and farmers' perception of and response to climate change are also being examined.

Taking into account ongoing research, the Swiss Federal Office for Agriculture is currently working on a climate strategy for agriculture that will present and prioritise options for action. The strategy will involve both reducing the greenhouse gas intensity of agriculture and adapting agriculture to changing climate conditions. In view of the numerous links with other topics such as rural ecosystems, health, water management, energy, tourism, and insurance, broad-based interdisciplinary support is planned.

6.3.8 Hydropower generation

At present, changes in the European energy market (liberalisation, increasing importance of wind power) are considered to have much stronger influence on the management of hydropower production than the relatively slow climatic changes. The complex interactions between climate change and hydropower production are subject of an ongoing study (NWB 2009). It will allow for an assessment of the need for action and for the development of adaptive measures. In the long run, it will be essential to fill the gap between decreasing hydropower production and increasing electricity demand by improving the efficient use of energy and by establishing new sources of renewable energy.

6.3.9 Tourism

In order to maintain the important economic role of tourism, the offer of individual destinations needs to be adjusted to changing local conditions. This is of particular importance for long-term investment planning.

In 2007, the national marketing and sales organization Switzerland Tourism established a working party involving a wide range of stakeholders from tourist resorts, hotel businesses, mountain railways, research and marketing to analyse consequences of climate change, to make available information on ways forward and to motivate its members to take appropriate action. In 2008, a report was published which examines scenarios resulting from climate change until the year 2030 (Müller and Weber 2008).

According to a survey conducted by Cableways Switzerland (Verband Seilbahnen Schweiz 2007), about 50% of the mountain railway companies are considering climate change in their strategic planning today, while about 80% intend to do so in the future. For the tourism industry, several adaptation measures are available, however, some may be very costly. Driven by market forces, the industry reacts to the challenges caused by climate change with various autonomous measures.

In skiing resorts, pressure for investments in adaptive measures (equipment and water reservoirs for artificial snow production, new transport infrastructure and levelling of new ski slopes at high altitudes) will increase as climate change continues. Unfortunately, most of these measures lead to an increased demand for energy and/or water and may affect pristine landscapes. Switzerland Tourism has acknowledged the role of tourism as a contributor to climate change and encourages its members to invest in measures to improve sustainability of operations. In some areas, regulations or financial support may be necessary to achieve this goal.

Climate change will cause shifts in offer and demand as well as shifts in the regions of origin of guests. Some touristic destinations will lose in attractiveness, others will profit from new opportunities. By adjusting their offer, tourist destinations may develop new core competences, and new guest groups may be attracted. Promising development models for the Swiss tourism industry are the concentration of winter sports in top destinations, the promotion of wellness-centres in the mountain region, and the diversification of attractions offered for summer recreation. These examples illustrate that adaptation takes place in a dynamic context, where minimising the cost of damage caused by climate change goes hand in hand with the search for innovative business opportunities.

6.3.10 Health

The 2003 heat wave made the public as well as political authorities aware of the potential dangers to health that are linked to climate change. In a common effort, the Federal Office of Public Health (FOPH) and the Federal Office for the Environment (FOEN) mandated a study to document the state of knowledge in the field of climate-related health risks for Switzerland (Thommen and Braun-Fahrländer 2004). The report concluded with a number of recommendations, which formed the basis for initial steps towards adaptation. Main recommendations included:

- appointment of a working group on climate and health;
- information of the population on how to protect oneself in situations of excessive heat and high tropospheric ozone concentrations;
- introduction of an early warning system to detect increased mortality during heat waves;
- build-up of monitoring systems for new potential risks from vector or food-borne diseases.

A standing committee under the shared lead of FOPH and FOEN was constituted in early 2005 and has had meetings at regular intervals since. The committee has the mandate to improve exchange of information and coordinate action amongst all federal agencies and scientific institutions involved in this field.

An information campaign on precautionary measures in case of heat waves was launched in early summer of 2005. Active campaigning continued for three years, while documentation remains available at a dedicated website operated by FOPH. The main target groups of the campaign were people working in the health service and caring for elderly people. In addition, information was provided on how excessive heat can affect babies and small children. Care facilities, homes, community care services as well as cantonal medical officers were contacted directly. General recommendations were passed on via the general and specialised media. So far over 350'000 flyers and fact sheets have been sent out. For recent developments in the field of weather hazard alerts, see section 6.3.3.

The reporting system allowing the Federal Statistical Office to assess trends in mortality within a short time frame was improved. The development and operation of a monitoring system for the various vector-borne diseases affecting human and animal health will be considered in the coming years.

6.3.11 Infrastructures

In addition to the strategy on protection against natural hazards (see section 6.3.2), which aims inter alia at the protection of infrastructures, measures relating to the protection of buildings in case of extreme events, e.g. winter storms, include the adaptation of construction standards.

The impact of higher temperatures on living and working conditions in buildings is considered to be rather limited as building insulation protects against solar radiation as well. Nevertheless, several measures are available to prevent excessive temperatures in buildings, e.g. appropriate design of exterior walls (shadowing), air-conditioning/ventilation, minimisation of waste heat from building equipment and appliances. Recommendations have been documented in a brochure issued by the expert group on sustainable building of the federal administration's coordinating body on construction and real estate KBOB (KBOB 2008).

6.3.12 Insurance business

Climate change affects almost all economical sectors and, thus, virtually all business activities of an insurance company. As many companies act as global players in interconnected markets, not only regional climate change will influence their business but also changes on a world-wide level. Insurers and reinsurers need to adapt their products, services and risk management tools and processes to changing climate as well as to changing regulatory and economical conditions.

For insurance companies it becomes more and more important to incorporate the latest scientific results into their business processes. They are moving from retrospective underwriting, based on past data, to prospective underwriting, taking future changes into account (Swiss Re 2006). To this end, possible consequences of climate change, in particular on extreme events, need to be included into risk modelling to estimate damages and the associated risk premium. If natural disasters become stronger and more frequent, insurers and re-insurers will have to raise premiums or limit coverage in order to be able to pay in case of loss. Preventive measures such as adapting and implementing urban planning and construction standards are necessary to make risks insurable again. Currently, the insurance industry develops new products, such as catastrophe bonds, to deal with more severe loss events that occur with high variability. Additionally, new forms of public-private partnerships involving risk transfer solutions are being explored, making societies more resilient by addressing the rising cost of natural catastrophes (Swiss Re 2008). In 2007, Swiss Re introduced the Climate Adaptation Development Programme (CADP). The goal of the CADP partnership is to develop and implement weather risk transfer solutions in non-OECD countries.

Operational adaptation measures encompass underwriting adjustments, such as price increases to account for higher claims, higher deductibles, lower limits and/or exclusions, e.g., of weather-sensitive materials. The benefit of such measures is that they can give incentives to the insurance-taker for risk adapted behaviour. A higher deductible may encourage house-owners to invest in loss prevention measures or to take the appropriate steps during or after an event. Underwriting adjustments, however, are only part of the solution. If extreme events increase in such a way as to produce frequent claims, preventive measures will need to be taken, as insurance can only cover the cost of rare events (OcCC 2007). Loss prevention is thus receiving renewed attention. It could play an important role in preserving the insurability of high-risk areas such as coast- and riversides (Mills 2009). For the numerous options available to the insurance industry to play an active role in mitigation of and adaptation to climate change see Mills (2009).

In conclusion, some of the impacts can be addressed through measures initiated solely by the insurance sector, some have to be addressed on the socio-political level. The ultimate goal will be to join efforts in order to reduce the consequences of natural catastrophes in a sustainable manner.

6.3.13 Summary on vulnerability and adaptation measures

Switzerland is still working at refining its vulnerability assessments and adaptation options. Several areas are reasonably well covered, with a good understanding of vulnerability and potential adaptive measures (Tab. 48). However, some of the measures to adapt to climate change are in conflict with other objectives. For example, issues arise in the area of water management with regard to biodiversity and protection of natural landscapes. Finding the optimal solution to fulfil the interdependent requirements represents a major challenge in adaptation.

Tab. 48 > Summary of information on vulnerability and adaptation to climate change

Vulnerable area	Vulnerability	Adaptation
Society and economy as a whole	Damage, casualties and disruptions caused by more frequent/intense extreme events; irreversible changes in climatic and hydrological conditions with unforeseeable consequences for environment, economy and society	National adaptation strategy to assure a coherent, coordinated approach; development of high-resolution climate models for assessment of impacts at regional/local scale; integration of climate change in strategy on natural hazards; improved preparedness for natural hazards
Water management / Water resources	Increased risk of floods and water shortages, making current lake level regulation schemes obsolete; lack of methodology for the development of quantitative water management plans; insufficient legislation for integrated water resource management (IWRM); loss of coolant capacity due to higher temperature of rivers and lakes	Research projects to improve the data base for assessment of potential impacts and planning of adaptive measures at the sectoral level; review of water management provisions (water reservoirs, managed lakes; code of practice for water use); recommendations and guidelines for IWRM.
Biodiversity	Loss in species diversity with consequences for e.g. food, medicine; degradation of ecosystem services, e.g. pollination, soil fertility, water purification	Fostering resilience of ecosystems, restoring habitat connectivity to enable adaptation of species, safeguarding genetic diversity (gene pool), improving databases, elaboration of a new national biodiversity strategy
Forests and forestry	Reduced productivity and larger damage from pests and forest fires	Guidelines for adaptive forest management (promotion of near-natural silviculture); research on site-specific adaptive measures; extension of early warning systems for pests and forest fires
Agriculture	Reduced productivity and larger damage from pests; decreasing yield stability due to extreme events; increasing damages of infrastructure	Development of a climate strategy for agriculture; breeding/selection of plants and animals; adaptation of cultivation methods and farm management (e.g., water management and irrigation, diversification, insurance)
Hydropower generation	Slight decrease of production; increased transport of sediment and other solid material in rivers	Evaluation of the need for the development of a long-term strategy for adaptive measures
Tourism	Decreasing snow-reliability at lower altitudes; changes in natural scenery; locally reduced ground stability, increased natural hazards; new opportunities for summer tourism	Short-term: "corrective" measures to assure usability of skiing areas. Long-term: adjustment of the offer to changing conditions (e.g., concentration, diversification); climate-proof investments
Human health	Increased mortality during heat waves; spread of vector-borne diseases	Information campaigns/weather alert systems; extension of existing monitoring systems to new risks
Infrastructure	Increasing risk of severe damage through extreme events; heat impairing living and working conditions in buildings	Adaptation of construction standards; exterior wall design (shadowing), air-conditioning/ventilation, minimisation of waste heat in buildings
Insurance business	Unfavourable trend in development of insured damage cost and future loss potential from extreme events; uncertainties with regard to the impact of climate change on the development of losses	"Prospective underwriting"; new products to deal with more severe loss events; use of incentives to promote risk-adapted behaviour of insurance-takers; support of preventive measures to safeguard insurability

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7 Financial resources and transfer of technology

Within the Swiss Federal government, two agencies are responsible for policy formulation and implementation in the area of development cooperation and cooperation with Eastern Europe and the Commonwealth of Independent States (CIS): The Swiss Agency for Development and Cooperation (SDC) deals with technical cooperation, financial aid and humanitarian aid. The State Secretariat for Economic Affairs (SECO) is responsible for measures related to trade and economic development. Both agencies assume a co-responsibility for the international financial institutions.

Swiss development cooperation activities and funding focus on three strategic priorities: 1. Reducing poverty; 2. Promoting human security and reducing security risks; 3. Contributing to pro-development globalisation. Within these strategic priorities environmental and climate protection play an important role. Switzerland engages in policy dialogue and negotiation processes, mitigation, and adaptation. Promoting adaptation to climate change and access to sustainable energy contributes to poverty reduction, avoiding climate related conflicts enhances human security and the promotion of fair climate regulations is one element of a pro-development globalisation. Furthermore, the Bali Action Plan under the UNFCCC with the four pillars of mitigation, adaptation, technology and finance provides a framework for orientation.

At policy level, Switzerland is playing an active role in international climate policy and is making a contribution to fair and binding political framework conditions. By participation and co-financing projects in the main multilateral institutions and by an active political dialogue Switzerland contributes to a climate-sensitive approach within these institutions and aims to ensure a more coherent implementation of policies and strategies and to promote the international division of labour. At bilateral level, Switzerland supports activities in mitigation and adaptation (refer to sections 7.2 and 7.4 for further details).

SDC has undergone a thorough restructuring process in 2008 and carries out its operations in four divisions: Global Cooperation, Regional Cooperation, Cooperation with Eastern Europe / Communities of Independent States and Humanitarian Aid. Within its Global Cooperation pillar, SDC is addressing global challenges such as climate change, food security, and migration. Building on decades of climate-relevant operational experiences in the fields of energy efficiency, renewable energy, agriculture, and forestry, SDC established a new Global Programme Climate Change. This Programme is operating through multiple partnerships at the political, multilateral and local levels and encompasses activities on both climate change mitigation and adaptation. It acts as a catalyst for the progressive integration of mitigation and adaptation in all of SDCs operations and maintains an agency-wide network for this purpose. Meanwhile, the Humanitarian Aid pillar of SDC is able to draw on its vast experience with climate-related issues in expanding its activities in relevant areas, such as Disaster Risk Reduction.

SECO's Economic Development Cooperation is divided into four operational branches: Macro-economic support, private sector promotion, trade promotion and infrastructure financing. Since 1992, SECO has been pioneering innovative modalities of technology transfer. For this purpose, SECO has partnered with the World Bank, Regional Development Banks, UNIDO, UNCTAD, ITC, ITTO and other specialised organisations, including from the Swiss private sector. SECO's programme benefits from the rich experience of Swiss research institutions and technology suppliers regarding environmentally sound technologies. SECO is continuing its engagement as built up in the last decade, completed by a new engagement around REDD (Reducing Emissions from Deforestation and land Degradation in developing countries).

Section 7.1 summarizes financial contributions to dedicated funds under the UNFCCC managed by the Global Environmental Facility (GEF). 7.2 provides in textual format information on Switzerland's bilateral activities related to adaptation including an example of one of the adaptation programmes. Section 7.3 gives a tabular overview on the financial contributions at multilateral and bilateral level. Section 7.4 reports on technology transfer activities related to mitigation both from the public and the private sector. Several projects are described in detail, including more information on the technology transferred.

7.1 Provision of « new and additional » financial resources

Switzerland considers its contributions to the funds under the UNFCCC and its Kyoto Protocol that are managed by the Global Environmental Facility (GEF) as additional resources and continues to strengthen its climate-related activities through its active engagement in a large number of organisations and processes in the field of international cooperation.

Contributions to dedicated funds under the UNFCCC
At COP 6bis in Bonn, 2001, Switzerland signed a political declaration issued jointly with the EU, Iceland, Norway, New Zealand and Canada, committing itself to payments to the Special Climate Change Fund (SCCF) on the basis of the originally proposed emissions-based burden-sharing formula. According to the annex of the Kyoto Protocol, the Swiss share of 1990 Annex I emissions is 0.3%. The base amount of the COP6bis Political Declaration was USD 410 million yielding a Swiss share of CHF 1.5375 million per year. This payment modality was subsequently approved by parliament.

Tab. 49 > Financial contributions to the UNFCCC Climate Funds managed by the GEF

	Contributions (CHF)			
	2005	2006	2007	2008
Least Developed Countries Fund	700'000	700'000	1'000'000	1'000'000
Special Climate Change Fund (Adaptation)	650'000	900'000	500'000	500'000
Special Climate Change Fund (Technology Transfer)	650'000	400'000	0	0

FOEN (2009 internal document)

7.2 Assistance to developing countries particularly vulnerable to climate change

Adaptation in SDC projects
SDC has undertaken a broad range of activities to promote climate resilient development especially in the most vulnerable developing countries. It seeks to create awareness on adaptation at different levels, such as at international and national policy level, sector level and at local level. Overall goal of SDC's Global Programme Climate Change in adaptation is to support developing and emerging countries in reducing their susceptibility to unavoidable climate change and minimising the social and economic costs by:

- Maintaining or increasing productive capital of land (forest, agriculture) at local level
- Reducing susceptibility to natural hazards in highly endangered areas at the local / regional level
- Increasing technology transfer and innovation in the field of adaptation in developing and threshold countries.

SDC's adaptation activities are mostly linked to sustainable management of soils, water and forests and envisage the most vulnerable countries and communities. Management of natural resources is not only at the heart of the fight against poverty (agricultural and forest production, soil moisture regime, bio-mass for energy) but also helps to prevent climatic risks (dryness, extreme events). Furthermore, emphasis is given to linking climate change adaptation activities with efforts on prevention and disaster risk reduction within the humanitarian aid. Switzerland has been active for many years in disaster risk reduction and has developed several methods and tools to better integrate disaster risk reduction into project planning and project management.

Several pilot projects or programmes on adaptation have been launched over the last few years such as the project "Vulnerability assessment and enhancing adaptive capacity to climate change in semi-arid India" or the "Climate Change Adaptation Programme" in Peru (for more details see Tab. 50).

Tab. 50 > Climate Change Adaptation Programme (PACC)

Project / programme title: Climate Change Adaptation Programme (PACC)			
Goal: Secure the livelihoods and reduce the vulnerability of poor people by promoting adaptation measures that enhance their capacity to better cope with adverse impacts of climate change. Purposes: To strengthen the capacity of the local and regional governments in Cusco and Apurimac, as well as the vulnerable poor communities to cope with adverse impacts of Climate Change by means of providing basic reliable information, policies, strategies and adaptation measures, integrated into sustainable development processes.			
Recipient country	Sector	Total funding	Years in operation
Peru	Water Resource Management, Food Security and Risk Management	CHF 4,9 million for programme implementation CHF 1,12 million for scientific Know-How Transfer	2008 - 2011
Description: The programme consists of the following four components: Assessment of the vulnerability and capacity to cope with adverse impacts to climate change in the regions of Cusco and Apurimac. For this purpose, vulnerability assessments and climate change models will be developed in close cooperation with regional and local authorities, scientific institutions and communities. Establishment of a regional information system for the collection of data and monitoring of climate variability and change. Implementation of adaptation measures in the fields of water resource management, food security and risk management. To manage knowledge and promote public policies. Strategic partners of the PACC are the Ministry of Environment (MINAM), Regional Government of Cusco and Apurimac and the Province and District Municipalities of the priority areas. The programme is supported by a consortium of three NGOs (Intercooperation, Libélula, Predes) and receives scientific advise from a consortium of Swiss scientific institutions.			
Expected added value of the programme: This programme is a pilot initiative and shall provide insights on: Linking scientific and traditional Know-how regarding climate change predictions; Establishing Know-how and capacities at the regional and local level for climate data collection and establishment of information systems; Develop capacity and demonstrate best practices to cope with climate change in water resource management, food security and risk management; Integrate adaptation measures into government policies, plans and budgets at different governmental levels (local, regional, national); Promote coordination of actions among different sector of local, regional and national governments.			
Technology transferred: Capacity building in tools and techniques for climate change adaptation in water resources management, food security and risk management; Know-how transfer regarding climate change modelling and vulnerability assessment as well as data collection and interpretation.			
Impact on greenhouse gas emissions/sinks: Focus exclusively on adaptation.			
SDC			

SDC has also provided support for several climate-related projects at the multilateral level, such as:

- UNDP Climate change capacity development for policy makers in developing countries: The project aims at strengthening national capacity of developing countries to develop policy options for addressing climate change across different sectors and economic activities. The project provides targeted assistance to 20 developing countries, most of them Least Developed Countries or Small Island Developing States.
- World Bank study "Economics of Adaptation to Climate Change": The overall objective is to help decision makers in developing countries better understand and assess the risks posed by climate change and to better design strategies to adapt to climate change. This $8 million study is being financed by the Governments of the UK, the Netherlands and Switzerland and consists of a 'global track' and a set of seven country studies.
- Climate-L.org (IISD in Cooperation with the UN Chief Executives Board for Coordination Secretariat): This innovative knowledge management project is providing consolidated information on the international activities related to climate policy. Web-based tools allow for the provision of high quality and timely information at a global level. Worldwide subscriptions to Climate-L.org have grown rapidly.

Several bilateral projects contribute positively to climate change adaptation although they are not specifically designed for this purpose. Mostly, these projects are aimed at sustainable resource management. Adaptation components are important in projects covering the sectors environment, agriculture and water. An analysis of SDC's portfolio in the field of natural resource management (forest, water, agricultural land) revealed that approximately 15% of all these projects or project components can be attributed to climate change adaptation.

Adaptation in SECO projects: Weather insurance
Since 2002, SECO is supporting the Commodity Risk Management Group (CRMG) of the World Bank by co-founding pilot projects on weather insurance for farmers. Those insurance products are developed according to pre-disaster analysis and index development that is the reference or baseline when weather fluctuations occur (drought, floods). Payments to farmers are triggered by specific patterns of the index, not by actual yields. Therefore weather indexed risk management products are considered as a new alternative to traditional crops insurance programmes. It reduces the occurrence of moral hazard and adverse selection.

In cooperation with Swiss Re (as reinsurer), SECO supported CRMG in its first index-based weather risk management transaction in India in June 2003, the first-ever weather insurance project in the country. Based in Andhra Pradesh, the pilot programme sold weather insurance policies protecting against low rainfall to groundnut and castor farmers. During the 2005 monsoon season 250,000 farmers bought weather insurance throughout the country; a significant portion of this risk was reinsured into the international risk markets. The case of India provides an interesting example how, very quickly, the project reached its exit strategy, that is, commercial markets are developed to the point where risk management products and services are readily accessible to those who need and want them. Experiences are shared with the International Task Force on Commodity Risk Management that offers a platform of dialogue among the private sector, UN organizations, donors and World Bank.

7.3 Provision of financial resources (incl. under Art. 11 KP)

From 2005 to 2008, Switzerland's official development assistance amounted to CHF 8.3 billion (between 2 and CHF 2.2 billion per year), whereof approximately 25% have been provided through multilateral assistance (core contributions and programmes) and 75% through bilateral assistance projects. Tab. 51 and Tab. 52 give an overview on multilateral and bilateral climate related contributions.

Climate-related contributions from SDC:

- Programmes and projects at global level (specific programme climate change, food security and water): Contributions to mitigation and adaptation components were systematically analysed.
- Programmes and projects in the regions (Latin America, West Africa, East- and Southern Africa, South Asia, East Asia, Central Asia and Western Balkan): Exact information on climate related contributions of these programmes or projects are not available. Based on an analysis of all regional projects the following judgements were made: Out of all activities in the sectors environment, agriculture and water, 20% of projects or project components are attributed to climate change mitigation and/or adaptation. Out of these projects, contribution to adaptation is 75%, contribution to mitigation 25%.
- Humanitarian aid: 60% of all projects or project components in the field of prevention and preparedness are calculated as climate change adaptation projects (as they are climate / weather related). Contributions to climate related emergency relief and reconstruction are not included.

SECO: 10% of bilateral ODA is attributed to be climate-related, mainly mitigation.
BAFU: 1/3 of multilateral contributions to the GEF is for climate-related funding, mainly mitigation. Out of this contribution, currently 97% is counted as ODA.

Tab. 51 > Financial contributions to multilateral institutions and programmes

	Multilateral contributions (million CHF)			
	2005	2006	2007	2008
Global Environmental Facility (GEF)	21.8	20.8	24.4	29.8
Multilateral institutions:				
1. World Bank (IDA)	153.0	159.0	166.0	174.0
2. International Finance Corporation	12.1	15.3	9.1	10.5
3. African Development Bank (BAD)	0	0	4.4	0
African Development Fund	16.5	7.9	0.7	66.3
4. Asian Development Bank (ADB)	0	0	0	0
Asian Development Fund (ADF)	16.7	15.4	15.1	13.4
5. European Bank for Reconstruction and Development (EBRD)	10.5	11.3	1.9	7.1
6. Inter-American Development Bank (IADB)	0	0	0	1.3
7. United Nations Development Programme (UNDP)	52.0	52.0	52.0	54.0
8. UNEP	4.4	4.5	4.5	4.9
UNEP Ozone Fund	3.4	2.0	2.0	2.5
9. UNFCCC and Kyoto Protocol	0.7	0.8	0.4	0.4
Kyoto Protocol Adaptation Fund				0.2
UNCCD	0.4	0.5	0.5	0.9
UNFF				0.1
International Tropical Timber Organization (ITTO)	3.8	3.9	0	0
Multilateral scientific, technological and training programmes:				
Consultative Group on International Agricultural Research (CGIAR)	12.0	12.0	12.0	11.9
International Fund for Agricultural Development (IFAD)	7.5	7.6	7.7	7.8
International Strategy for Disaster Reduction (ISDR)	0.8	0.8	0.8	0.8
International Union for the Conservation of Nature (IUCN)	1.0	1.3	1.0	0.7
UNIDO: Cleaner Production Centres (CPC), metrology and standards	5.1	9.0	3.7	4.1
World Bank Climate Funds: CF Assist; Forest Carbon Partnership Facility	0	2.3	0	8.8
UNCTAD: Biotrade	0.6	1.2	0.8	1.8
IPCC	0.1	0.1	0.1	0.1
UNITAR (climate change, environmental law)	0.6	0.6	0.6	0.3
OECD Climate Change	0.05	0.05	0.05	0.05
Total	323.05	328.35	307.75	401.75

Tab. 52 > Bilateral and regional financial contributions

	Disbursement Mitigation (in CHF)				Disbursement Adaptation (in CHF)			
Recipient region	2005	2006	2007	2008	2005	2006	2007	2008
SDC								
Global	3'993'000	3'930'000	2'705'000	3'547'000	5'153'000	5'432'000	4'339'000	5'875'000
Latin America	1'222'000	1'092'000	1'482'000	1'380'000	3'666'000	3'277'000	4'445'000	4'139'000
West Africa	797'000	632'000	665'000	730'000	2'392'000	1'896'000	1'995'000	2'191'000
East- and Southern Africa	1'228'000	1'281'000	1'111'000	1'348'000	3'684'000	3'844'000	3'334'000	4'044'000
South Asia	1'523'000	1'607'000	1'588'000	1'676'000	4'570'000	4'822'000	4'763'000	5'029'000
East Asia	873'000	1'189'000	807'000	906'000	2'620'000	3'566'000	2'421'000	2'718'000
Central Asia, Western Balkan	1'273'000	1'031'000	1'108'000	1'279'000	3'818'000	3'093'000	3'324'000	3'838'000
Humanitarian Aid (DRR)	0	0	0	0	9'883'000	11'870'000	10'781'000	11'396'000
SECO								
Global	23'800'000	23'300'000	20'200'000	20'500'000	0	0	0	0
Total	34'710'000	34'063'000	29'665'000	31'367'000''	35'786'000	37'799'000	35'402'000	39'228'000

Tab. 53 > Summary of information on financial resources and technology transfer

(million CHF)	2005	2006	2007	2008
Official development assistance (ODA)	2'207	2'063	2'022	2'235
Climate-related aid in bilateral ODA	70.5	71.9	65.1	70.6
Climate-related support programmes	IE	IE	IE	IE
Contributions to UNFCCC climate funds managed by GEF	2	2	1.5	1.5
Pledge for third and fourth GEF replenishment (Climate funds)	*2*	*2.1*	*1.5*	*1.5*
Activities implemented jointly	0	0	0	0
JI and CDM under the Kyoto Protocol (Climate Cent Foundation)*		5.049	9.821	19.999

Abbreviations: CDM: clean development mechanism, GEF: Global Environment Facility, JI: joint implementation. IE: included elsewhere.

Explanations: Financial support to climate-related programmes of multilateral institutions is reported under bilateral assistance.

*Annual expenditures according to projects under the flexible mechanisms derive from the Climate Cent Foundation (Climate Cent Foundation 2007 and 2008).

7.4 Activites related to transfer of technology

Under the Swiss foreign policy on energy of 2008 the Swiss Federal Council has mandated the relevant ministries (1) to increase their engagement regarding promotion of renewable energy and energy efficiency in the programmes of development cooperation; (2) to foster public private partnerships for sustainable energy projects; and (3) to increase relevant contributions to multilateral development banks.

In line with this decision, SDC and SECO have defined climate change mitigation as a priority area, respectively a cross-cutting issue. The focus is on access to modern energy infrastructure, including renewable energies, rural electrification, energy efficiency in the industry and in the buildings/construction sector, and reducing deforestation. Switzerland has a noteworthy track-record in energy projects, particularly in transition countries.

Switzerland has considerably deepened its inter-ministerial coordination through the platform Renewable Energy and Energy Efficiency Promotion in International Cooperation (www.repic.ch). This platform has successfully helped to improve knowledge exchange among the four federal agencies involved: SDC, SECO, Federal Office for the Environment and Swiss Federal Office of Energy. REPIC offers seed money

and technical advice for promising climate change initiatives, during the pre-competitive phases of project development, for technology and market testing. REPIC uses and pools the know-how and technology of Swiss companies, NGOs, and researchers. On the international scene, Switzerland participates in the newly established Climate Investment Fund and will be one of the three major driving forces for the "Scaling-up Renewable Energy Programmes in Low Income Countries" under this fund.

Importance of private sector initiatives for technology transfer

Technology transfer and innovation are crucial for any economic development. Technologies are mostly developed and owned by the private sector. In many fields of environmentally sound technologies, Swiss companies are leading in the development, diffusion and implementation of state-of-the-art solutions. Switzerland is an important hub in terms of R&D, foreign direct investment and technology exports. These climate relevant Swiss private sector activities, in the magnitude of several billion CHF per year, are supported by the Swiss export promotion agency "osec - Business Network Switzerland" (www.osec.ch) with its Swiss business hubs in many strategic export markets. Another important service for private technology suppliers is the Swiss export insurance scheme (www.serv-ch.com). The SERV is traditionally very important for Swiss exports e.g. in the context of new hydropower schemes.

Role of the public sector in technology transfer

In order to manage a successful technology transfer which uses the know-how and financing capacity of the private sector, Switzerland is convinced that the following elements need to be taken into consideration by governments; Switzerland is supporting various initiatives in this field regarding its national economy, but also – under its development cooperation – targeting developing and transition countries:

- Create a sound trade framework: Reduction of custom tariffs and non-tariff barriers
- Create an enabling investment framework: protection of private property, intellectual property rights (IPR), reduction of administrative hurdles for companies, fight against corruption; stability of the law, security, appropriate energy tariff setting etc.
- Strengthen financial markets: Improve access to finance particularly for SMEs and strengthen the risk management of financial intermediaries in its partner countries including capacity building in addressing environmental and social risks.
- Capacity building and information in order to prepare industry in developing countries to deal with the challenges of global production chains and new technologies.
- Realisation of pilot and demonstration projects

SECO activities related to transfer of technologies

The main responsibility for technology transfer matters is with SECO's «Economic Cooperation and Development» division responsible for planning and implementing economic and trade policy measures with developing countries, Eastern European and Central Asian states as well as the new EU Members («enlargement contribution»). Through its technology transfer activities, SECO seeks to integrate partner countries into the global economy and promote their sustainable economic growth.

SECO's role here is to gauge the economic consequences of climate change and support the implementation of suitable measures in partner countries in a manner that also makes economic sense. Its focus is on mitigating emissions of greenhouse gases. SECO also assists in the drafting of strategies in international institutions, such as the World Bank, and participates in international talks.

In December 2008 the Swiss Parliament passed the «Dispatch on the financing of economic and trade-policy measures in the context of development cooperation». This makes provisions for SECO to take on further commitments in climate-related matters. In essence, this focuses on: promoting emissions trading, technology transfer, investments in infrastructure, and market- oriented measures for the sustainable use of resources. Particular importance is attached to promoting energy efficiency and renewable energy sources. In its climate-related activities, SECO works closely with various international partners such as the multilateral development banks and international organizations such as UNIDO, UNCTAD and ITTO.

Within the scope of development cooperation, transition assistance and the enlargement contribution, SECO's objective with respect to climate is to foster ecologically sustainable and climate-neutral growth that also helps to lower poverty rates. SECO's activities are based on its specific competences and experience, concentrating on technology transfer in those sectors with the most potential for reducing climate-damaging emissions (i.e. high mitigation effect):

Carbon market

Switzerland has been a pioneer in CDM capacity building activities. After initiating and financing the successful World Bank programme for National Strategy Studies (NSS) on CDM potentials, SECO is a driver behind the Banks "Carbon Finance Assist" trust fund, a global programme for CDM capacity building:

Tab. 54 > Carbon Finance Assist – CDM Capacity Building for Megacities

Project / programme title: Carbon Finance Assist (World Bank Institute)

Goal: To contribute to the reduction of CO_2 emissions through the flexible mechanisms
Purpose: To contribute to the efficient and effective use of the flexible mechanisms by building up the necessary capacities in developing and transition countries in order to use the new carbon market.

Recipient country	Sector	Total funding	Years in operation
Global	Emission trading	CHF 3 million	2006 - 2009

Description:
Switzerland has a more than 10 years track-record of capacity building for climate change mitigation. After a series of over 20 national strategy studies for developing and transition countries financed through the World Bank, in 2006 Switzerland has pooled its funds with other donors in the Carbon Finance Assist trust fund managed by the World Bank Institute.
The programme consists of the following three components:

- Institutional capacity building
- Market development
- Outreach

Strategic partners at the national level are the Designated National Authorities. The programme is also closely cooperating with highly specialized consultants, research institutions and the private sector. More recently, the programme has joined forces with the large city grouping C-40 in order to seize CDM opportunities in megacities. Over 50% of the world's population live in urban areas – being responsible for 80% of global power consumption and emissions. However, cities are almost not represented as project owners in the CDM so far. The programme aims at closing this gap.

Expected added value of the programme:

- Formulation and implementation of the national CDM strategies;
- Establishing and strengthening of the designated national authorities (DNA);
- Demonstration of best practices in the use, incl. regulation and promotion of the CDM market;
- Promotion of South-South know-how (host country committee);
- Delivery of accurate market information, and match-making between CDM supply and demand: Carbon Expo (the world's largest CDM trade fair); annual state of the carbon market report;
- Development of CDM methodologies in strategic sectors where CDM faces difficulties, e.g. transport

Scaling up the CDM by capacity building at the sub-national / municipal level; 80% of the global CO_2 emissions are linked to cities – large cities being the "economic powerhouses" of many country; cities are often investors in potential CDM sectors such as public transport, lighting, building, waste management, power plants etc.

Technology transferred:

- Transfer of know-how regarding the establishment of DNAs and establishment of CDM/climate units within municipal administrations
- New CDM methodologies
- Capacity and skills development of public authorities at the national and sub-national level, regarding identification, structuring, implementation and marketing of CDM projects

Impact on greenhouse gas emissions/sinks:
Not quantified.

SECO

Promoting energy efficiency

SECO contributes to raising energy efficiency by providing financial incentives, financing pilot and demonstration projects, improving the framework conditions and offering professional consultancy services. It specifically seeks to use the know-how and capital available in the private sector, including Swiss companies. Swiss state-of-the-art technology has much to offer in the efficient management of industrial installations and in building technology.

Tab. 55 > Energy Efficiency – Rehabilitation of the District Heating System in the city of Iaşi, Romania

Project / programme title: Rehabilitation of the district heating system in the city of Iasi, Romania (co-financing with EBRD and Municipality of Iasi)

Goal: To rehabilitate the most affected parts of the district heating system of the city of Iasi in order to contribute to the reduction of CO_2 emissions, to sustainable heating tariffs as well as better service to consumers.
Purpose: To contribute to the efficient and effective use of the centrally provided district heating; to reduce fuel consumption; to increase service quality and avoid further switches to less efficient heat sources.

Recipient country	Sector	Total funding	Years in operation
Romania	District heating, energy efficiency, global environment	EUR 31.8 million of which EUR 7 million Swiss grant	2006 - 2010

Description:
In the Romanian city of Iasi currently more than 230'000 residents or 76% of the entire population rely on heat and hot water from district heating. The overall condition of the district heating system is bad as Iasi has not invested in maintenance in the past ten years but focused only on urgent repairs. The project's objective is to contribute to the rehabilitation of the city's district heating system to improve thereby the living condition of the inhabitants by ensuring a reliable supply of competitive and environmentally sound heat and also lay the basis for better economic development. The project is co-financed by the EBRD and the municipality of Iasi.

Expected added value of the programme:
Overall: The objective of the project is to contribute to the rehabilitation of the district heating system and thereby improve the living conditions of the local population by ensuring a reliable supply of competitive and environmentally sound heat and hot water.
The project has been approved with the aim to

- Increase energy efficiency by reducing heat losses in the distribution system
- Increase energy efficiency by increasing the efficiency of the thermal stations and to provide demand driven heat
- Thereby contribute to the reduction in emissions
- Provide a better service to customers so as to prevent disconnection and the switch to environmentally less efficient decentralized systems
- Increase the commercial performance of the district heating company to secure sufficient revenues while keeping tariffs affordable so as to guarantee centralised district heating services on a long term basis.

Technology transferred:

- First experience with factory assembled automated compact thermal stations
- Modern devices
- Awareness raising and training of optimized operation of the district heating system

Impact on greenhouse gas emissions/sinks:
Approximately 100'000 t CO_2 until 2012

SECO

Since more than a decade, together with UNIDO, SECO has created a global network of national cleaner production centres. These centres provide information to the public and private sectors, regulatory advise companies, and provide company assessment services regarding environmentally sound technologies. Thus, they are building grounds for a successful technology transfer in the partner countries. The cooperation with UNIDO includes regional and global knowledge management on the issue of environmental technology transfer.

Based on its positive experience with cleaner production, SECO developed so-called green credit lines in Colombia in 2003, which aim at fostering credit lines to SMEs willing to invest in environmentally friendly technologies. This instrument, which works through local banks, combines a guarantee element for the participating banks with an ex-post subsidy for borrowers subject to the fulfilment of certain environmental target indicators (e.g. emission reduction). The scheme is meant to provide a strong demonstration effect for both SMEs and financial intermediaries, showing the profitability of investing in environmentally friendly technologies. The positive experience of Colombia has led SECO to introduce similar schemes in Peru in 2004 and in Vietnam in 2007.

Further, through SIFEM, SECO is also investing in specific private equity funds in developing and transition countries, targeting companies/projects in the clean energy and energy efficiency sector.

Renewable energy sources

The unregulated use of oil, gas and coal as a source of energy is the main reason behind the incessant release of carbon emissions into the atmosphere and, as such, is a major contributing factor to climate change. Nonetheless, a running supply of energy is absolutely necessary to ensure economic growth and improve standards of living. The diversification of energy production to include renewable sources has a positive impact on the environment and climate and mitigates the adverse effects of fluctuating prices for fossil fuels.

SECO promotes attractive framework conditions, financial incentives, technology transfer and projects with a demonstration effect. This helps to make modern technologies for example hydropower, solar energy and biogas utilization, more easily available to the world's poorer countries. As a centre of research with significant technology exports, Switzerland also has much to offer in these particular areas.

Sustainable use of natural resources

Apart from energy consumption, the destruction of the rainforest, changes in land use and an intensification of farming are the main causes of climate-damaging emissions. SECO promotes the sustainable management of the tropical rainforest through the creation of sustainability standards and favourable framework conditions. In particular, SECO supports the formulation of global mechanisms that create financial incentives to protect the rainforest as an important carbon sink. In addition, SECO is involved in initiatives that seek to establish international sustainability standards for renewable resources (e.g. soy; cotton; biofuels).

Tab. 56 > International Sustainability Standard for Biofuels

Project / programme title: Roundtable on Sustainable Biofuels

Goal: To contribute to sustainable production and international trade of biofuels
Purpose: To contribute to the establishment of an international sustainability standard for biofuels

Recipient country	Sector	Total funding	Years in operation
Global	Biofuels	CHF 0.6 million	2005 - 2010

Description:
Switzerland has a long-standing experience in the establishment of international sustainability standards for agricultural commodities (tropical timber; soy, cotton, coffee) through multi-stakeholder processes. Such standards base on a broad and systematic inclusion of all relevant stakeholders and aim at a standard which is private sector driven and thus supported by all important market players.
SECO programme for the sustainable use of biofuels consists of the following three components:

- Institutional capacity building for Life Cycle Assessments (LCA) of biofuels
- Structuring of an International Roundtable on Sustainable Biofuels
- Quickcheck tool for biofuel producers to measure their environmental impact

Strategic partners are scientific institutes (including the Swiss Federal Institute for Material Research and Testing EMPA, and the Federal Technical University in Lausanne EPFL), biofuels producers, importers, governments and NGOs.

Expected added value of the programme:

- Training of partner countries (e.g. Brazil) in the establishment of an national Life Cycle Data base and the link with the most important European Life Cycle database, ecoinvent;
- Measuring of a concrete pilot case of biofuels, based on biofuel from organic and fair trade soy residues
- Delivery of an easy-to-handle and cost-free software for producers
-

Technology transferred:

- Transfer of know-how regarding the establishment of Life Cycle databases
- Measuring software for biofuels LCA
-

Impact on greenhouse gas emissions/sinks:
Not quantified.

SECO

The World Bank was the first multilateral institution to engage in a broad-based global REDD initiative, the Forest Carbon Partnership Facility (FCPF). SECO has supported this initiative from the start and has been an official partner since its launch in December 2007. To date, SECO has contributed USD 8.2 million to the FCPF. This money is used to help developing countries to work towards fulfilling the REDD principles. In doing so, they set up control systems, reinforce training programmes and use pilot projects to test how indigenous peoples can best be incorporated into the implementation of REDD.

SDC activities related to transfer of technologies

Promotion of renewable energy, energy efficiency and sustainable land management has been a priority for SDC since 1992. With its new Global Programme Climate Change, SDC is intensifying its efforts in these areas, under a dual objective of poverty alleviation and climate change mitigation.

Overall goal of SDC's Global Programme Climate Change in mitigation is to support developing and threshold countries in following a sustainable development path with low greenhouse gas emissions and therefore becoming less dependent on fossil fuels. This shall be achieved by focusing on:

- Facilitating and consolidating long-term energy supply in rural areas with a focus on locally available renewable potentials (mainly biomass and small hydro).
- Policy dialogue with authorities and investors in the field of energy efficiency in buildings to establish the basis for improved building standards.
- Promotion of fuel-switching and energy savings through efficiency measures in select small scale industries, including through targeted South-South know-how-transfer.
- Reducing emissions from deforestation and land degradation at the local level.
- Increasing technology transfer and innovation in developing and threshold countries in the field of mitigation.

Technology transfer is recognized as an important means to provide adequate modern energy services for economic development and poverty alleviation without creating adverse environmental effects. Energy is seen as a driving force to achieve sustainability in a broader context.

As far as energy efficiency in buildings is concerned, Switzerland has developed leading technological and scientific expertise. A transfer of this knowledge to developing and emerging countries makes it possible to save large amounts of energy reducing considerably the growth of emissions in this sector, while yielding important economic savings to energy users.

SDC's activities in the field of sustainable management of soil or forests do not focus too narrowly on emission reductions effects, but tend to yield multiple environmental, economic and social benefits. Better management of these resources is not only a vector for mitigation but is at the heart of the fight against poverty (agricultural and forest production, biomass for energy).

Tab. 57 > Energy Efficient Building Programme South Africa

Project / programme title: Energy Efficient Building Programme South Africa

Goal: To contribute to the reduction of CO_2 emissions and the alleviation of energy poverty in South Africa.
Purpose: To contribute to a significant reduction of energy consumption in the building sector through enhanced energy efficiency in the full life cycle of buildings.

Recipient country	Sector	Total funding	Years in operation
South Africa	Building	CHF 16 million	2008 - 2013

Description: The programme consists of the following three components:
Setting, enforcement and monitoring of the policy framework (strategies, regulations, standards, fiscal tools);
Building capacities and develop skills of builders, architects, engineers, labs, institutions, municipalities and others in the area of energy efficient buildings;
Implementation of projects to demonstrate energy efficiency a) in the production of building material (bricks), b) by the design and the construction of the building and c) by the use of energy efficient basic equipments and behaviour during the rest of the building lifecycle.

Strategic partners at the national level are the Department of Minerals and Energy, the Department of Housing, and the Department of Environment and Tourism. The programme will also closely work with training and research institutions and the private sector.

Expected added value of the programme:
Alignment with the National Energy Efficiency Strategy;
Linking operational level with policy level: Research results and best practices generated under component two and three are shared with the authorities in order to stimulate policy dialogue and promote policy framework setting;
Demonstration of best practices in the production of building material and use of energy efficient equipment;
Promotion of South-South Know-how and Technology Transfer;
Establishment of partnerships between South-African and Swiss Research Institutes;
Dissemination of best practices developed in South Africa to other South African countries (outreach).

Technology transferred:
Introduction of energy efficient technology of the brick sector (Vertical Shaft Brick Kiln) developed in India and Nepal to South Africa;
Transfer of Know-how regarding the production and use of energy efficient materials and technology in the construction of buildings through establishment of partnerships among South-African and Swiss Research Institutes;
Capacity and skills Development of workers of the building sectors.

Impact on greenhouse gas emissions/sinks:
The programme will contribute to reach the government's target of a final energy demand reduction of 10% for the residential sector and of 15% for the commercial and public building sector by 2015.

SDC

Tab. 58 > Competence network for Small and Micro Learning Enterprises (CoSMiLE) India

Project / programme title: Competence network for Small and Micro Learning Enterprises (CoSMiLE) India			
Goal: Improve the economic, environmental, and social conditions of entrepreneurs and workers of medium, small and micro enterprises (MSMEs) Purpose: Increased adoption of resource-efficient technologies and knowledge-sharing to enhance competitiveness of the targeted MSMEs.			
Recipient country	Sector	Total funding	Years in operation
India	MSMEs in energy intensive sectors (foundry, glass, brick, thermal and power gasifiers)	CHF 7 million	since 2002
Description: In many energy-intensive industries among MSMEs which use commercial fuels like coal, oil and gas, energy cost accounts for up to 20-50% of the total cost of production. Energy efficiency is at the centre stage for improving the competitiveness and reducing carbon emissions of MSMEs. The overall objective of CoSMiLE is to ensure efficient use of energy in these enterprises by adoption of energy efficient technologies and improvement in operating practices. CoSMiLE is a dynamic and informal grouping of actors consisting of owners and workers of small and micro enterprises, service providers like masons, contractors, fabricators, and local experts, and stakeholder institutions like industry associations, government departments, NGOs, financing institutions, and academic and research institutions. CoSMiLE provides services in technology development, technology dissemination and capacity building: Technology development: The technologies in vogue in the small scale sector are usually inefficient, but often require only small changes to transform them into proper designs for saving energy. Under the umbrella of the CoSMiLE initiative, several technologies in different sectors are developed (refer to technology transferred below). Technology dissemination: The CoSMiLE network provides technical support for implementation of economically attractive, energy efficient and environment-friendly technologies. Regional level workshops/seminars and one-to-one interaction with the target group are organized in order to sensitize the entrepreneurs about the technologies. Capacity building: Capacity building of partners and providing technical back-up or support to them is one of the major activities under the programme. The programme is developing physical or virtual platforms at different levels for exchanging information and experience among various participants. CoSMiLE provides multi-stakeholder dialoguing platforms on various issues such as technology, policy (e.g. facilitating inclusion of cleaner production initiatives in the global climate protection framework), and social sensitivity.			
Factors which led to the project's success: Holistic approach including development and dissemination of technologies and capacity building: Technologies are integrated in a social context and allow multiple benefits (e.g. improved working conditions for the workforce, better quality of life etc.). Attractivity of disseminated technologies: Most CoSMiLE technologies have a payback period of less than two years, product quality has been good and rate of rejection has gone down in most cases. Sensibilisation: A large number of entrepreneurs from MSMEs have realized the importance of investing in cleaner technologies. Learning orientation of the network has allowed formation of partners from different institutions. Potential for replication: The cleaner technologies demonstrated in various MSME sectors in India have good potential to be replicated in other developing countries (south-south cooperation).			
Technology transferred: Holistic package, containing also social and economic components and strong capacity building elements Foundries: Divided blast cupola for grey iron melting; pollution control systems Bricks: Setting up of vertical shaft brick kilns Glass: Energy efficient pot furnaces for glass melting Biomass gasifiers for a wide variety of thermal applications			
Impact on greenhouse gas emissions/sinks: Until 2008 CoSMiLE interventions have achieved cumulative CO_2-reductions of 340'000 tonnes.			
SDC			

7.5 Information under Article 10 of the Kyoto Protocol

Information on activities, actions and programmes undertaken in fulfilment of the commitments under Art. 10 of the Kyoto Protocol are given in various parts of the 5th National Communication. Tab. 59 below provides an overview, where this information is located.

Tab. 59 > Information under Article 10 of the Kyoto Protocol

Art. 10.a	National system for the development and continuous improvement of the national inventory	Section 3.4	73
Art. 10.b	Domestic and regional programmes aimed at mitigating climate change	Section 4.2	93
	Domestic adaptation strategies and measures	Section 6.3	171
Art. 10.c	Activities related to transfer of technology transfer	Section 7.4	190
Art. 10.d	Research and systematic observation	Section 8	199
Art. 10.e	Education, training and public awareness	Section 9	217

References[14]

Climate Cent Foundation 2007: Annual Report 2007. Stiftung Klimarappen, Zürich.

Climate Cent Foundation 2008: Annual Report 2008. Stiftung Klimarappen, Zürich.

[14] Where available, references are provided online at www. climatereporting.ch

8 Research and systematic observation

Research has made significant progress in understanding the climate system, its current changes and their impacts on humans and the environment. This improved scientific understanding results to a considerable extent from substantial improvements in the available data sets. Switzerland's research efforts and its systematic observation of various relevant parameters is a valuable contribution both for the national and the international scientific community.

8.1 General policy on research and systematic observation

8.1.1 Research structures and funding

According to the Federal Research Act (SR420.1), it is the responsibility of the Swiss Confederation to support and promote scientific research. The federal departments can commission research in areas of public interest, and parts of the federal administration host fully fledged research institutions. Research that is directly funded by government institutions falls into one of the federal research programmes. These programmes provide the conceptual framework and set research priorities in eleven policy areas[15]. They are used to coordinate research activities and promote collaboration between research institutions. With regard to climate, four programmes are particularly relevant: Environment, energy, spatial development and mobility, and sustainable transport.

In the following paragraphs data are based on the information system of ProClim-, the Forum for Climate and Global Change of the Swiss Academy of Sciences, where data on research activities, publications and a list of experts in climate research is held up to date. The database is publicly available at http://www.proclim.ch.

Climate research in Switzerland can be divided into several categories:

- National Centres of Competence in Research (NCCR)
- Individual research projects (funded by the National Science Foundation (NFS) or government institutions)
- Energy and transport research (mainly funded by the government)
- Participation in international research programmes (EU, COST, WCRP, IHDP, IGBP) by researchers at various universities, the federal institutes of technology (ETHZ and EPFL), universities of applied sciences (Fachhochschulen) and private and public research organizations
- Collaborations with international research centres and organizations (ECMWF, EUMETSAT, WMO, IPCC)

National Centres of Competence in Research
Two National Centres of Competence in Research (NCCR) are concerned with climate change issues – the NCCR „Climate“ and the NCCR „North-South“.

NCCR Climate
The NCCR Climate (www.nccr-climate.unibe.ch) was created in April 2001 with an intended duration of 12 years. The third 4-year period began in April 2009, albeit with substantial cutbacks (about 45%) in financial resources. The NCCR Climate brings together experts from a wide range of universities and research institutes. It addresses broad issues of natural climate variability and predictability by combining the contributors from relevant disciplines into an integrated network of competence. This network includes expertise from the physical, chemical, biological, economic and sociological disciplines and addresses research questions in various fields. It operates on three levels:

[15] http://www.ressortforschung.admin.ch/html/dokumentation/publikationen_de.html

- First, disciplinary research in individual research groups, ensuring continuous cutting-edge research, facilitating access to and sharing of latest results and methods through international co-operation (e.g. EU projects).
- Second, thematic research within the topical modules of NCCR Climate, coordinating and integrating the results in the wider context.
- Third, establishment of a university-based, long-term Swiss centre of competence on issues of climate variability, extreme events, climate projections, and the assessment of ecological and economic consequences and associated risks.

The overall goals of the NCCR Climate are to:

- Acquire a better understanding of climate system processes, variability and predictability and the complex inter-relationships between climate, economic and societal drivers.
- Adapt and refine scientific tools and knowledge for Switzerland, considering specific characteristics in physical, chemical, biological, geographical, economic and societal factors.
- Transfer and apply the knowledge to assess the risks and future cost of projected climate change, and to provide a basis for adaptation strategies.
- Educate young scientists of all disciplines with an emphasis on interdisciplinarity. NCCR Climate has established a series of thematic summer schools and developed forms of participatory learning.
- Investigate new financial and economic tools to hedge against the increased probability of extreme events.

Oeschger Centre for Climate Change Research, University of Bern

In October 2007, the University of Bern – the leading house of the NCCR Climate – has inaugurated the Oeschger Centre for Climate Change Research, OCCR. The centre focuses on oriented disciplinary and interdisciplinary research. The OCCR supports education (Graduate School of Climate Sciences) and research of NCCR Climate groups (and others) at the University of Bern.

Centre for Climate Systems Modelling, ETH Zürich

In November 2008, the ETH Zürich has inaugurated the Centre for Climate Systems Modelling, C2SM, a joint venture involving NCCR Climate researchers from the ETH and from partner institutions including MeteoSwiss, Empa, and ART. The Centre's overarching and integrating theme is "multi-scale interactions within the climate system". The C2SM receives funding from the ETH-Foundation, ETH Zürich, MeteoSwiss, Empa, and ART.

NCCR North-South, University of Bern

The NCCR North-South (www.nccr-north-south.unibe.ch) focuses on international research cooperation and promotes high-quality disciplinary, interdisciplinary and transdisciplinary research with the aim of contributing to an improved understanding of the status of different syndromes of global change, of the pressures these syndromes and their causes exert on different resources (human, natural, economic), and of the responses of different social groups and society as a whole.

By identifying the potential of social systems to mitigate syndromes, by considering their dynamics, and by adopting existing innovative solutions, the NCCR North-South primarily aims to help design ways to mitigate syndromes. The NCCR North-South enables Swiss research institutions to enhance partnerships with institutions in developing and transition countries, thereby building up competence and capacity on both sides to develop socially robust knowledge for mitigation action.

Individual projects are focused on one of the following themes.

- IP1: Conceptual Framework and Methodologies
- IP2: Natural Resources and Ecology
- IP3: Environmental Sanitation
- IP4: Health and Well-being
- IP5: Social practices and empowerment in urban societies
- IP6: Institutional Change and Livelihood Strategies
- IP7: Conflict Transformation
- IP8: Governance, Human Development and Environment

Activities in international research programmes

Switzerland participates in international research programmes (e.g. World Climate Research Programme WCRP) through individual research projects, research conducted at federal institutes and within co-ordinated programmes (NCCRs), the operation of monitoring stations and networks, as well as maintaining calibration and data centres (for monitoring see section 8.1.2 and 8.3). It also plays a leading role in several regional climate research programmes.

Switzerland also contributes significantly to the International Geosphere Biosphere Programme (IGBP). The international project office for the IGBP Past Global Changes (PAGES) project is located in Bern and is jointly funded by Switzerland through the Swiss National Science Foundation and the US. Swiss scientists are involved in the PAGES and Global Change and Terrestrial Ecosystems (GCTE) projects, the DIVERSITAS programme and most other core projects. Switzerland has also contributed significantly to the International Human Dimensions Programme (IHDP) on Global Environmental Change. Swiss researchers are active in fields relevant to the IHDP and have also made important contributions to the United Nations University over the years.

Switzerland is also hosting and funding the Mountain Research Initiative (MRI), a multidisciplinary scientific organization that addresses global change issues in mountain regions around the world. The MRI strives to support the design of integrated research strategies and programmes that further our understanding of the impacts of Global Change in mountain areas and that lead to tangible results for stakeholders and policy-makers. MRI is a joint project of IHDP and IGBP and is funded by the Swiss National Science Foundation.

At the 29th session of the IPCC (31.08.-04.09.2008), new Working Group I (WG I) co-chairs were elected to oversee development of the Physical Science Basis volume of the Fifth Assessment Report. Dr. Thomas Stocker of Switzerland and Dr. Dahe Qin of China are leading the work towards the next assessment report of WG I, due to appear in 2013. The WG I Technical Support Unit, which manages the organizational and administrative activities of WG I, is hosted by the University of Bern, Switzerland, and funded by the Swiss Federal Office for the Environment.

Funding

Swiss research is mainly funded by the National Science Foundation (programme research and individual projects), by the EU (EU research projects) and COST (projects in the framework of COST actions). In 2007, National Science Foundation funding for about 240 projects (including NCCR) on climate and global change amounted to about CHF 30 million. It has to be noted that many of these projects started or ended during 2007. The average funding per project is about CHF 130,000 per year. In 2007, the funding provided for EU projects in the same fields was about CHF 12 million (about 120 projects), and for COST projects (around 50, mostly non-resource-intensive coordination projects) about CHF 2 million.

Individual research projects

The majority of research projects are individual projects funded by the Swiss National Science Foundation or by government agencies such as FOEN. The distribution of the funding between different disciplines is shown in Tab. 60.

Tab. 60 > Projects funded by the Swiss National Science Foundation or government agencies

Natural sciences:	170 projects	17.6 million CHF/y
Technical:	13 projects	1.1 million CHF/y
Economics:	18 projects	1.2 million CHF/y
Social, political, legal:	8 projects	2.8 million CHF/y
NCCR programmes	3 programmes	8.0 million CHF/y

Research in EU projects

On 16.1.2003 Switzerland and the EU signed a research agreement, giving Switzerland the status of an "associate country" in the 6th EU research framework programme from 1.1.2004. Rather than participating in EU research on a "project by project" basis, Switzerland now contributes to the overall EU research budget. Thus, Swiss projects are financed directly by the EU research institutions. At the same time, Swiss researchers can now take on a leading role in any EU project. All the former restrictions on project activities have been suspended.

In the 2007, more than 100 projects in the field of climate and global change were pursued in the framework of EU research. The funding volume for projects carried out during (part of) this period was about CHF 30 million. The distribution of EU-funded Swiss projects in the different fields are shown in Tab. 61.

Tab. 61 > EU-funded research projects in different fields of research

Natural sciences:	53 projects	5.1 million CHF/y
Technical:	57 projects	6.1 million CHF/y
Social, political, economical:	8 projects	0.8 million CHF/y

Energy research

Switzerland's energy research and development (R&D) policy aims to contribute to a secure and sustainable energy supply; continue the strong position of Switzerland as a market place for energy technology and ensure the high quality of its energy research. The long-term goal is to reduce annual energy needs per person to 2 000 W. Consistent with the government's overall energy policy objectives, R&D focuses on energy efficiency, renewable energy sources and large-scale power production. International co-operation and efficient implementation of research findings have a high priority. Energy R&D policy is laid down in the four-year federal energy research programme (SFOE 2007h).

The energy research programme includes the objectives, means, focus areas and budget allocations for publicly-funded energy research in Switzerland (SFOE 2007h). They are drafted by the Federal Energy Research Commission (CORE), a high-level advisory body to the federal government, consisting of 15 members from industry and academia. The draft master plan is reviewed by the national energy research conference, held every four years and attended by the Swiss energy research community. On the basis of the conference feedback, CORE and the SFOE finalise the master plan and submit it to the federal government and parliament for approval.

Transport research

Swiss transport research is mainly carried out by the federal administration, the federal institutes of technology in Zürich (ETHZ) and Lausanne (EPFL), and regionally by the cantonal universities. Outside government, private research institutions such as consulting and engineering offices also conduct extensive research. Much of this research is coordinated by the association of Swiss road and traffic engineers (VSS). The federal offices conduct, support, coordinate, monitor and fund strategic research. National priorities of transport research are within the fields of external costs of transport, sustainable transport and road infrastructure construction (ARE 2007; FEDRO 2007).

Agricultural research
Research in the agriculture sector is coordinated by the Federal Office for Agriculture and to a large extent funded through the government framework research programme agriculture (Agroscope 2007), supplemented by funding from Swiss National Science Foundation (NSF) and EU Framework Programmes. Its main goals are to improve agricultural practice in the context of the political and economic framework, and in particular, in view of achieving sustainability in farming. Amongst other objectives, this includes research into farming practices that contribute to climate change mitigation or to improved practices to cope with potential future climate conditions. Individual research projects are carried out at the federal research stations Agroscope, ETH Zürich and various Swiss universities. Some of the projects are embedded in the framework of the SNSF-funded NCCR Climate, while others are commissioned by the government.

Forest research
Forest research in Switzerland is mainly carried out by the federal institutes of technology in Zürich (ETHZ) and Lausanne (EPFL), the Swiss Federal Institute for Forest Snow and Landscape Research (WSL) which is part of the ETH domain and universities. More in applied research engaged are third-level technical high schools and also private institutions mainly mandated by the federal or cantonal administrations. The research is focused on sustainable forest management, protection against natural hazards, ecology and biodiversity. A new focus is set on impact of climate change and adaptation measures (see section 8.2.5).

8.1.2 Systematic observation

The Global Climate Observing System (GCOS) supports the implementation of systematic climate observation in accordance with the requirements of the UN framework convention on climate change and the Kyoto Protocol. GCOS is coordinated at the global level by four organisations: the World Meteorological Organization (WMO), the UN Environment Programme (UNEP), the Intergovernmental Oceanographic Commission (IOC) of UNESCO, and the International Council for Science (ICSU).

Switzerland's contribution to GCOS has already been reported to UNFCCC in the third national communication (SAEFL 2001a) and fourth national communication (SAEFL 2005i). A progress report on the GCOS implementation in Switzerland has been submitted to the UNFCCC in September 2008 in response to a request[16] of the Subsidiary Body for Scientific and Technological Advice (SBSTA) of the UNFCCC in 2005 (MeteoSwiss 2008).

National GCOS coordination
Following the ratification of the Kyoto Protocol by the Swiss parliament in summer 2003, the national GCOS coordination was strengthened at the Federal Office of Meteorology and Climatology MeteoSwiss. The Swiss GCOS Office was established on 1 February 2006, building on the former GCOS focal point at MeteoSwiss. The main task of the office is the coordination of all climate measurements in Switzerland. Furthermore, the Swiss GCOS Office is the contact point for collaboration with the international GCOS secretariat at the World Meteorological Organisation (WMO), as well as with other national GCOS national coordinators worldwide. The Swiss GCOS Office participates as a member of the Swiss delegation at the UNFCCC Conference of the Parties (COP) and the corresponding SBSTA sessions.

Once a year, a so-called "Swiss GCOS Roundtable" is organized to foster information exchange between the different partner institutions. The coordination includes also long-term planning to ensure continuous and representative observations, e.g. by identifying the risk of discontinuity ahead of time and engaging in remedial action. As far as possible, new measurement techniques are also considered in the integrated observation system. In addition, the Swiss GCOS Office identifies resource-related problems affecting the operation of international data and calibration centres in Switzerland and provides financial and technological support for selected observations abroad.

[16] SBSTA Conclusion L.14 (COP 13, Bali 2007): http://unfccc.int/resource/docs/2007/sbsta/eng/l14.pdf

With its report "National Climate Observing System (GCOS Switzerland)" (Seiz and Foppa 2007), the Swiss GCOS Office has compiled the first inventory of Switzerland's long-term climate measurement series and international data centres, including an assessment of their future prospects. The inventory was compiled in cooperation with ProClim (the forum for climate and global change of the Swiss Academy of Sciences SCNAT), with contributions from federal offices, research institutes and universities responsible for the measurements. Based on the report and at the request of the Federal office of meteorology and climatology MeteoSwiss through the Federal Department of Home Affairs (FDHA), the Swiss Federal Council has agreed in June 2008 on a long-term financial contribution to GCOS Switzerland, starting from 2010. This contribution will support several long-term climate measurement series and international data centres in Switzerland (e.g. World Glacier Monitoring Service WGMS) whose future was identified to be uncertain in the report. This recent decision of the Federal Council is a major milestone for the Swiss GCOS activities.

The Swiss GCOS Office's outreach efforts include a variety of activities. A new Swiss GCOS Office webpage (http://www.gcos.ch) was launched in German, French and English, including a news section listing the upcoming events as well as a digital version of the Swiss GCOS inventory report. This enables a regular update of the information contained in the inventory report. The Swiss GCOS Office organised a GCOS information day in October 2008 to address people from science, public administration, politics, and the media. For this event, a brochure on GCOS Switzerland was released in German, French and English.

8.2 Research

8.2.1 Climate and global change research

In 2007, about 350 research projects on climate and global change and on related human aspects were in progress. The distribution of research projects into different disciplines funded by the National Science Foundation (about 240) and EU-funded projects (about 120) is presented in section 8.1.1.

Swiss climate and global change research results

Fig. 95 presents an overview on the activities and fields of Swiss research by listing the number of peer-reviewed publications with Swiss (co-)authors and its distribution on different fields during the years 2005-2008. Publications related to natural sciences dominate, partly because peer-reviewed publications play a more important role in natural sciences than in other disciplines, and partly because the natural sciences research community is much larger.

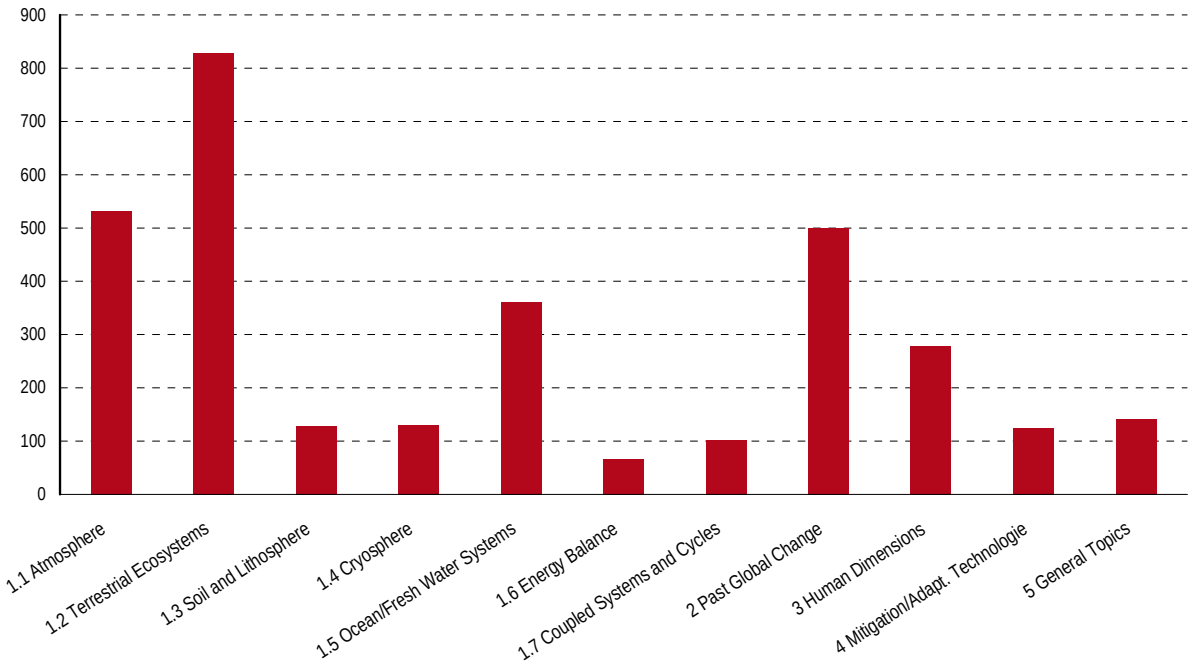
There is a long-standing tradition of terrestrial ecosystem research that covers applied research (e.g. at the Swiss Federal Institute for Forest, Snow and Landscape Research WSL) and pure research in various climate-related areas (e.g. at the universities of Basel, Bern, ETHZ). For example, forest ecosystem observations at the WSL date back many decades, and several current research projects investigate tree growth and forest dynamics in view of climate change.

A strong atmospheric research community in Switzerland looks into climate and climate-change related issues. The research groups are scattered across many universities and other research institutions (e.g. at the universities of Basel, Bern, Fribourg, ETH Lausanne and Zürich and MeteoSwiss), but they collaborate regularly in joint research projects and also contribute to international efforts, for example the recent PRUDENCE and ENSEMBLES project that delivered regional climate model scenarios for Europe. Other research topics include global climate modelling, climate change, aerosols and clouds as well as atmospheric dynamics, variability and extreme events and their effects both globally and on the Alpine region.

Research into past global changes is also well established in Switzerland. The research approach for climate reconstruction and analysis is very broad, including historical documents and data, lake and marine sediments, tree rings, cave deposits and ice cores. For example, Swiss researchers contributed significantly to the reconstruction of past GHG concentrations from ice cores that covers the past 800'000 years.

Fig. 95 > Publications of Swiss researchers

Number of peer-reviewed publications with Swiss (co-)authors and distribution on different topics over 2005-2008.



ProClim (2009)

Research highlights from NCCR Climate, period 2005–2009

Swiss researchers collaborate in NCCR Climate and contribute substantially in various fields of climate change research, particularly in the fields of reconstructing past climate, analysis of the present climate, modelling of future climate where long-standing expertise exists. But also the study of ecological impacts of climate change and possible economic, social and political mitigation and adaptation measures make part of the Swiss research portfolio. Some research highlights of the last few years are listed below, further details regarding the achievements of NCCR Climate are found on www.nccr-climate.unibe.ch.

Past climate

-Grid-based seasonal (or monthly) multi-proxy **reconstructions of temperature** for the last 500 years demonstrate the exceptionally warm autumn of 2006 and winter of 2007 in Europe, unprecedented in the last 700 years (Luterbacher et al. 2007).

-Summer temperatures back to AD 755 have been reconstructed based on tree ring series. They provide a key record for increased spatial representativeness of large-scale temperature reconstructions. The reconstructions show that the extreme summer 2003 was the warmest of the last 1250 years (Büntgen et al. 2006).

-The climate variability of the past half millennium has been studied using **ensemble simulations** for specific time windows. This allows analysing implications of forced changes on other climate variables. A clear multi-year response of the North Atlantic Oscillation to volcanic eruptions was identified (Spangehl and Raible 2008).

-Varved lake sediments from the Engadine were used to reconstruct temperature and precipitation at annual resolution back to 1580 AD (Blass et al. 2007).

Present and future climate

-Comprehensive **climate change scenarios** were developed using global and regional climate models, as well as probabilistic techniques.

-A comprehensive observational framework of **atmospheric humidity** from the surface to an altitude of 80 km over Switzerland has been built. Integrated water vapour is derived from GPS receivers, sun photometers and microwave radiometers (Morland and Mätzler 2007). The data are available online. *http://www.iapmw.unibe.ch/research/projects/STARTWAVE/*

-Analysis of radiation data has delivered a globally consistent signal of **solar dimming** until the mid 1980s followed by solar brightening. The brightening is consistent with the observed increase in land precipitation (Wild et al. 2008).

-Significant progress was made in the field of processes of the **dynamics and predictability of interannual variability**, as a novel blocking indicator that was used for a long-term blocking climatology from the ERA-40 re-analysis. Atmospheric blocking is shown to be important to the establishment of a phase shift of the NAO in the Euro-Atlantic sector(Altenhoff et al. 2008).

-Operational tools for seasonal forecasts and forecasts of extreme events using ensemble prediction techniques have been developed and are operational as the short-range limited-area ensemble prediction system COSMO-LEPS(Weigel et al. 2008).

-Studies on the role of land-surface processes suggest that changes in land-atmosphere coupling are the prime factors behind the interannual summer temperature (heat wave) variability increase (Seneviratne et al. 2006)**.**

Ecosystem studies

-A globally unique experiment with a multi-species natural forest provides data for the *in situ* water flux from several tree species under ambient and elevated atmospheric pCO_2. Together with other data, this information documents the interannual variation in water balance, and the reaction of forest trees to the 2003 drought (Leuzinger et al. 2005).

-The influence of land use and other site characteristics on the response of soil water to climate change was identified by analysing results from model simulations, and a new forest model was tested.

-A new model, PROGRASS, for grass/clover mixtures provides an explicit formulation of the interactions between functional types typical of temperate grasslands accurately reproduces fluxes and pools of carbon and nitrogen (Lazzarotto et al. 2008).

Socio-economic studies

-The coupling of a techno-economic top-down (GEMINI-E3) and a bottom-up (MARKAL) model for Switzerland is completed, allowing the analysis of future mitigation policies focusing on the transportation and residential sectors in Switzerland (Drouet et al. 2005).

-A newly developed life cycle assessment model is used to estimate the environmental impact of using forest wood chips as fuel substitute. While the environmental impact is non-negligible, the supply of forest wood chips leads to significantly lower emission scores than imported crude oil (Schulz et al. 2007).

8.2.2 Energy research

The SFOE, in collaboration with CORE, is responsible for co-ordinating energy R&D policy and implementing the master plan. It is directly involved in 90% of the publicly-funded energy R&D projects. These projects are managed under the SFOE's research programmes, currently 20 in total. The research programmes, in turn, fall into 14 subject areas that cover the whole energy R&D path: basic and applied research, pilot and demonstration projects, and market entry.

The SFOE programme leaders review the projects annually. The reviews as well as the final reports of individual projects are available on the SFOE internet site. Every two years, the SFOE also conducts a comprehensive survey of all publicly-funded energy R&D projects *(Projektliste der Energieforschung des Bundes)*. The latest, for 2004–2005, includes close to 970 projects. Information on individual R&D and evaluation projects of the Swiss federal administration can also be found on the ARAMIS database (*www.aramis.admin.ch*).

Federal energy research framework programme 2008-2011
For the years 2008–2011, the focus of public energy R&D is maintained on the same four areas as for 2004–2007: rational use of energy, renewables, nuclear energy, and energy policies and economics. Energy research continues to be guided by the vision of a 2 000 W per capita society, implying a need for major technological breakthroughs. Based on that vision, the plan sets the following four quantitative goals for 2050:

- Phase-out of fossil fuels for room heating.
- Cutting energy use in buildings by half.
- Tripling the use of biomass for energy.
- Reducing average fuel consumption of the passenger car fleet to 3 litres per 100 km.

In 2008–2011, the focus will be on developing technologies that:

- Have the highest possible system effectiveness and lowest possible emissions in transport, buildings and electricity generation.
- Use ambient and solar heat as well as biomass.
- Use in the shorter term hydro and geothermal power.
- Reduce in the longer term dependence on fossil fuels (photovoltaics, hydrogen, fourth-generation nuclear reactors).

8.2.3 Transport research

In the framework of transport research, the following research activities are relevant for climate policy:

- Internalization of external costs: Based on numerous research studies, Switzerland has updated figures for external costs (and benefits) of transport.
- Decoupling: Strategic studies are being carried out, looking for optimal policy mixes to decouple transport from economic growth.
- Many research activities have analysed the interrelation between transport and spatial development. On the basis of these studies, strategies for steering spatial organization (also based on market instruments) have been elaborated.
- Leisure traffic: An important field of investigation is the development of ever-increasing leisure traffic and possible instruments for curbing growth rates.
- Sustainable aviation: The Federal Office of Civil Aviation (FOCA) published the results of a research programme to develop strategies for the aviation sector, focusing on instruments to ensure balanced development taking into consideration ecological (especially climate change), economic and social aims (FOCA 2008a).

- Inclusion of aircraft into emissions trading: The FOCA started a detailed study investigating options how to include Swiss aviation into an emissions trading system.
- Aircraft emission trends: The FOCA calculates aircraft emissions at the highest possible degree of accuracy (tier 3a and 3b methods) in order to monitor technology developments and detailed emission trends. On the basis of these results, strategies and future environmental action plans are developed.
- Aircraft engine particle emissions: The FOCA actively contributes to the development of a particulate matter certification methodology for aircraft engines, through own research, in collaboration with the German aerospace centre and with the society of automotive engineers (SAE-E31).

8.2.4 Agricultural research

With regard to mitigation, current research addresses options to reduce methane and nitrous oxide emissions from Swiss animal husbandry and fertilizer management, quantification of carbon pools, sources and sinks in agricultural soils in relation to climate and management, quantification of gaseous N-exchange in fertilized grasslands, structural and energetic optimisation of animal houses and of plants for renewable energy.

In the area of adaptation, research focuses on using downscaled high-resolution climate scenarios to estimate changes in productivity and land suitability, implications of changes in weather variability for the production and quality of forage and arable crops and options for improved risk management, irrigation requirements and adaptation of water-use, effects of farming on natural hazards and preventive measures, forecasting and monitoring of pests in horticultural crops, conservation tillage to protect soils and to conserve soil water, as well as the farmers' perception and response to climate change.

8.2.5 Forest research

The climate projections for Switzerland suggest that the average summer will become warmer and drier in the coming decades, with great regional deviations and potentially more frequent extreme weather events like storms and heat waves. As a consequence, more pests and diseases, and insect calamities are expected. This will affect forests, although the details of the anticipated changes remain unclear. Forest management under uncertainty is the future challenge for silviculture.

To overcome the uncertainty and to develop scientifically based recommendations for adaptive forest management, the Swiss government launched the "forest and climate" research programme in 2009. This programme, with a budget of 2 CHF million for the first 3-year-period, will be carried out by the Federal Office for the Environment (FOEN) and the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL). The first phase deals with questions of highest priority for the development of forest adaptation measures: Particular emphasis is laid on scenario analysis of forests and trees under changed climate, and on the influence of climate change on forest services. Knowledge transfer of new findings on adaptive measures into the forest management practice is part of the overall objectives of the programme.

Climate change is only one factor altering the environment for plants, interacting with other potentially damaging factors like excess nitrogen input or elevated ozone levels. Therefore, the EU COST action "Climate Change and Forest Mitigation and Adaptation in a Polluted Environment" was launched in 2009. In Switzerland the FOEN and the WSL are engaged in this European action, which creates a platform of experts from different fields of climate and environmental research. The main objectives are to increase the understanding of the state and the potential of forest mitigation and adaptation to climate change in a polluted environment and to combine process-oriented research and long-term monitoring.

In the next 5 years, the climatological and physiological causes of the natural dispersal ranges of European tree species will be studied at the University of Basel. The project is funded by the European Research Council (ERC) within the 7th framework programme of the EU.

8.2.6 Adaptation research

Currently, adaptation research is not coordinated centrally. Specific questions related to the vulnerability and adaptation of ecosystems to climate change are addressed in the third phase of the NCCR Climate (8.2.1). Furthermore, adaptation to climate change is part of applied research, e.g. in the agriculture sector (8.2.4), in the area of water resource management (CCHydro, 6.3.4) or for tourism (Research Institute for Leisure and Tourism, University of Berne). An effort to integrate adaptation into an integrated assessment model will be undertaken in a joint project of the 'École Polytechnique Fédérale de Lausanne (EPFL) and FOEN in 2010-2011. Despite these initiatives, it will be important to develop a comprehensive, integrated view on adaptation research in the coming years.

8.3 Systematic observation

Switzerland has a long tradition of climate observation, with temperature and precipitation series going back more than 150 years, the world's longest total ozone series, glacier measurements dating back to the end of the 19th century and two of the world's oldest and most important calibration and data centres: the World Radiation Centre in Davos and the World Glacier Monitoring Service at the University of Zürich. The Swiss GCOS Office at the Federal Office of Meteorology and Climatology MeteoSwiss is responsible for coordinating climate observations of federal offices, research institutes and universities in Switzerland.

8.3.1 Atmospheric observations

Atmospheric observations are classified into three domains: surface, upper air, and atmospheric composition measurements (Tab. 62). The Federal Office of Meteorology and Climatology MeteoSwiss is responsible for the operation and maintenance of meteorological and climatological networks, guaranteeing regular measurements over the entire country. Currently, MeteoSwiss is building a new ground-based network of automatic weather stations that will merge and replace all existing different networks over the Swiss territory. By the end of the project "SwissMetNet", MeteoSwiss will have a state-of-the-art unified network with over hundred standard automatic weather stations, each of them measuring a large set of meteorological parameters. In a first phase, the renewal of the existing automatic climatological and meteorological network has been completed by the end of 2008. In a second phase (2009-2013), the complementary network and the conventional climatological network will be upgraded and integrated into SwissMetNet.

The core component of the climatological observation network is the Swiss National Basic Climatological Network (NBCN), consisting of 28 stations of greatest climatological importance for surface-based atmospheric observations (Fig. 96). The NBCN includes the 2 GCOS Surface Network (GSN) stations Säntis and Grand St. Bernard and the 5 Regional Basic Climatological Network (RBCN) stations (Begert et al. 2007). For precipitation, the 28 NBCN stations are supported by additional 46 stations to adequately describe the climatology of precipitation in Switzerland (Begert 2008). These so-called NBCN-P stations have been defined by an evaluation of the representativeness of the Swiss NBCN. The NBCN and NBCN-P stations are operated according to the GCOS Climate Monitoring Principles (GCOS 2004), in particular to ensure that climate signals or artificial inhomogeneities can be distinguished from systematic biases.

Since 1992, an extensive set of surface-based radiation parameters has been measured at the Payerne aerological station of MeteoSwiss as part of the Baseline Surface Radiation Network (BSRN). The BSRN network consists of 38 stations worldwide and represents the surface radiation observation section of GCOS. In addition, MeteoSwiss is redefining its radiation network including the assignment of a subset of stations for high quality measurements of radiation parameters for climate purposes. About 6 stations will build the new so-called Swiss Alpine Climate Radiation Monitoring Network (SACRaM).

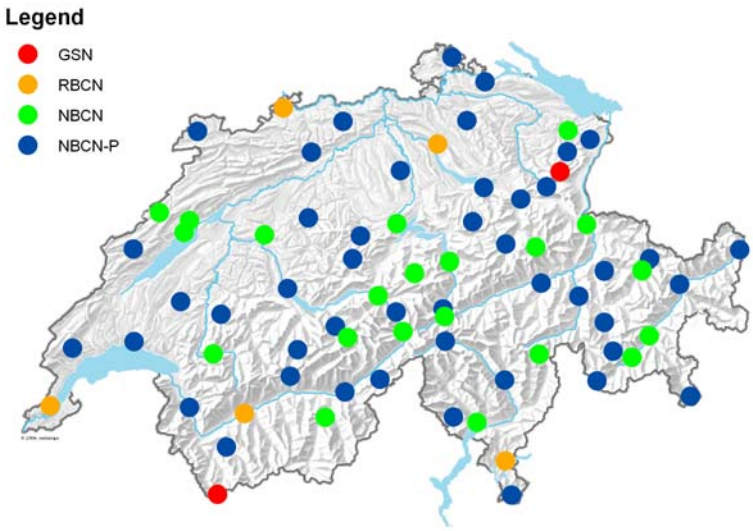
Tab. 62 > Switzerland's atmospheric observation networks

Domain	Variable	Number of stations and observation networks
Surface	Air temperature, Precipitation	2 GSN, 7 RBCN, 28 NBCN, 46 NBCN-P
	Radiation	1 BSRN, 6 SACRaM
Upper air	Upper air temperature, Wind speed and Direction, Water vapour	1 GUAN (Payerne will become part of GRUAN)
Composition	Ozone, Carbon dioxide, Methane, other GHGs, Aerosols	1 GAW global station 2 Ozone (total column, profile) 1 Carbon dioxide, 1 Methane, 1 Other GHGs 6 Aerosol (optical depth, properties)
	Pollen	14 NAPOL sites

MeteoSwiss

Fig. 96 > Overview of the Swiss National Basic Climatological Network (NBCN)

The Swiss National Basic Climatological Network (NBCN) consists of 28 stations for atmospheric observations near the surface. The NBCN includes the 2 GCOS Surface Network (GSN) stations and the 5 Regional Basic Climatological Network (RBCN) stations. For precipitation, the 28 NBCN stations are supported by additional 46 NBCN-P stations to adequately describe the climatology of precipitation in Switzerland



Begert et al. (2007), Begert (2008), swiss map: VECTOR200 © swisstopo (DV053906)

Upper air observations carried out at MeteoSwiss Payerne became part of the GCOS Upper Air Network (GUAN) in January 2008, meeting higher quality requirements for long-term monitoring of climate (Fig. 97). Moreover, Payerne has recently been invited by the WMO to become part of an initial set of about 10-15 sites worldwide forming the GCOS Reference Upper Air Network (GRUAN).

Several measurement stations in Switzerland are contributing to the WMO Global Atmosphere Watch (GAW) programme. The GAW programme focuses on global long-term measurements of ozone, greenhouse gases and selected reactive gases as well as aerosols.

At the Light Climatic Observatory (LKO) in Arosa, measurements of total ozone and estimates of the ozone profile obtained by means of special Dobson measurements started at the end of the 1920s respectively in the 1930s. At Payerne, meteorological radio soundings have been used since the 1960s to record ozone profiles up to an altitude of about 33km.

Fig. 97 > Payerne aerological station

Payerne is the atmospheric observation station of Switzerland, with operational and research surface and upper air measurement systems

Photo: MeteoSwiss

Atmospheric concentrations of greenhouses gases (GHG) such as carbon dioxide (since 2000) and methane (since 2005) are measured at the High Altitude Research Station Jungfraujoch. The Jungfraujoch observatory is equipped with instruments to measure a series of additional GHGs (e.g. nitrous oxide, sulphur hexafluoride) and climate relevant trace gases. Measurements of aerosol optical depth (AOD) are carried out at 6 observation sites in Switzerland. Additionally, at Jungfraujoch, further aerosol properties (e.g. scattering coefficient) are retrieved. In 2006, Jungfraujoch became one of 25 global GAW stations worldwide.

MeteoSwiss also assumes responsibility for operating the national pollen monitoring network (NAPOL). This network comprises a total of 14 stations, covering the country's major climate and vegetation regions. The stations operate during the vegetation period and are equipped with volumetric pollen traps.

8.3.2 Oceanic observations

Switzerland does not maintain measurements in the oceanic domain.

8.3.3 Terrestrial observations

Climate observations in the terrestrial domain are subdivided into the hydrosphere (river discharge, water temperature, lake ice phenology, water use, and isotopes), the cryosphere (snow, glaciers, permafrost) and the biosphere (land use, forest ecosystem, forest fires, and phenology) (Tab. 63).

The Federal Office for the Environment (FOEN) operates various hydrological monitoring networks and provides near real-time information, long-term measurement series and comprehensive overviews of discharge and water levels. Furthermore, the FOEN monitors water flows and – in cooperation with the Swiss Federal Institute of Aquatic Science and Technology (Eawag) and the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) – water quality for rivers, lakes and groundwater bodies. Daily river discharge data from 26 stations is supplied to the Global Runoff Data Centre (GRDC), which contributes to GCOS by supporting the Global Terrestrial Network for River discharge (GTN-R). The basic hydrological monitoring network operated by FOEN comprises 31 stations on Swiss lakes including lakes for a sustained monitoring to support the Global Terrestrial Network for Lakes (GTN-L). The national groundwater observation programme (NAQUA) covers a long-term quality module of 50 stations and a quantity observation module of 100 stations. In addition to their use in groundwater management and protection, long-term

isotope data series provide reference values for climatological studies. The isotopes in the water cycle network (ISOT), currently comprises 23 sites distributed throughout Switzerland. ISOT is operated by the FOEN in cooperation with the Climate and Environmental Physics Division of the University of Bern.

Snow cover (snow depth, snow water equivalent) is recorded by measurement networks operated by MeteoSwiss, the Swiss Federal Institute for Snow and Avalanche Research (SLF) and other cantonal and private institutions. Currently, an evaluation is in progress to redefine a subset of about 20 stations that measure snow depth since the early 20th century to establish a so-called Swiss climatological snow network.

Glacier variables studied (mass balance/ volume change, length change, glacier inventory, firn temperature and flow velocities) are currently being reviewed by the Cryospheric Commission (EKK) of the Swiss Academy of Sciences (SCNAT). Long-term measurements of mass balance are still being carried out for a small number of glaciers. For about 25 glaciers, data are available allowing long-term volume changes to be calculated for the past 100 years. Switzerland has one of the world's most extensive monitoring networks for glacier length changes, which is continued for around 100 glaciers assigned high priority. The aims are to integrate existing measurements into the GCOS Global Terrestrial Network for Glaciers (GTN-G), to define a future strategy and to incorporate modern measurement technologies into the monitoring programme.

PERMOS (Permafrost Monitoring Switzerland), operated by a number of university-based partner institutes, is based at the university of Zürich and currently co-funded by FOEN, SCNAT and MeteoSwiss. The monitoring predominantly relies on the measurement of ground temperatures, both at the surface and in the subsurface in boreholes. In addition, kinematics related to permafrost occurrence are quantified. So far, 10 borehole and 2 ground surface temperature sites have been approved to be part of PERMOS (Fig. 98). Additional 6 boreholes and 2 ground surface temperature sites are subject to re-evaluation in 2009. PERMOS as the national baseline network for permafrost will be funded through the Swiss GCOS Office on a sustained level from 2011 onwards. PERMOS contributes to the GCOS Global Terrestrial Network for Permafrost (GTN-P), providing valuable information on alpine permafrost.

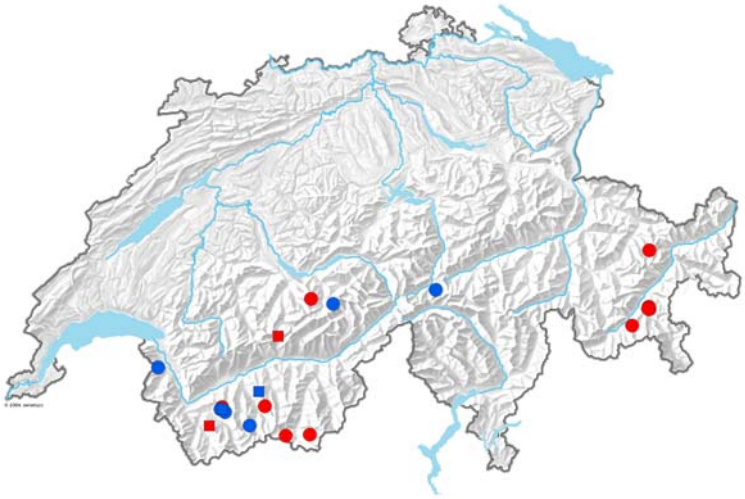
Tab. 63 > Switzerland's terrestrial observation networks

Domain	Variable	Number of stations and observation networks
Hydrosphere	River discharge	26
	Lake levels, area, temperature	31
	Groundwater	50 quality 100 quantity
	Isotopes	23 ISOT sites (13 precipitation, 7 surface water, 3 groundwater)
Cryosphere	Snow cover	ca 20 (to be defined)
	Glacier mass balance and length	25 mass balance and/or volume changes, ca. 100 length changes
	Permafrost borehole temperatures	12 (8 sites approved under reserve)
Biosphere	Biomass, Growth rate, Ecosystem and Microclimatological variables	50 study sites 18 monitoring sites (LWF)
	Phenology	12 (most important observation sites)

MeteoSwiss (2008)

Fig. 98 > Overview of the Swiss Permafrost Monitoring Network PERMOS

Recently 12 sites have been approved during an evaluation procedure (red). 8 additional sites are subject to a re-evaluation in 2009 (blue). PERMOS currently consists of borehole sites (dot) and sites with ground surface temperature measurements (square).



Seiz and Foppa (2007), swiss map: VECTOR200 © swisstopo (DV053906)

The carbon balance of forests is important with regard to national reporting under the Kyoto Protocol. It is based on data from the land use statistics and from three National Forest Inventory (NFI) surveys. The land use statistics of the Federal Statistical Office (FSO) record changes in land use every 12 years on average. For this purpose, aerial photographs acquired by the Federal Office of Topography (swisstopo) are used. Results from the third survey period (2004–2009) are currently analysed.

Since 1985, the state of Swiss forests has been documented by the Sanasilva inventory, which focuses on tree health. These surveys are carried out using approximately 50 study sites. One of several main characteristics assessed are growth rates, which are studied by the National Forest Inventory (NFI). Under the federal long-term forest ecosystem research (LWF) project, more intensive and wide-ranging studies are pursued as part of an integrated approach to forest monitoring. At 18 monitoring sites in Switzerland (i.e. LWF plots) external influences (e.g. air pollution) and changes in the forest ecosystem are assessed. Forest fire information and statistics are systematically compiled and stored in a centrally managed database at the WSL.

A national phenological monitoring network was established by MeteoSwiss in 1951. This now comprises 160 stations, distributed across various regions and elevations of Switzerland. Each year, observers record the dates of leaf unfolding (needle appearance), flowering, fruit ripening, leaf colouring and leaf fall for selected wild plants and crops. A selection of 12 most important observation sites over a variety of regions and elevations and taking into account phenological characteristics has been defined.

8.3.4 International activities

Switzerland's international data and calibration centres make a vital contribution to data quality and the global standardization of observations. The World Radiation Centre (WRC), established on the recommendation of the WMO in 1986 at the Physical Meteorological Observatory (PMOD) at Davos, serves as an international centre for the calibration of radiation instruments. Since 2006, the WRC manages two additional new facilities: the World Optical Depth Research and Calibration Centre (WORCC) and the European Ultraviolet Radiometer Calibration Centre (EUVC). The Swiss Federal Laboratory for Materials Testing and Research (Empa) has hosted the GAW quality assurance/scientific activity centre (QA/SAC Switzerland) since 2000. It is one of 4 such facilities worldwide and focuses on surface ozone, carbon

monoxide and methane. The World Calibration Centre (WCC) for surface ozone, carbon monoxide and methane (WCC-Empa) was established at Empa in 1996 at the request of the WMO. The World Glacier Monitoring Service (WGMS) in Zürich started to coordinate the international collection and publication of glacier data in 1986 and is responsible for the Global Terrestrial Network for Glaciers (GTN-G) within GCOS/GTOS. The already 110-year-old Swiss responsibility for a worldwide systematic glacier monitoring will be supported by long-term funding through the Swiss GCOS Office starting from January 2010.

Swiss institutions support technology transfer and local training to enhance the quality of climate-related observations outside Switzerland, especially in developing and emerging countries. The observations currently carried out by Swiss institutions abroad cover the following climate variables: ozone (Kenya), trace gases (Algeria, Kenya, Indonesia) and glaciers (worldwide). Switzerland is also involved in the GCOS Cooperation Mechanism activities, to support, as voluntary multi-governmental funding mechanism, the improvement of global observing systems for climate in developing countries.

Satellite observations are essential to obtain observations of the climate system from a near-global perspective. Switzerland is member of the European Space Agency (ESA) and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT). Both ESA and EUMETSAT have activities in the field of climate monitoring. The most important of these activities with involvement of Swiss institutions are focused on atmospheric (radiation, clouds, water vapour, atmospheric composition) as well as on terrestrial variables (snow, glaciers, and biosphere). As high-quality surface and in-situ observations remain of central importance for calibration and validation of satellite data, Switzerland with its many unique observation systems and in-situ climate records can play a leading role in advancing the complementary use of satellite data in the generation of climate data records.

Palaeo-historic data provide information about the long-term variability of the climate system, of which the limited instrumental record is just a brief part. Euro-Climhist is a Swiss database developed at the institute of history at the University of Bern, including records of early instrumental measurements, daily to seasonal weather reports and observations on lake and river freezing, snow cover, phenology and the impacts of natural disasters, as well as reports on perceptions of weather. The database is a valuable resource for analysing the climate history of Switzerland and Europe with a focus upon the medieval period. The continuation of the Euro-Climhist database is assured with funding through the Swiss GCOS Office.

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9 Education, training and public awareness

Switzerland has a long-standing tradition on raising public awareness for environmental issues. To some extent, this may be related to the (Alpine) landscape and its natural hazards that coined the notion that precautionary measures and risk management represent the only viable strategy to maintain the high standard of living in Switzerland in the long run.

The "traditional" natural hazards (such as e.g. landslides or flooding) still exist, however, some have been (or are projected to be) exacerbated by climate change. Furthermore, relatively new hazards (such as heat waves and droughts) are expected to occur more often according to regional climate model forecasts. Recurrent severe weather events over the past decades that might potentially be related to a changing climate have reinforced the public perception of climate change.

The sustained attention climate change has received from the public is reflected on the one hand by the way these topics are addressed by politicians: Not only the Green and left-wing parties, which traditionally covered these grounds, but increasingly also parties further to the right include aspects of climate policy in their agenda, thereby acknowledging the importance climate change issues have gained. On the other hand, also certain areas of business make use of climate related topics, be it as a marketing tool or an element of corporate image and culture.

According to a recent study on the public perception and knowledge with regard to environmental issues (Diekmann et al. 2008), climate change represents one of the top three concerns of Swiss citizens, only outweighed by concerns regarding healthcare costs and the funding of the state pension scheme. The results of the survey 2007 were compared to a similar study dating back to 1994. While the ranking of environmental concerns remained the same over the years, the percentage of people assigning a high or very high risk to climate change has increased from 54% in 1994 to 82% in 2007 (see Fig. 99). In line with the increased concern about climate change, the knowledge about the main cause for global warming has increased significantly (see Fig. 100).

Fig. 99 > Public perception of risk of climate change

Risk of climate change and global warming to society and the environment as perceived by the Swiss population in 1994 and 2007.

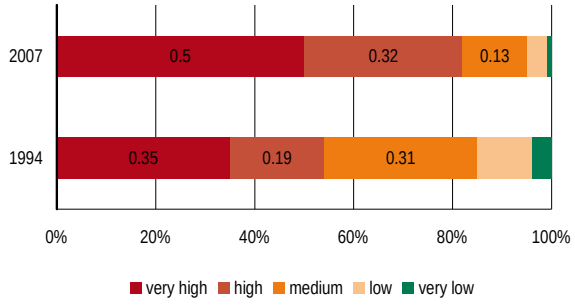
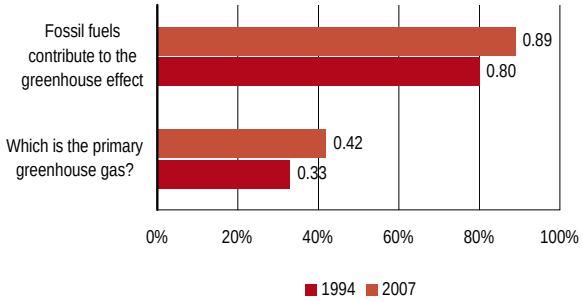


Fig. 100 > Knowledge about greenhouse effect

Comparison of percentage of correct answers to questions regarding greenhouse effect between 1994 and 2007.



Diekmann et al.(2008)

The increased knowledge may be related to the concerted effort of leading (Swiss) climate researchers in communicating the results of climate and climate-impact research and the cooperation between scientists and the media. The Swiss National Centre for Competence in Research on Climate, a nationwide research network funded by the Swiss National Science Foundation, facilitated the cooperation between Swiss

climate researchers and provided some sort of a national equivalent to international organizations. The fact that some of the leading Swiss scientist actively (and successfully) sought to communicate the results of their research combined with the establishment of independent scientific advisory bodies (OcCC, ProClim) certainly promoted the build-up of knowledge among journalists, politicians and the general public alike.

Efforts of various players to broadly disseminate knowledge about climate change via the education system also seem to bear fruit, as younger people tend to be more knowledgeable with regard to the scientific basis of climate change compared to older people (Diekmann et al. 2008). Myriads of different ways and channels to spread information on climate change are explored by institutions at federal, cantonal and local level. Significant efforts are also made by the scientific community and various non-profit organizations.

However, the increased knowledge still contrasts with behaviour, in particular in some areas. While, for example, waste handling and recycling show very high cooperation and compliance, measures involving bigger efforts or which are perceived as limiting individual freedom are not implemented (e.g. individual transport, leisure travel/activities) (FSO/FOEN 2008). According to Diekmann et al. (2008), knowledge about environmental issues has only a limited impact on behaviour. A far stronger influence is observed from the consciousness of environmental issues (Umweltbewusstsein), which itself is partly driven by the exposure to environmental impacts in the personal surroundings. Taking these results at face value means that sustained efforts to raise public awareness and illustrating impacts of climate change to a wide community does contribute to individuals taking action. A few examples of such activities are given in the following sections.

9.1 Climate-related activities by federal, state and local authorities

Many activities are jointly supported by federal, cantonal, communal and private sector agencies. It is sometimes very difficult to quantify the contribution of each partner in an objective way and to put weights to financial, personal or infrastructure contributions. In the following section, such multi-party initiatives have been assigned to one single sub-section. However, this doesn't mean, that the contribution from other institutions was necessarily smaller or less important.

9.1.1 Federal level

Climate change is a complex phenomenon that people find quite often hard to relate to due to the large spatial and temporal dimension it encompasses. The understanding of the scientific basis can be perceived as rather academic, which – on its own – may hinder emotional identification with the problem. While the awareness of the large-scale context is a necessary prerequisite, the relation to the individual's daily life is crucial for a personal commitment. Therefore, education and outreach activities need to address various different levels, ranging from the general understanding of the climate system and its drivers over to practical advice in areas of every-day life. Several federal agencies apart from the Federal Office for the Environment collaborate in covering these topics.

The Federal Office for the Environment and the Swiss Federal Office of Energy maintain comprehensive websites that cover aspects of climate change, climate politics and energy politics. The Federal Office of Meteorology and Climatology MeteoSwiss provides climatological services and information including a number of fact sheets covering a variety of climate topics. ProClim, MeteoSwiss, OcCC and FOEN jointly support the web portal www.climate-change.ch. The Federal Office for Spatial Development coordinates all efforts within the framework of Agenda 21, and the Federal Office for Civil Aviation maintains a website with fact sheets about aircraft emissions and climate impact from aviation.

There is also a specific mailbox (climate@bafu.admin.ch) that deals with climate-related enquiries from the general public. The Federal Office for the Environment provides access to the official documents submitted by the Swiss Confederation under the UNFCCC and the Kyoto Protocol (*www.climatereporting.ch*) and to the latest emission statistics.

These information channels are supplemented with a wide spectrum of magazines, reports and newsletters published by federal agencies (e.g. FOEN 2008j; Jungbluth et al. 2007; North et al. 2007; Seiz and Foppa 2007; Taverna et al. 2007), media releases, as well as talks and public appearances at exhibitions and meetings by representatives of the federal administration.

A series of nine posters illustrating the Swiss perspective on climate change, its impacts and potential measures for mitigation and adaptation has been produced in collaboration with the scientific advisory bodies OcCC and ProClim-. They are available for download as well as for display in schools, exhibitions and at special events (*http://www.bafu.admin.ch/klima/06538/06585/06671/index.html?lang=de*).

9.1.2 State (canton) level

The cantonal environmental authorities have set up and maintain websites where information and links related to climate change as well as practical guidance for environmentally friendly actions are found. The conference of the directors of the cantonal offices for the environment (www.kvu.ch) helps to exchange experiences, coordinate activities and promote best practices between the cantons. Activities related to education and outreach are very diverse, addressing a wide audience that ranges from school children, house-owners to professionals in specific sectors. The following list gives a few selected examples to illustrate the breadth and inventiveness of the cantonal authorities.

- "Energy detectives": Initiative of the canton of Basel Stadt that invites school children to investigate energy usage and search for energy-saving measures in their every-day life. A newsletter provides information on a particular topic, makes suggestions for activities, and invites children to special events (*www.energiedetektive.ch*).
- The cantons of Basel City and Geneva as well as the city of Zürich have committed themselves to the goal of the "2000-Watt Society". They are currently preparing action plans and launched communication campaigns.
- "The challenge of climate change": General information brochure published by the canton of Bern that illustrates impacts of climate change in respect of the local conditions, i.e. how the glaciers in the Bernese Alps retreat, how the snowline may rise in the future, or what the projected changes in precipitation pattern mean for the local hydrological balance (AUE 2006).
- "Minergie-Prize": Minergie ® is a label awarded to energy-efficient buildings. The canton of Bern has established a competition amongst its municipalities, rating the status, the development and the efforts in terms of energy efficiency in the building stock sector (*www.minergierating.ch/be*).
- "Climate trail": Various cantons (e.g. Bern, Luzern, Graubünden) have added information panels along hiking trails that show particularly strong evidence of climate change. The information panels represent snippets of information, provide more philosophical considerations, and give practical advice for actions.
- "Energy-Apéros": Informal meetings open to the general public that provide a platform for information exchange, networking and promotion of innovation in the area of energy efficiency.
- Various activities in the framework of Agenda 21.

9.1.3 Local level

Many towns and cities have joined the association "Klimabündnis" that is loosely linked to the European association of cities. Activities at the local level are often aimed at raising awareness for the general issue of climate change, combined with practical advice on how to make a difference in its own environment. A few creative examples are given below to illustrate some of these activities:

- NewRide: Initiative aimed at increasing the use of electric bikes and scooters as an alternative to less efficient individual transport (*www.newride.ch*).
- "Kids on the move": An international initiative joined by the city of Zürich, providing an incentive for school children to walk to school and reflect their own and their parents' mobility habits (*http://www.klimabuendnis.ch/cms/index.php?id=2,108,0,0,1,0*)
- "Ice cube bet": A huge ice block is displayed in a small building that conforms to the highest building standards with regard to energy efficiency and insulation. The public can witness how much ice melts away over a certain period of time during the summer months (*http://www.eisblockwette.ch/*).
- Various cities offer voluntary compensation of greenhouse gas emissions. By doing so, climate change and greenhouse gas emissions remain on the agenda and funds for mitigation and adaptation measures can be raised.
- Onex, a small town in the vicinity of Geneva, is pioneering in ways to increase energy efficiency with an emphasis put on communication. During 2008, 30 private households that aim at reducing the ecological footprint are monitored to document progress and set a benchmark. The University of Lausanne and the Swiss Federal Institute of Technology in Lausanne act as scientific advisory bodies that ensure stringent procedures for data acquisition.
- Energy region Goms: The alpine region Goms has adopted a plan to maximize renewable energy and energy efficiency in order to reach sustainable, decentralized energy production in the region by 2030. The aims are to strengthen the local structures and to promote sustainable development. The label "Energy region" will also be used for marketing purposes in the tourism sector.

9.2 Selected government-supported activities in the energy sector

The objectives of federal and cantonal energy policies are to encourage efficient energy use and promote the use of domestic and renewable energy. To achieve these goals, a sufficient number of specialised personnel with the necessary know-how for energy efficient construction, operation and maintenance of buildings and installations is required.

Training and further education in the energy sector is the joint responsibility of the Swiss Federal Office of Energy and the Conference of Cantonal Energy Directors. The commitment on the part of the federal government and the cantons is necessary because no trade or industry association exists that systematically focuses on providing education on the economical and ecological use of energy resources. The legal basis for the promotion of vocational training and further education in the area of energy are Article 11 of the Federal Energy Act and Article 13 of the Federal Energy Ordinance. The following activities in training and further education are supported:

- Provision of education programmes (courses, studies, etc.)
- Provision of teaching and learning materials
- Further education of teachers and tutors
- Provision of information about the range of programmes
- Subsidies and deficit guarantees

Strategy and priorities

The strategy is aimed at improving various key skills by providing suitable training and education for the relevant target groups. The main priority areas in training and further education are:

- Minimisation of heat consumption by improving building shells
- More energy-efficient heating and hot water systems through careful planning and installation
- Energy-efficient modernisation of buildings

- Use of renewable forms of energy (ambient and solar heat, wood, plus purchase of green power)
- Sustainable optimisation of systems (e.g. courses for janitors)

Priorities of projects relating to other areas:

- Energy-efficient systems and appliances in workshops, offices and apartments
- Adjustments of mobility behaviour
- Introduction of special courses in primary and secondary schools
- Use of biomass, especially bio-fuels

Target groups

Planners and builders develop and construct buildings that are subsequently in use for several decades. With a renovation cycle of around 30 years, for example for the building shell, a lot more energy has to be used in a building for its operation than for its construction or modernisation. Therefore priority has to be given to people who significantly influence energy consumption of buildings and systems:

- architects
- civil engineers and systems planners
- tradesmen (plumber, builders, electrical and gas fitters)
- janitors, real estate managers, maintenance personnel

Teachers and tutors at all levels (vocational schools, colleges of technology, universities, as well as primary and secondary schools) form a second important target group. They effectively establish a direct link between new know-how and social developments on the one hand, and pupils and students on the other.

Criteria for project partners

The following main criteria apply with respect to qualification for federal support for training and further education projects:

- clarification of need
- acceptance of project partners in the target group
- broad effect and relevance of products
- professional and teaching skills
- quality of implementation

The most important partners are professional and trade associations, colleges of technology and universities, primary and secondary schools, vocational and engineering schools, private organisations (e.g. companies, organisations).

Outlook: "continuing education in energy efficiency and renewable energy" initiative

The initiative "continuing education in energy efficiency and renewable energy" is a core element of the two action plans approved by the Federal Council in January 2008. The programme "energiewissen.ch" (energy knowledge) of the Swiss Federal Office of Energy aims at building up technical know-how to better exploit the energy savings potential and the use of renewable energies in the building sector. In addition to building planning services delivered by architects, the programme shall reach out to tradesmen of the construction sector as well as home owners and janitors.

The federal budget for continuing education in the energy sector has been doubled in 2009 to reach CHF 2 million, and it serves to fund education programmes of the cantons, professional associations as well as technical schools and universities of applied sciences. The following core activities, divided between different target groups, are supported:

- architects, engineers: consolidation of the existing master of advanced studies "energy in buildings"; initiative for energy efficiency; text book series "Construct and Refurbish Sustainably".
- tradesmen: energy consulting for tradesmen; certificate course by professional associations for refurbishment, wood stoves, solar systems and heat pumps; continuing education Minergie© buildings; basic energy knowledge in the field of professional training.
- investors and home owners: basic documentation for investors and private home owners.
- facility operators, janitors: technical courses regarding energy and environment; facility optimization for janitors.
- pupils and teachers: education with hands-on experience; provide and enhance systematic training documents.

9.3 Further activities with government support

Scientific advisory bodies
The scientific advisory bodies ProClim- and OcCC are the most prominent organizations that regularly publish the latest information on climate change research.

Initiated in 1988, ProClim- is an independent organization of the Swiss Academy of Sciences. Its mission includes the promotion of interdisciplinary scientific collaboration and the distribution and exchange of information on global change science within Switzerland. It aims at providing a holistic view on climate change, including the physical climate system, biogeochemical processes and the human dimensions of global change. ProClim- seeks to further nationwide networking amongst people and institutions involved. An important tool in this respect is the climate change information system, which provides easy access to information on ongoing research activities and expertise. Additionally, ProClim- organizes the annual "Swiss Global Change Day", where the Swiss climate change community meets and discusses the latest results in climate change research.

The Advisory Body on Climate Change (OcCC) was appointed in 1996 by the Federal Department of Home Affairs (FDHA) and the Federal Department of the Environment, Transport, Energy and Communication (DETEC). Its role is to formulate recommendations on questions regarding climate and global change for politicians and the federal administration. The mandate to create this body was given to the Swiss Academy of Sciences (scnat), which selected approximately 30 people from research, the private sector and the federal administration to participate in this body. The Federal Office for the Environment (FOEN) provides federal representation.

ProClim- and OcCC maintain websites where a wealth of information, contact details of various experts as well as links to related institutions in Switzerland and abroad can be found (www.climate-change.ch, www.proclim.ch, www.occc.ch). They are involved in translating and distributing the summaries of the IPCC reports. Various brochures and reports aimed at the general public have been published recently. They discuss the latest IPCC results from a Swiss point of view (OcCC 2008) and climate change projections in Switzerland for 2050 and their impacts on the environment, the economy and society (OcCC 2007).

A further scientific advisory body with governmental support it the National Platform for Natural Hazards, PLANAT (outlined under 6.3.2) specialised for coordinating concepts in the field of prevention against natural hazards.

Further activities
Apart from these two well-established institutions, various other initiatives are supported by federal agencies. As climate change becomes particularly visible in the Alpine regions of Switzerland, several tourist destinations have set up hiking trails along which information about the climate system, its past and future changes and the main drivers of climate change are explained. Most of these information panels were developed in collaboration with a research group of one of the leading Swiss universities in climate research. The Swiss Federal Institute of Technology in Zürich has gone one step further and developed a freely available e-learning environment based on the hiking trail in the Engadine (*www.klimaweg.ethz.ch* .

The Swiss Academies of Arts and Sciences have been mandated to support the foundation "Science et Cité", which is aimed at a dialogue between science and society on various topics. Climate change is among the themes that are regularly present on the agenda of Science et Cité, and this years' festival "basecamp09" is dedicated to the International Year of Planet Earth. An exhibition will tour various Swiss cities and local events and excursions will complement the exhibition.

The Federal Office for the Environment (FOEN) is also involved in shaping the area of education and training in the environment sector. While education is controlled at the cantonal level, FOEN provides input on priorities and financial support to specific projects. Mostly, FOEN is delegating the implementation to partner organization, such as the education branch of WWF Switzerland, or the foundation for environmental education (SUB/FEE). A recent in-depth analysis of the federal support in environmental education (Widmer et al. 2006) has shown that the effort is effective and well-received in particular in the general education sector, and that a sustained effort is desirable.

9.4 Private sector initiatives

There exists a myriad of ongoing private sector initiatives related to climate change in Switzerland. Their focus range from fostering individual actions (e.g. environmentally conscious consumption or environmentally friendly renovations and constructions etc.), improving information and education about climate change (e.g. in schools) and raising public awareness and involvement, to climate protection initiatives in Swiss companies, cities and regions. Additionally, Swiss companies and foundations are also very active in supporting climate change events, projects, campaigns and funds etc. outside Switzerland.

Examples of initiatives by Swiss companies
In Switzerland, there is a long standing tradition of voluntary climate protection measures by companies (see also section 4 -Policies and measures). Climate change is not only perceived as a challenge by Swiss companies, but also as a chance for new business opportunities, improving sustainable development and competitiveness.

- **Voluntary compensation of CO_2 emissions**
  Many Swiss companies are undertaking voluntary efforts to minimize their climate impacting emissions and making their contribution to climate protection. Some have even decided to voluntarily compensate their (unavoidable) CO_2 emissions, by mainly using carbon offset projects.
  Examples of climate-neutral services: The first fully climate neutral hotel chain in the world is located in Switzerland. Beside the effort to reduce their emissions by energy efficiency and other climate-friendly measures, the hotel chain offsets its remaining emissions. Also Swiss youth hostels offer guests the option of a climate neutral overnight stay. Examples of other climate-neutral services are flights, printing or sending of letters and packets.
  Examples of climate-neutral products: There are several companies offering climate-neutral products, such as food and drinks, T-Shirts, flower bouquets etc.
- **WWF Climate Group**
  Several Swiss companies have joined the WWF Climate Group, to contribute voluntar-

ily to climate protection. The members commit themselves to emit as little CO_2 as possible in production processes and products. In the following are, specific objectives are developed together with WWF: Products and services (e.g. more energy efficient appliances), operational CO_2-emissions and utilization of renewable energies and/or employee and customer relations.

- **Energy Agency for the Economy**
  The agency assists companies to reduce CO_2 emissions, increase energy efficiency and tap the potential of cost-efficient and climate-friendly measures in the Swiss industry, trade and service sector (see also section 4 -Policies and measures). The Energy Agency for the Economy mainly coordinates, evaluates and imparts knowledge and information about possible measures and instruments in the different companies and sectors.
- **Swiss Association for Environmentally Conscious Management**
  The Swiss Association for Environmentally Conscious Management (ÖBU) encompasses 330 Swiss companies of all sizes and from all economic sectors. One of its top priorities is climate change. By anticipating future developments concerning natural resources, needs of society and changes in the legal framework, ÖBU strengthens the sensibility of Swiss companies about challenges and new potential business opportunities related to climate change. The objective is to foster innovation, sustainable development, and competitiveness of the Swiss economy in the long run. The activity of ÖBU is based on different instruments, such as exchange of experiences (workshops, conferences, strategies, working groups etc.), a platform for its members (presentation of good practice examples, publications etc.) and improvement of framework conditions, namely by fostering the dialogue between policy and economy.

Information

Swiss companies and associations organize an ever increasing number of activities and events, aimed at increasing public awareness and consciousness towards climate change, its challenges and potential measures for mitigation or adaptation.

- Fora and conferences on climate change
  Various conferences and fora on climate change and related issues are organized by companies, organizations or universities. Purpose of these events is to inform the public, policy makers, business people and academics, provide a platform for exchanging ideas, transferring knowledge, and discussing climate protection measures and challenges. Examples of institutionalized fora are the national Climate Forum, which is aimed at facilitating integrated research activities and strengthening networks between scientists, policy makers and the public.
- Alliance for a responsible climate policy
  54 Swiss organizations and societies (environmental, religious, consumer, union and development aid NGOs) have joined forces to promote a credible and effective Swiss climate policy. Members and supporters of these organizations represent more than 1.8 million people, corresponding to 25% of the Swiss population. The Alliance provides information for the media and policy makers and lobbies for a stringent climate policy.
- Information for consumers
  Several environmental and governmental organization, companies, consumer and other associations provide information on ecological behaviour, sustainable consumption and individual climate protection measures through media, such as internet, brochures, lists of particularly environmentally friendly products etc. Tools, such as CO_2-calculators, climate checks, labelling and certifications assist individuals, consumers and homeowners to adopt more environmentally friendly decisions and behaviours.
- WWF and Greenpeace Switzerland
  WWF and Greenpeace Switzerland have long track records on energy and climate is-

sues and have launched – among many other initiatives in Switzerland – several information and education campaigns to increase public awareness in Switzerland.

- Swiss Transport and Environment Association
  The Swiss Transport and Environment Association (VCS) is continuously promoting human-oriented and environmentally sound mobility since 1979. As Switzerland's second-largest transport association, it lobbies for a sustainable transport policy.
  Each year, as part of its commitment to climate policy, the association publishes the VCS environmental guide for car buyers (German: *www.autoumweltliste.ch* French: *www.ecomobiliste.ch*), which rates various models by CO_2, pollutant and noise emissions. As well as an environmental assessment of over 500 models and best-buy lists, the publication provides a wide range of advice and information for prospective buyers.

Education
Amongst other informative or educational materials, WWF Switzerland has elaborated a comprehensive teachers' aid on climate and climate change (in German, French and Italian). Greenpeace Switzerland regularly offers camps and projects with school classes, e.g. for the installation of solar power devices.

9.5 International cooperation

Switzerland is cooperating in various international efforts, e.g. in the framework of Agenda21. Two recent examples of Swiss contributions to international education and outreach activities are listed below.

World Climate Conference WCC-3
Switzerland hosted the WCC-3 of the WMO in September 2009. This international conference is partly a scientific conference, where latest results are discussed, and partly a forum for policy makers to define a common strategy. During the conference, Switzerland and Denmark organized a ministerial meeting on adaptation with the aim of underlining the importance of the science-based climate predictions and risk assessments as discussed at WCC-3 for planning of adequate adaptation measures.

World Wide Views on Global Warming
Switzerland is part of the world-wide initiative that gives citizens all over the world the opportunity to communicate their positions on issues related to the international climate policy that will be shaped at the UN climate conference in Copenhagen (COP15) in December.

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[18] Where available, references are provided online at www. climatereporting.ch

Annex 1: Swiss GHG inventory – summary and trend tables

Excerpt from the Swiss 2009 GHG inventory submission to the UNFCCC secretariat (FOEN 2009). For the complete inventory, see www.climatereporting.ch > Annual Greenhouse Gas Inventories.

Fig. 101 > NIR summary table 1.A (sheet 1)

SUMMARY 1.A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7A) (Sheet 1 of 3)

Inventory 2007
Submission 2009 v1.1
SWITZERLAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		Net CO_2 emissions/removals	CH_4	N_2O	HFCs[1]		PFCs[1]		SF_6		NO_x	CO	NMVOC	SO_2
					P	A	P	A	P	A				
		(Gg)			CO_2 equivalent (Gg)						(Gg)			
Total National Emissions and Removals		**42'981.73**	**167.29**	**10.45**	**2'207.81**	**629.52**	**84.22**	**77.08**	**0.00**	**0.01**	**80.06**	**313.18**	**191.78**	**13.55**
1. Energy		**41'357.63**	**13.29**	**1.06**							**74.74**	**297.23**	**31.96**	**11.42**
A. Fuel Combustion	Reference Approach [2]	41'907.30												
	Sectoral Approach [2]	41'254.98	5.04	1.06							74.49	297.17	26.00	11.13
1. Energy Industries		3'343.71	0.08	0.37							2.80	1.16	0.12	1.93
2. Manufacturing Industries and Construction		5'803.59	0.55	0.14							8.52	12.50	0.45	3.49
3. Transport		16'208.96	0.94	0.38							44.44	195.40	18.49	0.17
4. Other Sectors		15'309.81	3.41	0.15							13.69	70.97	4.79	5.54
5. Other		588.91	0.05	0.02							5.04	17.15	2.16	0.00
B. Fugitive Emissions from Fuels		102.65	8.25	0.00							0.25	0.06	5.95	0.29
1. Solid Fuels		NO	NO	NO							NO	NO	NO	NO
2. Oil and Natural Gas		102.65	8.25	0.00							0.25	0.06	5.95	0.29
2. Industrial Processes		**2'086.25**	**0.33**	**0.27**	**2'207.81**	**629.52**	**84.22**	**77.08**	**0.00**	**0.01**	**0.38**	**6.77**	**10.97**	**1.98**
A. Mineral Products		1'891.47	0.03	NO							0.02	4.17	4.99	1.32
B. Chemical Industry		15.21	0.30	0.27	NO	NO	NO	NO	NO	NO	0.08	0.90	0.08	0.47
C. Metal Production		179.13	IE,NO	NO				NA,NO		0.00	0.24	1.31	0.51	0.02
D. Other Production [3]		NO									NO	0.02	5.05	NO
E. Production of Halocarbons and SF_6						NO		NO		NO				
F. Consumption of Halocarbons and SF_6					2'207.81	629.52	84.22	77.08	0.00	0.00				
G. Other		0.44	NO	NO	NO	NA,NO	NO	NO	NO	NO	0.04	0.37	0.33	0.18

Note: **A** = Actual emissions based on Tier 2 approach of the IPCC Guidelines.
P = Potential emissions based on Tier 1 approach of the IPCC Guidelines.

FOEN (2009)

Fig. 102 > NIR summary table 1.A (sheet 2)

SUMMARY 1.A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7A)
(Sheet 2 of 3)

Inventory 2007
Submission 2009 v1.1
SWITZERLAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/removals	CH_4	N_2O	HFCs [1]		PFCs[1]		SF_6		NO_x	CO	NMVOC	SO_2
				P	A	P	A	P	A				
	(Gg)			CO_2 equivalent (Gg)						(Gg)			
3. Solvent and Other Product Use	**177.11**		**0.17**							**0.01**	**0.02**	**46.58**	**0.01**
4. Agriculture		**134.74**	**8.12**							**4.56**	**7.28**	**4.64**	**0.05**
A. Enteric Fermentation		110.41											
B. Manure Management		23.85	1.32									NO	
C. Rice Cultivation		NO										NO	
D. Agricultural Soils[4]		NO	6.79									3.97	
E. Prescribed Burning of Savannas		NO	NO							NO	NO	NO	
F. Field Burning of Agricultural Residues		0.48	0.01							0.25	7.28	0.67	
G. Other		NO	NO							4.30	NO	NO	0.05
5. Land Use, Land-Use Change and Forestry	[5] **-654.57**	**0.08**	**0.02**							**IE,NE**	**IE,NE**	**95.52**	**NE**
A. Forest Land	[5] -1'751.60	0.08	0.00							IE	IE	95.01	
B. Cropland	[5] 576.19	NO	0.02							IE	IE	IE	
C. Grassland	[5] 93.62	NO	NO							IE	IE	0.51	
D. Wetlands	[5] 14.50	NO	NO							NE	NE	NE	
E. Settlements	[5] 330.79	NE,NO	NE,NO							NE	NE	NE	
F. Other Land	[5] 81.92	NE,NO	NE,NO							NE	NE	NE	
G. Other	[5] NE	NE	NE							NE	NE	NE	NE
6. Waste	**15.31**	**18.85**	**0.81**							**0.37**	**1.89**	**2.12**	**0.09**
A. Solid Waste Disposal on Land	[6] 0.06	13.30								0.00	0.03	0.00	
B. Waste-water Handling		0.60	0.65							0.19	0.33	0.00	
C. Waste Incineration	[6] 15.25	0.19	0.10							0.18	1.53	0.48	0.07
D. Other	NO	4.76	0.07							NO	0.00	1.63	0.02
7. Other ***(please specify)*** [7]	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Other non-specified	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

FOEN (2009)

Fig. 103 > NIR summary table 1.A (sheet 3)

SUMMARY 1.A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7A) (Sheet 3 of 3)

Inventory 2007
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GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/removals	CH_4	N_2O	HFCs		PFCs		SF_6		NO_x	CO	NMVOC	SO_2
				P	A	P	A	P	A				
	(Gg)			CO_2 equivalent (Gg)						(Gg)			
Memo Items: (8)													
International Bunkers	**3'919.34**	**0.07**	**0.12**							**15.56**	**3.96**	**0.60**	**1.24**
Aviation	3'919.34	0.07	0.12							15.56	3.96	0.60	1.24
Marine	NO	NO	NO							NO	NO	NO	NO
Multilateral Operations	**NO**	**NO**	**NO**							**NO**	**NO**	**NO**	**NO**
CO_2 Emissions from Biomass	**3'283.20**												

(1) The emissions of HFCs and PFCs are to be expressed as CO_2 equivalent emissions. Data on disaggregated emissions of HFCs and PFCs are to be provided in Table 2(II) of this common reporting format.

(2) For verification purposes, countries are asked to report the results of their calculations using the Reference approach and to explain any differences with the Sectoral approach in the documentation box to Table 1.A.(c). For estimating national total emissions, the results from the Sectoral approach should be used, where possible.

(3) Other Production includes Pulp and Paper and Food and Drink Production.

(4) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(5) For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(6) CO_2 from source categories Solid Waste Disposal on Land and Waste Incineration should only be included if it stems from non-biogenic or inorganic waste streams. Only emissions from Waste Incineration Without Energy Recovery are to be reported in the Waste sector, whereas emissions from Incineration With Energy Recovery are to be reported in the Energy sector.

(7) If reporting any country-specific source category under sector "7. Other", detailed explanations should be provided in Chapter 9: Other (CRF sector 7) of the NIR.

(8) Countries are asked to report emissions from international aviation and marine bunkers and multilateral operations, as well as CO_2 emissions from biomass, under Memo Items. These emissions should not be included in the national total emissions from the energy sector. Amounts of biomass used as fuel are included in the national energy consumption but the corresponding CO_2 emissions are not included in the national total as it is assumed that the biomass is produced in a sustainable manner. If the biomass is harvested at an unsustainable rate, net CO_2 emissions are accounted for as a loss of biomass stocks in the Land Use, Land-use Change and Forestry sector.

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Fig. 104 > NIR summary table 1.B (sheet 1)

SUMMARY 1.B SHORT SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7B)
(Sheet 1 of 1)

Inventory 2007
Submission 2009 v1.1
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GREENHOUSE GAS SOURCE AND SINK CATEGORIES		Net CO_2 emisions/removals	CH_4	N_2O	HFCs[1]		PFCs[1]		SF_6		NO_x	CO	NMVOC	SO_2
					P	A	P	A	P	A				
		(Gg)			CO_2 equivalent (Gg)						(Gg)			
Total National Emissions and Removals		**42'981.73**	**167.29**	**10.45**	**2'207.81**	**629.52**	**84.22**	**77.08**	**0.00**	**0.01**	**80.06**	**313.18**	**191.78**	**13.55**
1. Energy		**41'357.63**	**13.29**	**1.06**							**74.74**	**297.23**	**31.96**	**11.42**
A. Fuel Combustion	Reference Approach[2]	41'907.30												
	Sectoral Approach[2]	41'254.98	5.04	1.06							74.49	297.17	26.00	11.13
B. Fugitive Emissions from Fuels		102.65	8.25	0.00							0.25	0.06	5.95	0.29
2. Industrial Processes		**2'086.25**	**0.33**	**0.27**	**2'207.81**	**629.52**	**84.22**	**77.08**	**0.00**	**0.01**	**0.38**	**6.77**	**10.97**	**1.98**
3. Solvent and Other Product Use		**177.11**		**0.17**							**0.01**	**0.02**	**46.58**	**0.01**
4. Agriculture [3]			**134.74**	**8.12**							**4.56**	**7.28**	**4.64**	**0.05**
5. Land Use, Land-Use Change and Forestry		[4] **-654.57**	**0.08**	**0.02**							**IE,NE**	**IE,NE**	**95.52**	**NE**
6. Waste		**15.31**	**18.85**	**0.81**							**0.37**	**1.89**	**2.12**	**0.09**
7. Other		**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Memo Items: [5]														
International Bunkers		**3'919.34**	**0.07**	**0.12**							**15.56**	**3.96**	**0.60**	**1.24**
Aviation		3'919.34	0.07	0.12							15.56	3.96	0.60	1.24
Marine		NO	NO	NO							NO	NO	NO	NO
Multilateral Operations		**NO**	**NO**	**NO**							**NO**	**NO**	**NO**	**NO**
CO_2 Emissions from Biomass		**3'283.20**												

Note: A = Actual emissions based on Tier 2 approach of the IPCC Guidelines.
P = Potential emissions based on Tier 1 approach of the IPCC Guidelines.

(1) The emissions of HFCs and PFCs are to be expressed as CO_2 equivalent emissions. Data on disaggregated emissions of HFCs and PFCs are to be provided in Table 2(II) of this common reporting format.

(2) For verification purposes, countries are asked to report the results of their calculations using the Reference approach and to explain any differences with the Sectoral approach in the documentation box to Table 1.A.(c). For estimating national total emissions, the result from the Sectoral approach should be used, where possible.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(5) Countries are asked to report emissions from international aviation and marine bunkers and multilateral operations, as well as CO_2 emissions from biomass, under Memo Items. These emissions should not be included in the national total emissions from the energy sector. Amounts of biomass used as fuel are included in the national energy consumption but the corresponding CO_2 emissions are not included in the national total as it is assumed that the biomass is produced in a sustainable manner. If the biomass is harvested at an unsustainable rate, net CO_2 emissions are accounted for as a loss of biomass stocks in the Land Use, Land-use Change and Forestry sector.

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Fig. 105 > NIR summary table for CO_2 eq (sheet 1)

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS (Sheet 1 of 1)

Inventory 2007
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GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs [2]	PFCs [2]	SF_6 [2]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**42'981.73**	**3'513.00**	**3'240.66**	**629.52**	**77.08**	**175.41**	**50'617.40**
1. Energy	**41'357.63**	**279.05**	**329.72**				**41'966.40**
A. Fuel Combustion (Sectoral Approach)	41'254.98	105.78	329.69				41'690.45
1. Energy Industries	3'343.71	1.72	116.06				3'461.49
2. Manufacturing Industries and Construction	5'803.59	11.48	42.07				5'857.13
3. Transport	16'208.96	19.76	118.05				16'346.77
4. Other Sectors	15'309.81	71.68	46.85				15'428.34
5. Other	588.91	1.14	6.67				596.72
B. Fugitive Emissions from Fuels	102.65	173.28	0.03				275.95
1. Solid Fuels	NO	NO	NO				NO
2. Oil and Natural Gas	102.65	173.28	0.03				275.95
2. Industrial Processes	**2'086.25**	**6.95**	**83.15**	**629.52**	**77.08**	**175.41**	**3'058.37**
A. Mineral Products	1'891.47	0.65	NO				1'892.11
B. Chemical Industry	15.21	6.30	83.15	NO	NO	NO	104.66
C. Metal Production	179.13	IE,NO	NO	NA,NO	NA,NO	62.14	241.27
D. Other Production	NO						NO
E. Production of Halocarbons and SF_6				NO	NO	NO	NO
F. Consumption of Halocarbons and SF_6 [2]				629.52	77.08	113.27	819.87
G. Other	0.44	NO	NO	NA,NO	NO	NO	0.44
3. Solvent and Other Product Use	**177.11**		**53.72**				**230.83**
4. Agriculture		**2'829.49**	**2'516.23**				**5'345.72**
A. Enteric Fermentation		2'318.64					2'318.64
B. Manure Management		500.85	408.39				909.24
C. Rice Cultivation		NO					NO
D. Agricultural Soils [3]		NO	2'103.94				2'103.94
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		10.00	3.91				13.90
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry [1]	**-654.57**	**1.74**	**5.59**				**-647.24**
A. Forest Land	-1'751.60	1.74	0.90				-1'748.96
B. Cropland	576.19	NO	4.69				580.89
C. Grassland	93.62	NO	NO				93.62
D. Wetlands	14.50	NO	NO				14.50
E. Settlements	330.79	NE,NO	NE,NO				330.79
F. Other Land	81.92	NE,NO	NE,NO				81.92
G. Other	NE	NE	NE				NE
6. Waste	**15.31**	**395.77**	**252.25**				**663.33**
A. Solid Waste Disposal on Land	0.06	279.30					279.36
B. Waste-water Handling		12.53	201.02				213.55
C. Waste Incineration	15.25	3.99	30.75				50.00
D. Other	NO	99.94	20.47				120.42
7. Other *(as specified in Summary 1.A)*	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**

Memo Items: [4]							
International Bunkers	3'919.34	1.40	38.18				3'958.92
Aviation	3'919.34	1.40	38.18				3'958.92
Marine	NO	NO	NO				NO
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**3'283.20**						**3'283.20**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	51'264.64
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	50'617.40

[1] For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

[2] Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

[3] Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

[4] See footnote 8 to table Summary 1.A.

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Fig. 106 > NIR summary table 10 - CO_2 emissions trends (sheet 1)

TABLE 10 EMISSION TRENDS
CO_2
(Part 1 of 2)

Inventory 2007
Submission 2009 v1.1
SWITZERLAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	**41'252.87**	**43'240.70**	**43'415.93**	**41'102.75**	**40'203.12**	**40'892.80**	**41'775.60**	**41'297.17**	**42'535.17**	**42'736.75**
A. Fuel Combustion (Sectoral Approach)	41'113.63	43'104.69	43'283.30	40'972.75	40'080.75	40'772.52	41'646.31	41'171.21	42'412.15	42'619.45
1. Energy Industries	2'492.80	2'771.85	2'852.54	2'503.36	2'525.61	2'551.80	2'756.46	2'715.25	3'030.66	2'872.42
2. Manufacturing Industries and Construction	5'950.98	5'830.20	5'665.16	5'461.47	5'537.01	5'386.28	5'224.29	5'384.21	5'537.66	5'574.46
3. Transport	14'575.81	15'042.44	15'346.43	14'288.26	14'477.24	14'151.71	14'189.21	14'749.87	14'959.43	15'553.02
4. Other Sectors	17'650.07	19'000.38	18'943.48	18'228.11	17'033.48	18'159.46	18'942.15	17'776.74	18'328.34	18'052.56
5. Other	443.97	459.83	475.69	491.55	507.41	523.27	534.20	545.13	556.06	566.99
B. Fugitive Emissions from Fuels	139.24	136.00	132.63	130.00	122.37	120.28	129.29	125.96	123.02	117.29
1. Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Oil and Natural Gas	139.24	136.00	132.63	130.00	122.37	120.28	129.29	125.96	123.02	117.29
2. Industrial Processes	**2'831.33**	**2'500.17**	**2'362.01**	**2'117.01**	**2'282.12**	**2'107.83**	**1'924.76**	**1'747.32**	**1'767.04**	**1'811.32**
A. Mineral Products	2'564.98	2'237.10	2'100.16	1'914.10	2'103.26	1'985.64	1'791.29	1'607.49	1'609.96	1'610.13
B. Chemical Industry	13.60	13.93	14.26	14.59	14.92	15.25	15.25	15.24	15.25	15.25
C. Metal Production	251.71	248.20	246.75	187.59	163.32	106.42	118.03	124.27	141.38	185.30
D. Other Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	1.04	0.94	0.83	0.73	0.62	0.52	0.20	0.32	0.44	0.64
3. Solvent and Other Product Use	357.79	342.07	327.84	309.11	298.75	284.80	267.44	248.18	228.86	229.09
4. Agriculture										
A. Enteric Fermentation										
B. Manure Management										
C. Rice Cultivation										
D. Agricultural Soils										
E. Prescribed Burning of Savannas										
F. Field Burning of Agricultural Residues										
G. Other										
5. Land Use, Land-Use Change and Forestry[2]	**-2'359.50**	**-1'676.29**	**-1'157.07**	**-3'221.90**	**-5'517.91**	**-5'305.74**	**-4'529.62**	**-2'515.36**	**-1'687.11**	**-1'379.56**
A. Forest Land	-3'488.41	-2'802.00	-2'282.56	-4'326.59	-6'643.63	-6'438.35	-5'663.34	-3'649.01	-2'820.44	-2'511.52
B. Cropland	607.64	606.29	605.63	602.91	600.52	596.53	594.83	593.12	591.42	589.71
C. Grassland	17.50	17.40	17.54	66.20	81.32	86.00	87.95	89.13	90.20	90.61
D. Wetlands	-8.96	-8.28	-8.14	-2.02	15.26	19.96	19.81	19.61	19.40	19.13
E. Settlements	402.37	400.53	400.66	346.89	339.05	345.69	346.36	346.78	347.11	347.18
F. Other Land	110.35	109.77	109.80	90.70	89.56	84.43	84.77	85.00	85.21	85.32
G. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
6. Waste	**62.00**	**59.31**	**55.01**	**49.59**	**41.63**	**36.70**	**33.73**	**31.30**	**28.95**	**25.16**
A. Solid Waste Disposal on Land	9.13	10.70	10.66	9.51	5.81	5.14	4.48	4.36	4.32	2.85
B. Waste-water Handling										
C. Waste Incineration	52.87	48.60	44.34	40.08	35.82	31.56	29.25	26.93	24.62	22.31
D. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7. Other *(as specified in Summary 1.A)*	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Total CO_2 emissions including net CO_2 from LULUCF	**42'144.48**	**44'465.95**	**45'003.72**	**40'356.55**	**37'307.70**	**38'016.38**	**39'471.91**	**40'808.60**	**42'872.91**	**43'422.76**
Total CO_2 emissions excluding net CO_2 from LULUCF	**44'503.98**	**46'142.24**	**46'160.78**	**43'578.46**	**42'825.61**	**43'322.12**	**44'001.53**	**43'323.96**	**44'560.02**	**44'802.32**
Memo Items:										
International Bunkers	**3'065.92**	**2'991.86**	**3'184.16**	**3'319.07**	**3'428.71**	**3'654.00**	**3'804.56**	**3'951.57**	**4'143.03**	**4'450.95**
Aviation	3'065.92	2'991.86	3'184.16	3'319.07	3'428.71	3'654.00	3'804.56	3'951.57	4'143.03	4'450.95
Marine	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 Emissions from Biomass	2'881.67	3'148.61	3'038.90	3'057.26	2'861.57	3'059.70	3'351.02	2'970.64	3'007.36	2'977.13

Note: All footnotes for this table are given at the end of the table on sheet 5.

Fig. 107 > NIR summary table 10 - CO_2 emissions trends (sheet 2)

TABLE 10 EMISSION TRENDS
CO_2
(Part 2 of 2)

Inventory 2007
Submission 2009 v1.1
SWITZERLAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	Change from base to latest reported year
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	%
1. Energy	**41'707.63**	**42'467.18**	**41'617.90**	**42'759.47**	**43'131.03**	**43'740.31**	**43'312.28**	**41'357.63**	**0.25**
A. Fuel Combustion (Sectoral Approach)	41'593.85	42'349.42	41'504.29	42'657.99	43'024.28	43'634.44	43'201.93	41'254.98	0.34
1. Energy Industries	2'782.05	2'906.52	2'962.03	2'942.19	3'257.13	3'404.01	3'637.61	3'343.71	34.13
2. Manufacturing Industries and Construction	5'747.90	5'769.71	5'687.14	5'664.57	5'705.12	5'810.04	5'863.84	5'803.59	-2.48
3. Transport	15'795.29	15'504.70	15'399.84	15'579.05	15'696.40	15'783.77	15'880.57	16'208.96	11.20
4. Other Sectors	16'690.70	17'588.31	16'872.84	17'887.46	17'778.67	18'047.39	17'230.84	15'309.81	-13.26
5. Other	577.92	580.18	582.44	584.71	586.97	589.24	589.07	588.91	32.65
B. Fugitive Emissions from Fuels	113.78	117.76	113.61	101.48	106.75	105.87	110.35	102.65	-26.28
1. Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO	0.00
2. Oil and Natural Gas	113.78	117.76	113.61	101.48	106.75	105.87	110.35	102.65	-26.28
2. Industrial Processes	**1'948.28**	**1'984.82**	**1'937.24**	**1'910.66**	**2'021.08**	**2'104.33**	**2'071.41**	**2'086.25**	**-26.32**
A. Mineral Products	1'730.59	1'762.26	1'697.17	1'661.93	1'758.99	1'853.00	1'859.04	1'891.47	-26.26
B. Chemical Industry	15.29	15.33	15.29	15.22	15.26	15.21	15.25	15.21	11.85
C. Metal Production	201.64	206.43	223.46	231.87	245.40	235.80	196.52	179.13	-28.83
D. Other Production	NO	NO	NO	NO	NO	NO	NO	NO	0.00
E. Production of Halocarbons and SF_6									
F. Consumption of Halocarbons and SF_6									
G. Other	0.76	0.80	1.32	1.64	1.44	0.32	0.60	0.44	-57.69
3. Solvent and Other Product Use	222.56	210.86	200.49	191.00	179.61	178.27	176.44	177.11	-50.50
4. Agriculture									
A. Enteric Fermentation									
B. Manure Management									
C. Rice Cultivation									
D. Agricultural Soils									
E. Prescribed Burning of Savannas									
F. Field Burning of Agricultural Residues									
G. Other									
5. Land Use, Land-Use Change and Forestry(2)	**745.16**	**212.08**	**375.09**	**-1'583.59**	**294.94**	**859.21**	**1'070.29**	**-654.57**	**-72.26**
A. Forest Land	-386.52	-917.83	-753.57	-2'710.88	-830.82	-346.12	-95.81	-1'751.60	-49.79
B. Cropland	588.00	586.29	584.57	582.86	581.15	580.06	578.12	576.19	-5.18
C. Grassland	91.74	92.25	93.12	93.91	94.27	122.30	111.43	93.62	434.95
D. Wetlands	18.92	18.56	18.23	17.88	17.58	20.60	17.44	14.50	-261.84
E. Settlements	347.48	347.14	346.92	346.67	346.69	386.49	366.67	330.79	-17.79
F. Other Land	85.55	85.66	85.83	85.96	86.06	95.87	92.45	81.92	-25.77
G. Other	NE	NE	NE	NE	NE	NE	NE	NE	0.00
6. Waste	**21.77**	**18.82**	**15.85**	**15.63**	**15.33**	**15.30**	**15.27**	**15.31**	**-75.30**
A. Solid Waste Disposal on Land	1.78	1.13	0.48	0.31	0.07	0.04	0.01	0.06	-99.33
B. Waste-water Handling									
C. Waste Incineration	20.00	17.69	15.38	15.31	15.25	15.25	15.25	15.25	-71.15
D. Other	NO	NO	NO	NO	NO	NO	NO	NO	0.00
7. Other *(as specified in Summary 1.A)*	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**0.00**
Total CO_2 emissions including net CO_2 from LULUCF	**44'645.41**	**44'893.76**	**44'146.58**	**43'293.17**	**45'641.99**	**46'897.40**	**46'645.69**	**42'981.73**	**1.99**
Total CO_2 emissions excluding net CO_2 from LULUCF	**43'900.25**	**44'681.68**	**43'771.49**	**44'876.76**	**45'347.05**	**46'038.20**	**45'575.39**	**43'636.30**	**-1.95**
Memo Items:									
International Bunkers	**4'661.85**	**4'399.10**	**4'060.24**	**3'642.63**	**3'432.79**	**3'489.52**	**3'667.95**	**3'919.34**	**27.84**
Aviation	4'661.85	4'399.10	4'060.24	3'642.63	3'432.79	3'489.52	3'667.95	3'919.34	27.84
Marine	NO	NO	NO	NO	NO	NO	NO	NO	0.00
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	0.00
CO_2 Emissions from Biomass	2'818.96	2'965.22	2'899.22	3'077.61	3'075.45	3'265.25	3'324.82	3'283.20	13.93

Note: All footnotes for this table are given at the end of the table on sheet 5.

Fig. 108 > NIR summary table 10 - CH_4 emissions trends (sheet 1)

TABLE 10 EMISSION TRENDS Inventory 2007
CH_4 Submission 2009 v1.1
(Part 1 of 2) SWITZERLAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	26.90	26.06	23.92	21.95	20.86	19.71	18.79	17.44	17.10	17.32
A. Fuel Combustion (Sectoral Approach)	8.78	8.88	8.25	7.57	6.86	6.78	6.91	6.26	6.13	6.02
1. Energy Industries	0.07	0.08	0.09	0.08	0.08	0.09	0.10	0.09	0.10	0.09
2. Manufacturing Industries and Construction	0.37	0.38	0.39	0.39	0.40	0.41	0.42	0.42	0.42	0.43
3. Transport	4.47	4.15	3.77	3.13	2.77	2.42	2.24	2.13	1.95	1.87
4. Other Sectors	3.81	4.21	3.94	3.91	3.54	3.81	4.09	3.55	3.60	3.57
5. Other	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
B. Fugitive Emissions from Fuels	18.12	17.19	15.67	14.37	14.00	12.93	11.88	11.19	10.97	11.30
1. Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Oil and Natural Gas	18.12	17.19	15.67	14.37	14.00	12.93	11.88	11.19	10.97	11.30
2. Industrial Processes	**0.43**	**0.41**	**0.40**	**0.38**	**0.37**	**0.35**	**0.35**	**0.34**	**0.34**	**0.34**
A. Mineral Products	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03
B. Chemical Industry	0.39	0.37	0.36	0.34	0.33	0.31	0.31	0.31	0.31	0.31
C. Metal Production	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO
D. Other Production										
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use										
4. Agriculture	**144.87**	**145.14**	**142.83**	**140.81**	**140.46**	**140.99**	**139.90**	**137.64**	**136.81**	**135.15**
A. Enteric Fermentation	117.85	118.24	116.33	114.54	114.61	115.44	114.53	112.53	111.48	110.67
B. Manure Management	26.54	26.42	26.02	25.79	25.38	25.07	24.89	24.63	24.85	24.00
C. Rice Cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural Soils	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
E. Prescribed Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agricultural Residues	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
G. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5. Land Use, Land-Use Change and Forestry	**0.39**	**0.05**	**0.02**	**0.01**	**0.10**	**0.16**	**0.08**	**0.53**	**0.09**	**0.00**
A. Forest Land	0.39	0.05	0.02	0.01	0.10	0.16	0.08	0.53	0.09	0.00
B. Cropland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Grassland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Wetlands	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
E. Settlements	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
F. Other Land	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
G. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
6. Waste	**34.85**	**34.30**	**33.41**	**30.77**	**27.74**	**27.51**	**26.88**	**26.75**	**25.27**	**24.31**
A. Solid Waste Disposal on Land	33.00	32.22	31.22	28.41	25.27	24.86	23.95	23.65	22.05	21.03
B. Waste-water Handling	0.21	0.22	0.22	0.23	0.23	0.24	0.24	0.24	0.24	0.25
C. Waste Incineration	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
D. Other	1.44	1.67	1.78	1.95	2.06	2.23	2.51	2.67	2.79	2.84
7. Other *(as specified in Summary 1.A)*	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Total CH_4 emissions including CH_4 from LULUCF	**207.44**	**205.97**	**200.58**	**193.92**	**189.53**	**188.71**	**186.00**	**182.71**	**179.61**	**177.12**
Total CH_4 emissions excluding CH_4 from LULUCF	**207.05**	**205.92**	**200.56**	**193.90**	**189.43**	**188.56**	**185.92**	**182.18**	**179.52**	**177.12**
Memo Items:										
International Bunkers	0.09	0.08	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.08
Aviation	0.09	0.08	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.08
Marine	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 Emissions from Biomass										

Note: All footnotes for this table are given at the end of the table on sheet 5.

Fig. 109 > NIR summary table 10 - CH_4 emissions trends (sheet 2)

TABLE 10 EMISSION TRENDS
CH_4
(Part 2 of 2)

Inventory 2007
Submission 2009 v1.1
SWITZERLAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	Change from base to latest reported year
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	%
1. Energy	16.05	16.31	14.82	14.03	13.88	13.91	13.74	13.29	-50.60
A. Fuel Combustion (Sectoral Approach)	5.58	5.64	5.31	5.44	5.41	5.55	5.44	5.04	-42.63
1. Energy Industries	0.08	0.08	0.07	0.08	0.09	0.09	0.09	0.08	15.49
2. Manufacturing Industries and Construction	0.47	0.47	0.47	0.47	0.48	0.49	0.50	0.55	46.01
3. Transport	1.71	1.53	1.38	1.28	1.18	1.07	0.99	0.94	-78.94
4. Other Sectors	3.27	3.49	3.33	3.56	3.60	3.84	3.80	3.41	-10.38
5. Other	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	-7.52
B. Fugitive Emissions from Fuels	10.46	10.67	9.51	8.59	8.47	8.37	8.31	8.25	-54.46
1. Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO	0.00
2. Oil and Natural Gas	10.46	10.67	9.51	8.59	8.47	8.37	8.31	8.25	-54.46
2. Industrial Processes	**0.34**	**0.34**	**0.34**	**0.34**	**0.34**	**0.34**	**0.33**	**0.33**	**-23.71**
A. Mineral Products	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	-31.32
B. Chemical Industry	0.31	0.31	0.31	0.31	0.31	0.31	0.30	0.30	-22.83
C. Metal Production	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	0.00
D. Other Production									
E. Production of Halocarbons and SF_6									
F. Consumption of Halocarbons and SF_6									
G. Other	NO	NO	NO	NO	NO	NO	NO	NO	0.00
3. Solvent and Other Product Use									
4. Agriculture	**134.99**	**136.52**	**135.50**	**133.50**	**132.16**	**133.17**	**133.88**	**134.74**	**-6.99**
A. Enteric Fermentation	110.52	111.74	110.87	109.30	108.15	108.85	109.52	110.41	-6.31
B. Manure Management	24.00	24.30	24.16	23.73	23.53	23.84	23.88	23.85	-10.15
C. Rice Cultivation	NO	NO	NO	NO	NO	NO	NO	NO	0.00
D. Agricultural Soils	NO	NO	NO	NO	NO	NO	NO	NO	0.00
E. Prescribed Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO	0.00
F. Field Burning of Agricultural Residues	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.00
G. Other	NO	NO	NO	NO	NO	NO	NO	NO	0.00
5. Land Use, Land-Use Change and Forestry	**0.01**	**0.01**	**0.15**	**0.20**	**0.01**	**0.02**	**0.04**	**0.08**	**-78.77**
A. Forest Land	0.01	0.01	0.15	0.20	0.01	0.02	0.04	0.08	-78.77
B. Cropland	NO	NO	NO	NO	NO	NO	NO	NO	0.00
C. Grassland	NO	NO	NO	NO	NO	NO	NO	NO	0.00
D. Wetlands	NO	NO	NO	NO	NO	NO	NO	NO	0.00
E. Settlements	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0.00
F. Other Land	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0.00
G. Other	NE	NE	NE	NE	NE	NE	NE	NE	0.00
6. Waste	**23.33**	**22.08**	**21.63**	**19.47**	**20.20**	**20.00**	**18.96**	**18.85**	**-45.92**
A. Solid Waste Disposal on Land	19.32	18.01	17.11	14.80	15.40	14.90	13.70	13.30	-59.70
B. Waste-water Handling	0.25	0.25	0.26	0.26	0.26	0.42	0.44	0.60	177.63
C. Waste Incineration	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.89
D. Other	3.57	3.63	4.08	4.22	4.35	4.49	4.62	4.76	229.42
7. Other *(as specified in Summary 1.A)*	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**0.00**
Total CH_4 emissions including CH_4 from LULUCF	**174.72**	**175.27**	**172.44**	**167.54**	**166.59**	**167.44**	**166.94**	**167.29**	**-19.36**
Total CH_4 emissions excluding CH_4 from LULUCF	**174.71**	**175.26**	**172.29**	**167.34**	**166.58**	**167.42**	**166.91**	**167.20**	**-19.25**
Memo Items:									
International Bunkers	0.08	0.07	0.07	0.06	0.06	0.06	0.06	0.07	-23.90
Aviation	0.08	0.07	0.07	0.06	0.06	0.06	0.06	0.07	-23.90
Marine	NO	NO	NO	NO	NO	NO	NO	NO	0.00
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	0.00
CO_2 Emissions from Biomass									

FOEN (2009)

Fig. 110 > NIR summary table 10 - N_2O emissions trends (sheet 1)

TABLE 10 EMISSION TRENDS
N_2O
(Part 1 of 2)

Inventory 2007
Submission 2009 v1.1
SWITZERLAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	**0.86**	**0.94**	**1.02**	**1.02**	**1.07**	**1.11**	**1.16**	**1.18**	**1.21**	**1.24**
A. Fuel Combustion (Sectoral Approach)	0.86	0.94	1.02	1.02	1.07	1.11	1.16	1.18	1.21	1.24
1. Energy Industries	0.16	0.17	0.18	0.19	0.20	0.21	0.23	0.24	0.27	0.30
2. Manufacturing Industries and Construction	0.17	0.16	0.15	0.14	0.15	0.14	0.13	0.12	0.12	0.12
3. Transport	0.33	0.41	0.48	0.50	0.54	0.56	0.60	0.62	0.62	0.63
4. Other Sectors	0.18	0.19	0.19	0.18	0.17	0.18	0.19	0.18	0.18	0.18
5. Other	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
B. Fugitive Emissions from Fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1. Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Oil and Natural Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Industrial Processes	**0.56**	**0.56**	**0.49**	**0.46**	**0.54**	**0.53**	**0.52**	**0.29**	**0.33**	**0.33**
A. Mineral Products	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
B. Chemical Industry	0.56	0.56	0.49	0.46	0.54	0.53	0.52	0.29	0.33	0.33
C. Metal Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Other Production										
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	0.36	0.34	0.33	0.31	0.30	0.28	0.26	0.24	0.23	0.21
4. Agriculture	**9.23**	**9.22**	**9.14**	**9.03**	**8.89**	**8.64**	**8.77**	**8.42**	**8.37**	**8.30**
A. Enteric Fermentation										
B. Manure Management	1.45	1.44	1.42	1.42	1.39	1.37	1.38	1.35	1.34	1.31
C. Rice Cultivation										
D. Agricultural Soils	7.77	7.77	7.71	7.60	7.49	7.25	7.37	7.05	7.02	6.97
E. Prescribed Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agricultural Residues	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
G. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5. Land Use, Land-Use Change and Forestry	**0.04**	**0.02**	**0.02**	**0.02**	**0.03**	**0.03**	**0.02**	**0.04**	**0.02**	**0.02**
A. Forest Land	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.00
B. Cropland	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
C. Grassland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Wetlands	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
E. Settlements	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
F. Other Land	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
G. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
6. Waste	**0.65**	**0.65**	**0.66**	**0.66**	**0.66**	**0.68**	**0.69**	**0.69**	**0.70**	**0.70**
A. Solid Waste Disposal on Land										
B. Waste-water Handling	0.58	0.59	0.59	0.59	0.60	0.60	0.60	0.61	0.61	0.61
C. Waste Incineration	0.05	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05
D. Other	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04
7. Other *(as specified in Summary 1.A)*	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Total N_2O emissions including N_2O from LULUCF	**11.69**	**11.74**	**11.66**	**11.51**	**11.49**	**11.26**	**11.41**	**10.86**	**10.86**	**10.80**
Total N_2O emissions excluding N_2O from LULUCF	**11.66**	**11.72**	**11.63**	**11.48**	**11.47**	**11.24**	**11.39**	**10.82**	**10.84**	**10.78**
Memo Items:										
International Bunkers	**0.10**	**0.09**	**0.10**	**0.10**	**0.11**	**0.11**	**0.12**	**0.12**	**0.13**	**0.14**
Aviation	0.10	0.09	0.10	0.10	0.11	0.11	0.12	0.12	0.13	0.14
Marine	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 Emissions from Biomass										

FOEN (2009)

Fig. 111 > NIR summary table 10 - N_2O emissions trends (sheet 2)

TABLE 10 EMISSION TRENDS
N_2O
(Part 2 of 2)

Inventory 2007
Submission 2009 v1.1
SWITZERLAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	Change from base to latest reported year
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	%
1. Energy	**1.25**	**1.25**	**1.23**	**1.21**	**1.18**	**1.15**	**1.13**	**1.06**	**23.10**
A. Fuel Combustion (Sectoral Approach)	1.25	1.25	1.23	1.21	1.18	1.15	1.13	1.06	23.10
1. Energy Industries	0.33	0.36	0.38	0.40	0.39	0.39	0.41	0.37	127.66
2. Manufacturing Industries and Construction	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.14	-21.93
3. Transport	0.61	0.57	0.53	0.49	0.46	0.43	0.40	0.38	15.46
4. Other Sectors	0.16	0.17	0.16	0.17	0.17	0.18	0.17	0.15	-15.72
5. Other	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	29.99
B. Fugitive Emissions from Fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-7.88
1. Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO	0.00
2. Oil and Natural Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-7.88
2. Industrial Processes	**0.37**	**0.39**	**0.37**	**0.33**	**0.35**	**0.25**	**0.32**	**0.27**	**-52.14**
A. Mineral Products	NO	NO	NO	NO	NO	NO	NO	NO	0.00
B. Chemical Industry	0.37	0.39	0.37	0.33	0.35	0.25	0.32	0.27	-52.14
C. Metal Production	NO	NO	NO	NO	NO	NO	NO	NO	0.00
D. Other Production									
E. Production of Halocarbons and SF_6									
F. Consumption of Halocarbons and SF_6									
G. Other	NO	NO	NO	NO	NO	NO	NO	NO	0.00
3. Solvent and Other Product Use	0.19	0.17	0.17	0.17	0.16	0.17	0.17	0.17	-51.23
4. Agriculture	**8.31**	**8.22**	**8.21**	**8.00**	**8.01**	**8.02**	**7.99**	**8.12**	**-12.05**
A. Enteric Fermentation									
B. Manure Management	1.32	1.29	1.29	1.28	1.28	1.30	1.30	1.32	-8.88
C. Rice Cultivation									
D. Agricultural Soils	6.98	6.92	6.91	6.71	6.72	6.71	6.67	6.79	-12.66
E. Prescribed Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO	0.00
F. Field Burning of Agricultural Residues	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00
G. Other	NO	NO	NO	NO	NO	NO	NO	NO	0.00
5. Land Use, Land-Use Change and Forestry	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**-50.65**
A. Forest Land	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	-78.68
B. Cropland	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	-34.04
C. Grassland	NO	NO	NO	NO	NO	NO	NO	NO	0.00
D. Wetlands	NO	NO	NO	NO	NO	NO	NO	NO	0.00
E. Settlements	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0.00
F. Other Land	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0.00
G. Other	NE	NE	NE	NE	NE	NE	NE	NE	0.00
6. Waste	**0.72**	**0.73**	**0.74**	**0.76**	**0.77**	**0.80**	**0.81**	**0.81**	**25.95**
A. Solid Waste Disposal on Land									
B. Waste-water Handling	0.61	0.62	0.63	0.63	0.63	0.64	0.64	0.65	12.08
C. Waste Incineration	0.05	0.06	0.06	0.07	0.08	0.10	0.10	0.10	109.28
D. Other	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.07	228.41
7. Other *(as specified in Summary 1.A)*	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**0.00**
Total N_2O emissions including N_2O from LULUCF	**10.86**	**10.78**	**10.74**	**10.50**	**10.50**	**10.40**	**10.43**	**10.45**	**-10.59**
Total N_2O emissions excluding N_2O from LULUCF	**10.84**	**10.77**	**10.71**	**10.47**	**10.48**	**10.39**	**10.41**	**10.44**	**-10.46**
Memo Items:									
International Bunkers	**0.15**	**0.14**	**0.13**	**0.11**	**0.11**	**0.11**	**0.12**	**0.12**	**27.84**
Aviation	0.15	0.14	0.13	0.11	0.11	0.11	0.12	0.12	27.84
Marine	NO	NO	NO	NO	NO	NO	NO	NO	0.00
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	0.00
CO_2 Emissions from Biomass									

Note: All footnotes for this table are given at the end of the table on sheet 5.

Fig. 112 > NIR summary table 10 – HFCs, PFCs and SF_6 emissions trends (sheet 1)

TABLE 10 EMISSION TRENDS
HFCs, PFCs and SF_6
(Part 1 of 2)

Inventory 2007
Submission 2009 v1.1
SWITZERLAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990) (Gg)	1991 (Gg)	1992 (Gg)	1993 (Gg)	1994 (Gg)	1995 (Gg)	1996 (Gg)	1997 (Gg)	1998 (Gg)	1999 (Gg)
Emissions of HFCs[3] - (Gg CO_2 equivalent)	**0.02**	**0.19**	**6.15**	**13.02**	**29.21**	**168.76**	**208.67**	**270.38**	**315.28**	**362.09**
HFC-23	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	0.00	0.00	0.00
HFC-32	NO	NO	NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-41	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-43-10mee	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-125	NO	NO	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02
HFC-134	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-134a	0.00	0.00	0.00	0.01	0.02	0.11	0.13	0.16	0.18	0.19
HFC-152a	NO	NO	NO	NO	NO	0.03	0.04	0.05	0.04	0.05
HFC-143	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-143a	NO	NO	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
HFC-227ea	NO	NO	NO	NO	NO	NO	NO	NO	0.00	0.00
HFC-236fa	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-245ca	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Unspecified mix of listed HFCs[4] - (Gg CO_2 equivalent)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions of PFCs[3] - (Gg CO_2 equivalent)	**100.21**	**84.70**	**69.26**	**29.69**	**17.66**	**14.69**	**17.20**	**23.85**	**28.32**	**39.56**
CF_4	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C_2F_6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C_3F_8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C_4F_{10}	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
c-C_4F_8	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C_5F_{12}	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C_6F_{14}	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00
Unspecified mix of listed PFCs[4] - (Gg CO_2 equivalent)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions of SF6[3] - (Gg CO_2 equivalent)	**143.62**	**145.92**	**148.21**	**126.35**	**112.04**	**95.00**	**92.27**	**129.94**	**159.18**	**145.78**
SF_6	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.01

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Fig. 113 > NIR summary table 10 – HFCs, PFCs and SF_6 emissions trends (sheet 2)

TABLE 10 EMISSION TRENDS
HFCs, PFCs and SF_6
(Part 2 of 2)

Inventory 2007
Submission 2009 v1.1
SWITZERLAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	Change from base to latest reported year
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	%
Emissions of HFCs[3] - (Gg CO_2 equivalent)	**421.72**	**495.79**	**520.87**	**574.00**	**639.68**	**629.35**	**609.50**	**629.52**	**2'794'236.70**
HFC-23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
HFC-32	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	100.00
HFC-41	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-43-10mee	0.00	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-125	0.02	0.03	0.03	0.04	0.04	0.04	0.04	0.05	100.00
HFC-134	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-134a	0.21	0.24	0.25	0.26	0.29	0.28	0.27	0.28	1'591'280.23
HFC-152a	0.04	0.04	0.07	0.03	0.03	0.03	0.03	0.02	100.00
HFC-143	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-143a	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	100.00
HFC-227ea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
HFC-236fa	NO	NO	NO	NO	NO	NO	NO	NO	0.00
HFC-245ca	NO	NO	NO	NO	NO	NO	NO	NO	0.00
Unspecified mix of listed HFCs[4] - (Gg CO_2 equivalent)	NO	NO	NO	NO	NO	NO	NO	NO	0.00
Emissions of PFCs[3] - (Gg CO_2 equivalent)	**93.17**	**52.64**	**50.87**	**87.91**	**74.97**	**56.79**	**74.50**	**77.08**	**-23.08**
CF_4	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-78.56
C_2F_6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	129.12
C_3F_8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13'813.90
C_4F_{10}	NO	NO	NO	0.00	0.00	NO	NO	NO	0.00
c-C_4F_8	NO	NO	0.00	0.00	0.00	0.00	0.00	0.00	100.00
C_5F_{12}	NO	NO	NO	NO	NO	NO	NO	NO	0.00
C_6F_{14}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
Unspecified mix of listed PFCs[4] - (Gg CO_2 equivalent)	NO	NO	NO	NO	NO	NO	NO	NO	0.00
Emissions of SF6[3] - (Gg CO_2 equivalent)	**203.36**	**235.16**	**210.57**	**195.30**	**181.99**	**204.95**	**180.62**	**175.41**	**22.14**
SF_6	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	22.14

Note: All footnotes for this table are given at the end of the table on sheet 5.

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Fig. 114 > NIR overall summary table 10 (sheet 1)

TABLE 10 EMISSION TRENDS
SUMMARY
(Part 1 of 2)

Inventory 2007
Submission 2009 v1.1
SWITZERLAND

GREENHOUSE GAS EMISSIONS	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)
CO_2 emissions including net CO_2 from LULUCF	42'144.48	44'465.95	45'003.72	40'356.55	37'307.70	38'016.38	39'471.91	40'808.60	42'872.91	43'422.76
CO_2 emissions excluding net CO_2 from LULUCF	44'503.98	46'142.24	46'160.78	43'578.46	42'825.61	43'322.12	44'001.53	43'323.96	44'560.02	44'802.32
CH_4 emissions including CH_4 from LULUCF	4'356.25	4'325.36	4'212.17	4'072.22	3'980.20	3'962.99	3'905.98	3'836.93	3'771.74	3'719.53
CH_4 emissions excluding CH_4 from LULUCF	4'348.06	4'324.26	4'211.78	4'071.90	3'978.03	3'959.73	3'904.25	3'825.70	3'769.89	3'719.47
N_2O emissions including N_2O from LULUCF	3'624.48	3'639.83	3'613.50	3'566.95	3'562.72	3'491.45	3'537.71	3'365.97	3'366.85	3'348.90
N_2O emissions excluding N_2O from LULUCF	3'613.15	3'632.21	3'606.28	3'559.85	3'554.82	3'483.15	3'530.35	3'353.86	3'359.75	3'342.88
HFCs	0.02	0.19	6.15	13.02	29.21	168.76	208.67	270.38	315.28	362.09
PFCs	100.21	84.70	69.26	29.69	17.66	14.69	17.20	23.85	28.32	39.56
SF_6	143.62	145.92	148.21	126.35	112.04	95.00	92.27	129.94	159.18	145.78
Total (including LULUCF)	**50'369.07**	**52'661.96**	**53'053.00**	**48'164.78**	**45'009.55**	**45'749.27**	**47'233.74**	**48'435.67**	**50'514.29**	**51'038.62**
Total (excluding LULUCF)	**52'709.04**	**54'329.53**	**54'202.46**	**51'379.28**	**50'517.38**	**51'043.45**	**51'754.26**	**50'927.69**	**52'192.44**	**52'412.10**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)
1. Energy	42'085.55	44'080.54	44'235.42	41'880.46	40'974.16	41'651.33	42'529.55	42'029.95	43'269.87	43'485.55
2. Industrial Processes	3'258.04	2'911.98	2'744.54	2'437.70	2'616.89	2'558.95	2'410.02	2'267.68	2'380.22	2'469.51
3. Solvent and Other Product Use	467.93	448.06	429.25	405.60	390.27	371.23	348.48	323.61	298.79	293.63
4. Agriculture	5'903.39	5'906.79	5'832.67	5'754.74	5'705.88	5'638.35	5'655.50	5'499.09	5'467.90	5'410.34
5. Land Use, Land-Use Change and Forestry(5)	-2'339.97	-1'667.57	-1'149.46	-3'214.49	-5'507.83	-5'294.18	-4'520.52	-2'492.03	-1'678.15	-1'373.48
6. Waste	994.13	982.17	960.58	900.77	830.18	823.59	810.71	807.37	775.66	753.07
7. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (including LULUCF)(5)	**50'369.07**	**52'661.96**	**53'053.00**	**48'164.78**	**45'009.55**	**45'749.27**	**47'233.74**	**48'435.67**	**50'514.29**	**51'038.62**

(1) The column "Base year" should be filled in only by those Parties with economies in transition that use a base year different from 1990 in accordance with the relevant decisions of the COP. For these Parties, this different base year is used to calculate the percentage change in the final column of this table.

(2) Fill in net emissions/removals as reported in table Summary 1.A. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(3) Enter actual emissions estimates. If only potential emissions estimates are available, these should be reported in this table and an indication for this be provided in the documentation box. Only in these rows are the emissions expressed as CO_2 equivalent emissions.

(4) In accordance with the UNFCCC reporting guidelines, HFC and PFC emissions should be reported for each relevant chemical. However, if it is not possible to report values for each chemical (i.e. mixtures, confidential data, lack of disaggregation), this row could be used for reporting aggregate figures for HFCs and PFCs, respectively. Note that the unit used for this row is Gg of CO_2 equivalent and that appropriate notation keys should be entered in the cells for the individual chemicals.

(5) Includes net CO_2, CH_4 and N_2O from LULUCF.

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Fig. 115 > NIR overall summary table 10 (sheet 2)

TABLE 10 EMISSION TRENDS SUMMARY (Part 2 of 2)

Inventory 2007
Submission 2009 v1.1
SWITZERLAND

GREENHOUSE GAS EMISSIONS	2000	2001	2002	2003	2004	2005	2006	2007	Change from base to latest reported year
	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	(%)
CO_2 emissions including net CO_2 from LULUCF	44'645.41	44'893.76	44'146.58	43'293.17	45'641.99	46'897.40	46'645.69	42'981.73	1.99
CO_2 emissions excluding net CO_2 from LULUCF	43'900.25	44'681.68	43'771.49	44'876.76	45'347.05	46'038.20	45'575.39	43'636.30	-1.95
CH_4 emissions including CH_4 from LULUCF	3'669.12	3'680.72	3'621.23	3'518.29	3'498.39	3'516.17	3'505.84	3'513.00	-19.36
CH_4 emissions excluding CH_4 from LULUCF	3'668.86	3'680.45	3'618.18	3'514.09	3'498.24	3'515.83	3'505.09	3'511.26	-19.25
N_2O emissions including N_2O from LULUCF	3'366.23	3'343.25	3'328.33	3'253.58	3'253.66	3'225.09	3'233.44	3'240.66	-10.59
N_2O emissions excluding N_2O from LULUCF	3'360.28	3'337.43	3'321.25	3'246.07	3'248.42	3'219.84	3'228.21	3'235.07	-10.46
HFCs	421.72	495.79	520.87	574.00	639.68	629.35	609.50	629.52	2'794'236.70
PFCs	93.17	52.64	50.87	87.91	74.97	56.79	74.50	77.08	-23.08
SF_6	203.36	235.16	210.57	195.30	181.99	204.95	180.62	175.41	22.14
Total (including LULUCF)	**52'399.02**	**52'701.33**	**51'878.46**	**50'922.25**	**53'290.68**	**54'529.75**	**54'249.58**	**50'617.40**	**0.49**
Total (excluding LULUCF)	**51'647.64**	**52'483.15**	**51'493.24**	**52'494.14**	**52'990.35**	**53'664.95**	**53'173.31**	**51'264.64**	**-2.74**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	Change from base to latest reported year
	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	(%)
1. Energy	42'432.64	43'197.46	42'309.14	43'429.80	43'788.22	44'389.61	43'952.67	41'966.40	-0.28
2. Industrial Processes	2'788.63	2'897.00	2'840.24	2'876.30	3'033.92	3'081.34	3'041.11	3'058.37	-6.13
3. Solvent and Other Product Use	281.72	264.81	252.72	243.80	230.44	230.00	229.16	230.83	-50.67
4. Agriculture	5'411.35	5'415.95	5'390.84	5'284.77	5'258.67	5'281.68	5'287.40	5'345.72	-9.45
5. Land Use, Land-Use Change and Forestry (5)	751.37	218.18	385.22	-1'571.89	300.33	864.80	1'076.27	-647.24	-72.34
6. Waste	733.31	707.93	700.30	659.47	679.10	682.32	662.98	663.33	-33.28
7. Other	NO	NO	NO	NO	NO	NO	NO	NO	0.00
Total (including LULUCF)(5)	**52'399.02**	**52'701.33**	**51'878.46**	**50'922.25**	**53'290.68**	**54'529.75**	**54'249.58**	**50'617.40**	**0.49**

(1) The column "Base year" should be filled in only by those Parties with economies in transition that use a base year different from 1990 in accordance with the relevant decisions of the COP. For these Parties, this different base year is used to calculate the percentage change in the final column of this table.

(2) Fill in net emissions/removals as reported in table Summary 1.A. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(3) Enter actual emissions estimates. If only potential emissions estimates are available, these should be reported in this table and an indication for this be provided in the documentation box. Only in these rows are the emissions expressed as CO_2 equivalent emissions.

(4) In accordance with the UNFCCC reporting guidelines, HFC and PFC emissions should be reported for each relevant chemical. However, if it is not possible to report values for each chemical (i.e. mixtures, confidential data, lack of disaggregation), this row could be used for reporting aggregate figures for HFCs and PFCs, respectively. Note that the unit used for this row is Gg of CO_2 equivalent and that appropriate notation keys should be entered in the cells for the individual chemicals.

(5) Includes net CO_2, CH_4 and N_2O from LULUCF.

Documentation box:
• Parties should provide detailed explanations on emissions trends in Chapter 2: Trends in Greenhouse Gas Emissions and, as appropriate, in the corresponding Chapters 3 - 9 of the NIR. Use this documentation box to provide references to relevant sections of the NIR if any additional information and further details are needed to understand the content of this table.
• Use the documentation box to provide explanations if potential emissions are reported.

Annex 2: Summary of reporting of the supplementary information under Art. 7, para. 2 of the Kyoto Protocol

Tab. 64 > Supplementary information under the Kyoto Protocol

Information reported under Article 7, paragraph 2	Section
National systems in accordance with Article 5, paragraph 1	3.4
National registries	3.5
Supplementarity relating to the mechanisms pursuant to Articles 6, 12 and 17	5.3
Policies and measures in accordance with Article 2	4
Domestic and regional programmes and/or legislative arrangements and enforcement and administrative procedures	4.2
Information under Article 10	
Art 10a	3.4
Art 10b	4.3 and 6.3
Art 10c	7.4
Art 10d	8
Art 10e	9
Financial resources (Annex II only)	7

Abbreviations and Acronyms

AAU	Assigned amount units
AOD	Aerosol optical depth
ARE	Swiss Federal Office for Spatial Development
ART	Agroscope Reckenholz-Tänikon Research Station
BSRN	Baseline Surface Radiation Network
C2SM	Centre for Climate Systems Modelling
CADP	Climate Adaptation Development Programme
CDC	Caisse des Dépôts et Consignations
CDM	Clean development mechanism
CER	Certified emission reduction
CFCs	Chlorofluorocarbons
CH_4	Methane
CHF	Swiss francs
CHR	International Commission for the Hydrology of the Rhine basin
CIS	Commonwealth of Independent States
CMP	Meeting of the Parties to the Kyoto Protocol
CO	Carbon monoxide
CO_2	Carbon dioxide
COP	Conference of the Parties
CORE	Federal Energy Research Commission
CORINAIR	CORe INventory of AIR emissions
COST	European Cooperation in the Area of Scientific and Technical Research
CRF	Common reporting format
CRMG	Commodity Risk Management Group
CRT	Continuously Regenerating Trap
DES	Data exchange standard
DETEC	Federal Department of Environment, Transport, Energy and Communications
DGC	Directorate General of Customs
EAE	Energy Agency for Electrical Appliances
EASA	European Aviation Safety Agency
ECAC	European Civil Aviation Conference
ECMWF	European Centre for Medium-Range Weather Forecasts
EEA	European Environmental Agency
EKK	Cryospheric commission
EMEP	European Monitoring and Evaluation Programme
EMIS	Swiss national air pollution data base
EMPA	Swiss Federal Laboratories for Materials Testing and Research
EnAW	The Energy Agency for the Economy

EPA	Environmental Protection Act
EPFL	Swiss Federal Institute of Technology Lausanne
ETH/ETHZ	Swiss Federal Institute of Technology Zürich
ERC	European Research Council
ERU	Emission reduction units
ESA	European Space Agency
ETS	Emission Trading System
EU	European Union
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
EUVC	European ultraviolet radiometer calibration centre
FAL	Swiss Federal Research Station for Agroecology and Agriculture
FCPF	Forest Carbon Partnership Facility
FDFA	Federal Department of Foreign Affairs
FDHA	Federal Department of Home Affairs
FEDRO	Federal Roads Office
FFA	Federal Finance Administration
FOAG	Swiss Federal Office for Agriculture
FOCA	Federal Office of Civil Aviation
FOEN	Federal Office for the Environment
FOITT	Federal Office of Information Technology, Systems and Telecommunication
FOPH	Federal Office of Public Health
FSO	Federal Office of Statistics
GAW	Global Atmosphere Watch
GAW-WCC	GAW-World Calibration Centre
GAW-WORCC	GAW-World Optical depth Research and Calibration Centre
GCTE	Global Change and Terrestrial Ecosystems
GCOS	Global Climate Observing System
GDP	Gross domestic product
GEF	Global Environment Facility
GEP	Global Environmental Programme (of SDC)
Gg	Gigagram (1,000 tonnes)
GHG	Greenhouse gas
GNP	Gross national product
GOOS	Global Ocean Observing System
GPCC	Global Programme Climate Change
GRDC	Global Runoff Data Centre
GRUAN	GCOS Reference Upper Air Network
GSN	GCOS Surface Network
GTN-G	Global Terrestrial Network – Glaciers
GTN-L	Global Terrestrial Network –Lakes
GTN-P	Global Terrestrial Network – Permafrost

GTN-R	Global Terrestrial Network – River discharge
GTOS	Global Terrestrial Observing System
GUAN	GCOS Upper Air Network
GWh	Giga Watt hours
GWP	Global warming potential
HCL	Hydrochloric acid
HDD	Heating degree days
HF	Hydrogen fluoride
HFCs	Hydrofluorocarbons
HGV	Heavy goods vehicle
HVF	Heavy vehicle fee
IAR	Independent assessment report
IEA	International Energy Agency
ICAO	International Civil Aviation Organization
ICPR	International Commission for the Protection of the Rhine
ICSU	International Council for Science
ICT	Information and communication technology
IDM	Internal document management system
IDP	Inventory development plan
IGBP	International Geosphere Biosphere Programme
IISD	International Institute for Sustainable Development
IHDP	International Human Dimensions Programme
ISOT	Isotopes in the water cycle network
ITC	International Trade Centre
ITTO	International Tropical Timber Organization
IOC	Intergovernmental Oceanographic Commission
IPCC	Intergovernmental Panel on Climate Change
IPR	Intellectual property rights
ISDC	Interdepartmental Sustainable Development Committee
JI	Joint implementation
ITL	International transaction log
km	kilometre
kW	kilo Watt
LCA	Life Cycle Analysis
lCER	Long-term certified emissions reduction
LDC	Least Developed Countries
LKO	Light climatic observatory
LPG	Liquefied petroleum gas
LULUCF	Land Use, Land Use Change and Forestry
MDGs	UN Millennium Development Goals
MeteoSwiss	Federal Office of Meteorology and Climatology

MSWI	Swiss municipal solid waste incinerator plants
Mt	Million tonnes
NAPOL	National pollen monitoring network
NAQUA	National groundwater observation programme
NBCN	Swiss National Basic Climatological Network
NC3	Switzerland's third National Communication
NC4	Switzerland's fourth National Communication
NCCR	National Centre of Competence in Research
NFI	National Forest Inventory
NGO	Non-governmental organization
NH_3	Ammonia
NIR	National Inventory Report
NIS	National Inventory System
NMVOC	Non-methane volatile organic compound
NO_X	Nitrogen oxides
N_2O	Nitrous oxide
ÖBU	Swiss Association for Environmentally Conscious Management
OcCC	Swiss Advisory Body on Climate Change
OCCR	Oeschger Centre for Climate Change Research
OECD	Organization for Economic Cooperation and Development
p.a.	per annum
PCDD	Polychlorinated dibenzodioxins
PCDF	Polychlorinated dibenzofuranes
PERMOS	Permafrost monitoring Switzerland
PFCs	Perfluorocarbons
PJ	Petajoule (277.8 GWh)
PLANAT	National Platform for Natural Hazards
PM	Particulate matter
PMOD/WRC	Physikalisch-meteorologisches Observatorium Davos / World Radiation Centre
ProClim	Swiss Forum for Climate and Global Change
PV	Photovoltaics
QA	Quality Assurance
QC	Quality Control
QMS	Quality management system
RBCN	Regional Basic Climatological Network
REDD	Reducing Emissions from Deforestation and land Degradation
REPIC	Renewable Energy & Energy Efficiency Promotion in International Co-operation
RES	Reference Energy System
RMU	Carbon removal unit
SACRaM	Swiss Alpine Climate Radiation Monitoring network

SBSTA	Subsidiary Body for Scientific and Technological Advice
SCNAT	Swiss Academy of Sciences
SDC	Swiss Agency for Development and Cooperation
seco	State Secretariat for Economic Affairs
SEF	Standard electronic format
SF_6	Sulphur hexafluoride
SFOE	Swiss Federal Office of Energy
SIA	Swiss Society of Engineers and Architects
SICCP	Swiss Interdepartmental Committee for Climate Policy
SLF	Swiss Federal Institute for Snow and Avalanche Research
SMEs	Small and medium enterprises
SNB	Swiss National Bank
SO_2	Sulphur dioxide
SQL	Structured Query Language
tCER	Temporary certified emissions reduction
TFA	Treated floor area
TOW	Technical ordinance on waste
TWh	Tera Watt hour
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organisation
VOC	Volatile organic compounds
VAT	Value-added tax
vkm	vehicle kilometres
VTG	Defence Sector within the Federal Department of Defence Civil Protection and Sport
WCC	World Calibration Centre
WCRP	World Climate Research Programme
WGMS	World Glacier Monitoring Service
WMO	World Meteorological Organization
WORCC	World Optical depth Research and Calibration Centre
WSL	Swiss Federal Institute for Forests, Snow and Landscape Research
WWF	World Wildlife Fund